Chapter 6

The Networks That Produce Amenity

CONTENTS

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The previous two chapters described broad patterns of change in the national economy. While there are themes common to all business networks, each is changing in unique ways. A close examination of each network is needed to understand many of the changes taking place. These examinations provide a basis for hypotheses about the future that could not be constructed by extrapolation. They also offer a different perspective on the practical choices facing public policy makers. In some cases, the discussions reveal the need for reforms that apply only to specific business sectors. In others, they show how programs designed to facilitate national economic growth will help or hinder productive restructuring in a given sector.

The sector discussions in this chapter test national themes to see how they apply in practical cases. Each addresses the following questions:

- How does the network operate as an integrated system, combining goods and services to connect primary resources to final markets?
- How are the roles of the different component businesses within the network changing? How are the connections between them changing the performance of the whole?
- How does the scale and scope of enterprises within the network affect the production process?
- What is the significance of new developments in the geographic location of production facilities?
- What is the relative importance of technology, trade, regulation, and other forces shaping change in the networks?
- What shape may these networks take in the future?
- What practical choices affect the direction the networks take?

Each discussion represents, in effect, one column of table 4-6 in chapter 4. Organization of the chapter by amenity group maintains a clear view of the integrated performance of networks.

Examinations of specific business sectors comprising the larger amenity network appear as follows:

- Most amenity networks make heavy use of inputs from one production sector. An analysis of the current and possible future performance of such business sectors therefore appears in the section covering the related amenity group. The discussions of Health and Education, for example, cover many issues relevant to the Social Service sector. Transactional Activities are treated in the discussion of Personal Business and Communication.
- Where appropriate, the amenity discussions also contain a review of intermediate demand for the products of the primary business sectors analyzed.
- While manufacturing issues appear throughout the amenity discussions (e.g., the manufacture of textiles and apparel is discussed in the Clothing and Personal Care section, and food manufacturing in Food), a final section pulls the pieces together and provides an overview of changes in manufacturing.

FOOD[1]

Prospects

Most farm products are produced by businesses managed more like manufacturing facilities than the farm operations of an earlier generation. A growing fraction of all American spending on the Food amenity goes to add value after food Products leave farming operations. This value comes in the form of increased variety in fresh foods as well as varying degrees of processing. Processing alternatives now include such things as tablecloth restaurants, fast food, and a range of frozen and fresh entrees in grocery stores.

[1]Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Food," sector study, Washington, DC, 1987.

The American food production and distribution system has been reshaped by changing consumer incomes and expectations (see ch. 2). Parts of the industry never before exposed to foreign competition find themselves struggling to maintain market share. Imports of processed foods (such as confections, alcoholic beverages, and processed foods with an ethnic appeal) have grown so rapidly that they now approximately equal U.S. food exports (which depend almost entirely on bulk commodities and products like meat and meals that require little processing—see ch. 9). Imports of food processing equipment and food processing licenses have also grown.

Technology has had an uneven effect on the businesses that comprise the food network. Farm productivity and the productivity of many food manufacturing activities has grown rapidly, while productivity growth in wholesale and retail enterprises has been sluggish. Technologies likely to have the most profound effect on the operation of the American Food system may not appear as measured productivity gains in any component business (as will be the case with the provision of Clothing and Personal Care). Information technology can tie retail, wholesale, transportation, food processing, and farm operations together in ways that facilitate system-wide flexibility and productivity. New packaging and preservation techniques can improve the quality of products reaching consumers and can reshape the structure of the businesses moving farm products to forks.

Several different outcomes are possible during the next 20 years:

- The food production system could grow in away that would make it a tightly integrated, high-technology production network. Improved management systems can be implemented through information technology and lowered costs made possible by new, safe packaging and preservation technologies, which allow a greater variety of fresh products to be available at comparatively low costs. Foods can be tailored to regional or ethnic tastes, for special dietary needs (e.g., low-sodium or low calorie) and for other specialized markets (e.g., elderly individuals looking for a high-quality menu that can be prepared at home with little effort)-all without a significant increase in cost. Competition on the basis of quality could increase consumer knowledge of the health implications of their diets.
- The flexibility of the new communication system could allow a variety of comparatively small producers of farm products and small manufactured food processors to enter networks once reserved for very large firms. Improved on-farm technology, coupled with improved packaging, communication, and transportation networks, could lead to increased productivity in specialized food products like cultivated fish and many varieties of fruits and vegetables.
- Capital equipment could replace many clerical and low-skill tasks in retail, and wholesale operations could be automated. With the possible exception of meat processing, the productivity of food processing facilities could increase to the point where dangerous and low paid occupations would be largely replaced by machinery.
- Lack of effective competition could decrease product quality and the potential of new efficiencies may not rebound to the advantage of consumers. Foreign products could provide much of the variety available on store shelves. Large oligopolies, investing little in research or new equipment, could compete largely on the basis of advertising rather than product quality. Low-income and rural areas could find themselves facing a sharp decline in real choice and an increase in real food prices. Productivity and food preservation could be achieved by methods with adverse health effects. Oligopolies in food services could replace regional and ethnic diversity with homogeneous national products.
- Small farms could be reduced to little more than hobbies with virtually all food value produced on very large farms (many of which may be owned by a single family). The “post-harvest” businesses could be divided between sophisticated manufacturing enterprises on the one hand, and meat-packing, wholesale, grocery, and restaurant operations—which show virtually no productivity gains and provide large numbers of poorly paid jobs—on the other.

These alternatives are obviously not mutually exclusive. Signs of each can be found in existing trends.

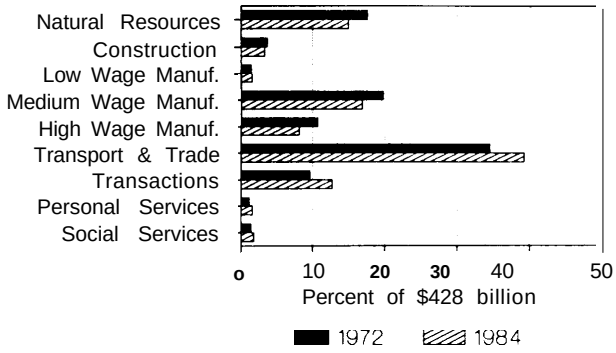
The role of government in the Food network varies greatly from sector to sector. The farming industry

is heavily influenced by government programs—through both heavy Federal funding of research and massive price support programs. Federal farm programs totaled $60 billion between 1981 and 1986.[2] Federal regulations provide extensive if uneven coverage of food-product safety.

Structure and Performance

The system that brings food to American forks provides business throughout the U.S. economy. Of the approximately $427 billion of value-added in the economy generated directly and indirectly by Food consumption in 1984, nearly 40 percent ended up in the transportation and wholesaling industry, grocery stores, and restaurants. Approximately 15 percent resulted from farm and other resource inputs. Food manufacturing contributed approximately 17 percent of value-added. During the past decade, farming, other natural resource inputs, and manufacturing have lost their share of the American food dollar (measured in constant dollars), while transportation, trade, and transactional enterprises have gained (see figure 6-l).

Figure 6-l. -Value-Added To Meet Demand for Food ($428 billion* in 1984)



● Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

The Farm Sector

Technology and Productivity. -Enormous productivity gains in farming were among the most obvious symbols of economic transformation at the turn of the century. During the past 60 years, the U.S. agricultural sector has undergone two technological revolutions—the mechanization of farming, and the widespread use of chemical inputs. Less than 3 percent of the U.S. work force feeds the U.S. population and provides a large surplus for export. A century ago, the majority of American workers were employed on farms.

The system is far from running out of ideas. Rates of productivity growth are expected to be rapid for the next two decades.[3] Agriculture is probably on the verge of a third technological revolution, stemming from advances in biotechnology, information-processing technology, and a variety of other innovations.

A study analyzing the potential impacts of 150 emerging technologies on future agricultural production predicts strong productivity growth throughout the next two decades.[4] In the near term, the largest increases are forecast for the dairy sector, with milk productivity projected to increase at an annual rate of 3.9 percent—compared with 2.6 percent over the past two decades. The application of biotechnology to crop production is expected to proceed more slowly, with widespread adoption forecast after the year 2000.

Scale and Scope.–It is not surprising that enormous growth in farm productivity led to massive structural changes in American farming. The new production systems changed activities on the farm, requiring sophisticated management practices, new technical expertise, and heavy investment in capital equipment. They have also reshaped the economics of large and small farming operations. The question of whether new agricultural technologies have selectively benefited large or small farms is a matter of dispute and recent litigations

What cannot be disputed is that the number of farms in the United States has decreased by nearly two-thirds since the pre-World War II peak of 6.5 million. Of the 2.3 million farms that remained in 1985, 5 percent—about 100,000 farms—accounted

2 *Economjc Report of the President, 1987* (Washington, DC: U.S. Government Printing Office, 1987), p. 154.

3 U.S. Congress, office of Technology Assessment, *Technology, Public Policy, and the Changing Structure of American Agriculture,* OTA-F-285 (Washington, DC: U.S. Government Printing Office, March 1986).

4 Ibid.

5 Decision of the Superior Court of Alameda County, CA, "California Agrarian Action Project, Inc. et al., v. Regents of the University of California," Nov. 17, 1987.

for half of the Nation's agricultural production, up from 42 percent in 1960. In terms of net farm income, the largest farms—those with annual gross revenues of more than $500,000, or 1.2 percent of all farms—claimed two-thirds of total income in 1982. In contrast, farms with annual revenues of less than $99,000, which constituted 86.5 percent of all farms in 1982, accounted for less than 2 percent of net farm income. Moderate-sized farms—those with annual sales of between $100,000 and $199,000, and perhaps the closest match to the traditional notion of the "family farm"-represented 8.1 percent of all farms in 1982, and claimed a 14.6 percent share of net farm income.

Consolidation of farm enterprises is expected to continue through the remainder of the century. By the year 2000, small and part-time farms with annual sales less than $100,000 are likely to represent 80 percent of all U.S. farms but may earn only 4 percent of cash receipts. Large-scale farms, on the other hand, with annual sales greater than $250,000–only 14 percent of all farms—may earn 80 to 90 percent of all cash receipts.[6]

Geography.-The geography of farm activity is heavily influenced by public programs. Farm product costs vary widely around the nation. In 1982, for example, wheat grown in the northeast cost $2.26 per bushel to produce, while producers in the northern Plains States had costs as low as $1.25. Small farming operations in some areas were able to produce at lower costs than large farms in others.[7] It is possible for farms in several regions to be profitable because public programs regulate prices. Subsidized irrigation and policies allowing the "mining" of groundwater also have the effect of encouraging farm activity in areas which would otherwise find profitable agriculture difficult.

Food Manufacturing

The food manufacturing sector plays a critical role in the Food system, purchasing 70 percent of U.S. agricultural production and largely determining the mix of products available to consumers. It is also the most concentrated sector in the Food network.

Technology and Productivity. -Labor productivity in the food manufacturing business has grown so rapidly during the past several decades that it has outstripped demand growth. Employment in the industry actually declined between 1950 and 1985.[8] With an appropriate research program in food process engineering, annual productivity increases of 2.5 to 3.5 percent are easily possible in food manufacturing during the next decade.[9]

Innovations in food manufacturing have had the effect of reducing a variety of factor costs in addition to improving labor productivity, and are likely to continue to do so. Table 6-1 summarizes a study that covered a variety of innovations under development in the food manufacturing industries. Most of the innovations resulted in a faster process that made more efficient use of energy and raw materials, and most required more capital equipment. Almost without exception they resulted in both improved quality and lower costs.

The rapid growth in imports of manufactured food products and the poor performance of U.S. exports in this area (see ch. 9) do not result from an imbalance in food processing technology. [n fact, the productivity of the U.S. industry is probably higher than that of most U.S. trade competitors—including those in Western Europe.[10]

New technologies are expected to have a major effect on the physical processing of food products and the way the products are packaged. Most result from straightforward advances in production engineering. Bioengineering may result in a curious variety of radically new technologies. Artificial citrus juice, for example, has already been produced in lab oratories.[11] Intensive efforts are being made to develop calorie-free cake and ice cream.[12]

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[6] *Technology, Public Policy, and the Changing Structure of American Agriculture,* **op. cit., footnote 3**

[7] **Ibid; and U.S. Congress, Office of Technology Assessment,** *A Review of U.S. Competitiveness in Agricultural Trade, OTA-TM-TET-29* **(Washington, DC: U.S. Government Printing Office, October 1986), p. 46.**

8 U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, Table 6.7b.

9 U.S. Congress, Office of Technology Assessment, *Agricultural Postharvest Technology and Marketing Economics Research—A Technical Memorandum, OTA-TM-F-21* **(Washington, DC: U.S. Government Printing Office, April 1983), p.** 47.

10 Center on Transnational Corporations, *Transnational Corporations in Food and* **Beverage Processing (New York: United Nations, 1982), cited in John M. Connor et al.,** *The Food Manufacturing Industries* **(Lexington, MA: D.C. Heath & Co., 1985), pp. 22-23.**

11 J. Flynn, "Want Some O.J.? It's Fresh from the Test Tube," *Business Week, No. 2973, Nov. 17, 1986,* pp. *160-161.*

12 "Will Foods of the Future Be Safe?" *The New York* **Times, Nov. 19, 1986, p. C15.**

Table 6-1.—The Impact of Innovation in Food Manufacturing (simple counts of primary and secondary impacts)

Impacts on production inputs	Reduced use of factor	Increased use of factor	
Labor	325	8	
Energy	128	9	
Packaging materials	126	23	
Plant time	238	10	
Transportation	26	0	
Equipment	96	269	
Impacts on product quality	**Higher quality**	**Same quality**	**Lower quality**
Lower price	28	14	2
Same price	26	4	0
Higher price	77	5	2[a]

[a]Both cases occurred in packaged fluid milk production.

SOURCE: John M. ConnoR "Market Structure and Technological Opportunities in the U.S. Food Manufacturing Industry," contract report prepared for the Office of Technology Assessment, March 1986.

New packaging and preservation techniques present a major opportunity for savings. Losses of fruits and vegetables during transportation and storage have been estimated to be as high as 30 percent of the total supply .[13] Packaging may also contribute as much as 30 percent of the value-added to processed foods. [14] Packaging costs exceed the cost of food products in beer, soft drinks, breakfast cereals, frozen specialties, canned soups, baby foods, and pet food.[15] Packaging weight and bulk contributes significantly to transportation and warehousing costs. If nothing else, the lack of standardization in packaging results in a situation where transportation, wholesaling, and retailing must handle from 2,500 to 5,000 different container sizes. [16]

A major shift in containers is already underway. Glass and metal containers contain a shrinking fraction of the fruit and vegetables purchased by American shoppers.[17] Plastics and other polymeric materials will continue to displace glass and metal containers. New technology has the potential to increase food quality, prolong shelf-life, and reduce shipping weight and volume. Multi-layer packaging can provide long shelf-life without refrigeration for many products. Aseptic processing and packaging, which involves fast heating and sealing, is now used in fruit juice and is being introduced for wines, fruit purees, dairy products, tomato products, and edible oils. Packaging with precise mixtures of oxygen and carbon dioxide can allow fresh fruit to ripen to, but not beyond, desired levels. A freshness indicator can provide visible warning to merchants and consumers when fish products are not safe.

Irradiation of food to preserve freshness has promise in some areas but has encountered consumer resistance. Economies of scale will be pronounced for relatively small, free-standing irradiation facilities. Low-unit costs, however, can be realized only with fairly high processing levels. Consequently, only large firms may be able to justify investment in irradiation. But jointly owned facilities, centrally located in important agricultural areas, could be an economic option for small- and medium-sized processors.[18]

Many if not most of the innovations that will lead to productivity growth in food manufacturing are unlikely to be developed by the food manufacturing industries themselves. The industry spends only about 0.4 percent of sales on research and development—far lower than the average for all manufac-

13 *Agricultural Postharvest Technology and Marketing Economics Research–A Technical Memorandum,* **op. cit., footnote 9, p. 47.**

14 T.W. Dowries et al., "The Impact of New Technologies on the Food Packaging and Preservation Industries," contract report prepared for the Office of Technology Assessment, 1985.

15 John M. Connor **et al., op. cit., footnote 10, p. 38.**

16 C.W. Abdulla, "Potential **Effects of Standardized Packaging Systems on Grocery Manufacturing and Distribution, " contract report prepared for the Office of Technology Assessment, 1985, p. 64.**

17 Canned fruits and **vegetables declined from 20 percent of per capita consumption of 1979 to 18 percent in 1984. Canned fruits (not including juice) declined from 13 percent in 1979 to 11 percent in 1984. U.S. Department of Commerce, International Trade Administration, 1986** *U.S. Industrial OutLook,* **Washington, DC, January 1986.**

18 R, M, Morrison *and T. Roberts, Food irradiation: New Perspectives on a Controversial/ Technology,* **contract report prepared for the Office of Technology Assessment, December 1985.**

turing. Between 1969 and 1977, 90 percent of patents applicable to the six major food manufacturing industries were granted to government laboratories, educational institutions, individuals, foreign firms, or domestic companies outside food manufacturing.[19] Between 1971 and 1977, only 12 percent of the Putnam awards for innovations that increase efficiency of food processing were given to U.S. food manufacturers; 45 percent of awards were given to small firms. A study of these awards shows clearly that food processing firms use mergers as a substitute for in-house research—one-quarter of the Putnam awards went to firms that were acquired shortly before or after getting the award.[20]

Scale **and Scope.–** The number of food manufacturing firms has been decreasing at an average annual rate of 2.5 percent since 1947. Concentration varies widely. Only 9 makers of chewing gum exist today, but there are nearly 2,000 wholesale bakers.[21] Much of the growth of large firms has been achieved through acquisitions rather than internal expansion. With $14 billion spent on purchasing, 1985 was a boom year for mergers; tobacco companies began to diversify. R.J. Reynolds spent $5 billion to acquire Nabisco. Phillip Morris acquired General Foods for $5.6 billion. Nestle S.A. purchased Carnation for $3 billion. Beatrice purchased Esmark for $2.7 billion in 1984.[22]

The discussion in chapter 5 showed the difficulty of linking firm size to rates of innovation. A careful study of innovation in food processing suggests that innovation increases with firm size until total assets reach $125 million to $150 million, when they begin to decline.[23] Another study indicates that rates of innovation also increase with market concentration levels, until four firms have captured 50 to 60 percent of the market, but decline thereafter.[24]

One concern about concentration in food processing is that firms in food manufacturing invest more heavily in advertising to differentiate products than in research to produce real innovation. Food manufacturers typically spend at least ten times as much on advertising as on research and development.[25] In 1979, firms in food and tobacco manufacturing accounted for 32 percent of spending for advertising, but only 12 percent of manufacturing receipts. The largest four firms accounted for 21 percent of advertising in 1982.[26]

The meatpacking industry deserves special attention, since it has been an exception to many trends in the industry. With the exception of beef, most meat processing has moved out of the retail stores and into specialized processing centers. Meatcutters preparing beef products are the last skilled trade to have a presence in grocery stores. The prospect of moving these jobs to factories would complete a separation between retail and food processing businesses (see box 6-A).

Distribution sectors

Wholesale and retail trade in food has grown rapidly. Grocery stores and restaurants gained share of retail sales between 1975 and 1985, while most other retail sectors lost share.[27] While some productivity gains have been measured in these businesses, technology plays a comparatively minor direct role. The indirect effects of the information technology entering these businesses, however, may be large.

Wholesalers have moved slowly to use computers to control inventories, monitor shipments, schedule work, plan storage layouts, and dispatch trucks. A variety of technologies, such as automatic handling equipment, have the potential to improve productivity of food wholesale operations by as much as 50 percent.[28] Explanations for the slow rate of adoption vary. Is it lack of competition, inefficient management, or the shortage of trained personnel in wholesale firms capable of managing a transition to new technology? Do the large number of products and container types make automation impractical? The debate cannot be resolved easily.

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[19] W. F. Mueller, J. Culbertson, and B. Peckham, *Market Structure and Technological Performance in the Food Manufacturing Industries,* University of Wisconsin, Monograph 11, NC-1 17, Madison, WI, 1982.

[20] Ibid.

[21] J. M. Connor et a]., "The Organization and Performance of the Food Manufacturing Industries," in B.W. Marion, cd., *The Organization and Performance of the U.S. Food System* (Lexington, MA: D.C. Heath and Co., 1986), p. 211.

[22] *1986 U.S. Industrial Outlook*, op. cit., footnote 17, P. 40-1.

[23] Mueller et al., op. cit., fOOtnOte 19.

[24] J. M. Connor et al., *The Food Manufacturing Industries*, Op. cit., footnote 10, pp. 322-323.

[25] Ibid., pp. *23, 87-89.*

[26] Internal *Revenue* Service data, cited in J.M. Connor et al., *The Food Manufacture@ industries,* op. cit., footnote 10, p. *81.*

[27] *1986 U.S. Industrial Outlook,* op. cit., footnote 17, p. 57-1.

[28] G. Grinnell, and L. Friedman, "Productivity Potential in Dry Grocery Centers," U.S. Department of Agriculture, Economic Research Service, AER 484, Washington, DC, 1982.

Box 6-A.–Boxed Beef

In 1920, the four largest beef packers were vertically integrated and commanded 49 percent of all sales. An anti-trust settlement in 1920 dictated a long process of change. By 1970, the combined share of four largest packers fell to 15.8 percent. '

In the 1950s, improvements in refrigeration technology and other changes led to greater centralization of cattle processing in feedlots. Retailers like Safeway began consolidating meat cutting into local processing centers. In 1967, the independent (and non-union) Iowa Beef Packing Co. (now IBP, Inc.) opened a semi-automated slaughtering and processing plant in Dakota City, Nebraska.

Boxed beef's share of total beef production from all sources is now probably more than 40 percent. Rapidly expanding fast food chains have provided eager markets for their products. The number of meatcutters and butchers employed in retailing has dropped significantly between 1970 and 1980.[2]

Largely as a result of centralized facilities which allowed more sophisticated equipment, meatcutting productivity nearly tripled between 1950 and 1981, measured in beef and pork packed per worker. Partial automation reduced skills and heavy lifting, although the tasks were made much more specific. Injury rates and turnover remain high, while the industry no longer requires a large pool of skilled butchers and meatcutters.[3]

1 J. McCoy, Livestock*and* **Meal Marketing (Westport, CT:** AVI **Publishing, 1979),** p. **180.**

[2]**U S. Department of Labor, Bureau of Labor Statistics,** *Employment Projections for 1995,* **Bulletin 2197, Washington, DC, March 1984, p. 48.**

[3]S.W. Hiemstra, **"Technological and Organizational** Changes in the U.S. Beef Packing Industry," contract report prepared **for the Office** of Technology Assessment, 1984

Food reaches consumers through two channels: food retailers (primarily grocery stores), and food service businesses (restaurants and institutional food outlets). Concentration is increasing in both sectors. However, some convergence exists between the sectors as the variety and extent of processing offered by grocery "superstores" increases. Many of these stores now offer a variety of prepared salads and entrees ready for eating.

Management changes have played a major role in the food service industries. Fast food had the effect of substituting customer labor for service jobs. Technical improvements led to some productivity gains in restaurants between 1958 and 1976, with the introduction of microwaves, deep-fat friers, and other equipment, but productivity has actually fallen since 1976.[29] In food retailing, advanced electronic cash registers and scanners have improved productivity in check-out, though—as the later discussion will show—productivity changes are difficult to measure in individual stores.

Scale **and** Scope.-The number of wholesale establishments was trimmed by nearly half between 1950 and 1982, and consolidation shows no sign of abating. The eight largest general wholesalers accounted for 26.5 percent of sales in 1982, as compared with 16.2 percent in 1972. Yet the consolidation of warehouse ownership may actually increase competition if larger, sophisticated firms compete in the same region. A recent U.S. Department of Agriculture study concluded that "there are more local suppliers now than in the mid seventies."[30]

The total number of grocery stores has fallen after peaking in the mid 1970s. While conventional supermarkets still claim the majority of grocery sales (59 percent in 1984), their role is rapidly declining.[31] Superstores, which account for only 3.7 percent of all grocery stores, account for 28 percent of grocery sales.[32] These stores may have 30,000 to 200,000 square feet of sales area and as much as $1 million per week in sales. At the other end of the spectrum, the number of convenience stores, where the average sale is $1 to $3, have tripled between 1963 and 1984, and now account for 12 percent of all grocery sales.[33] Specialty stores like bakeries have steadily lost share. In 1982 they commanded only 6 percent of grocery sales.[34] Smaller grocery stores are owned increasingly by smaller firms rather than national chains.

[29]R.B. Carries and f-f. **Bran, "Productivity and New Technology in Eating and Drinking Places, " in** *A BLS Reader on Productivity,* **U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2171, June 1983, pp. 67-72.**

[30]W.B. Epps, "Food Wholesaling," *Food Marketing Review, 1985,* U.S. **Department of Agriculture, Economic Research Service, AER 549, Washington, DC, March 1986, p. 21.**

[31]P.R. **Kaufman,** "Food Retailing," *Food Marketing Review, 1985,* U.S. **Department of Agriculture, Economic Research Service, AER 549, Washington, DC, March 1986.**

[32]*1986* **Industrial** *Outlook,* **op. cit., footnote 17, P. 57-7.**

[33]Kaufman, **op. cit., footnote 31,** P. 26.

34 B.W. Marion, cd., op. cit., **footnote 21, p. 295.**

The larger stores are located almost exclusively in suburban areas. Urban and rural areas may suffer declining choices. Inner-city residents often pay substantially more for similar items than shoppers in suburban supermarkets. A study in Hartford, Connecticut found that a family of four forced to shop at local stores paid $1,500 more annually than if they had gone to suburban markets.[35] Many inner city residents do not have automobiles and are forced to shop in local stores.

The nature of products provided in new, larger grocery facilities has changed significantly. Many have become multi-purpose retail outlets providing pharmacies, teller machines, and a variety of food specialties as well as standard grocery products. A recent survey found that 75 percent of all supermarkets offer health/natural food and gourmet food. At least one-third have low-calorie selections. There is sharply declining interest in "price brand" generic products, the share of which fell from 17 percent in 1982 to 14.6 percent in 1985.[36]

The new grocery stores may also serve as local meeting places and social centers. Many command customer loyalties if only because the time saved by going to a convenience store outweighs the savings that could be achieved by careful shopping. A recent survey indicated that only 1 in 10 consumers said they would shop at a store other than their principal supermarket to get advertised specials.[37]

Grocery stores also serve as major financial centers. Supermarkets cash one-third of all non-government checks.[38]

Food service is an enormous enterprise in the United States, providing nearly 1 out of 13 U.S. jobs. The activities fall into the categories shown in table 6-2. Approximately 70 percent of sales are commercial, the rest in institutions. Because of demographics, there has been a decline in food served in educational facilities and an increase in food sold through hospitals and long-term care facilities. Fast food is rapidly gaining share.

Table 6-2.—Sales of Meals and Snacks in 1977 and 1982 (percent of all sales in year)

Type of sale	1977	1982
Commercial	69.1	70.6
Restaurants, lunchrooms	30.2	30.7
Fast food	24.9	26.4
Other	14.0	13.5
Institutional	30.9	29.4
Educational institutions & day care	10.3	8.6
Hospitals & care facilities	7.7	8.2
Plants, office buildings	4.4	4.5
Military	2.0	1.7
Vending machines	3.1	2.8
Other	3.4	3.6

SOURCE: Michael Van Dress, U.S. Department of Agriculture, private communication, U.S. Congress, Office of Technology Assessment, "Food, " sector study, Washington, DC, 1987,

Table 6-3 shows that there has also been a strong movement toward restaurant chains. If anything, the table understates the power of chains, since many independently owned establishments are franchises. Franchises account for 35 percent of all commercial sales. About two-thirds of these franchises are owned by individuals.[39] As a result, nearly half of the sales shown for "1-unit" firms in table 6-3 may be sales by franchised operations. The gap between annual sales of franchises and annual sales of independent restaurants is growing rapidly.[40]

Table 6-3.—Distribution of Eating Places (sales, in billions of dollars)

Number of units	1963	1967	1972	1977	1982
1[a]	80.4	77.4	65.9	59.5	52.3
2-3	5.8	5.3	6.3	6.8	7.1
4-10	2.9	3.7	4.7	6.1	7.2
2-10	8.7	9.0	11.0	12.9	14.3
11 or more	11.0	13.6	23.2	27.6	33,4
Fast food	14.6	19.0	30.3	37.6	39,4

[a]Includes franchises (see text).

SOURCE: J.J. Putnam, H.R. Linstrom, and M.G. Van Dress, "Food Service," in Food Marketing Review, 1985, U.S. Department of Agriculture, Economic Research Service, AER 549, Washington, DC, March 1986, p. 44,

35 Hartford Citizen's Research Educational Network, "The poor pay More: Food Shopping in Hartford," Hartford, CT, 1984.

36 *1986 U.S.* Industrial *Outlook,* op. Cit., footnote 17, P 57-7.

37 Louis Harris and Associates, Inc., "Trends: Consumer Attitudes and the Supermarket," survey conducted for the Food Marketing Institute, Washington DC, 1985.

38 R.E. O'Neill, "What's New in EFT," *Progressive Grocer,* August 1985, pp. 59-66.

39 U.S. Department of Commerce, Bureau of Industrial Economics, "Franchising in the Economy 1982 -1984," Washington, DC, January 1984.

40 J. R. Schmelzer, "The Commercial Foodservice Sector: Trends in Growth and Market Structures," Working Paper Series WP-56, Michigan State University, East Lansing, MI, September 1981.

New Technologies and System Integration

A variety of new technologies promise to improve the integrated performance of the American Food network in ways that are difficult to demonstrate by examining productivity in individual business sectors (as with Clothing and Personal Care). The two classes of technologies most likely to affect the integrated performance of the food production and distribution system are new packing and preservation technologies (already discussed), and the use of modern communications and information processing systems.

Computers, optical scanners, and other electronic information technologies are now common, but only recently have firms directed their attention toward uses that could pay system-wide benefits. Food-system firms were among the first to take a cooperative approach toward extending the applications of computers. The most visible product of their efforts is the Uniform Price Code (UPC), the now-ubiquitous bar code that is "read" by point-of-sale scanners and portable scanning guns or wands that record incoming shipments and are used to perform shelf inventories.

Retailers, through their new ability to analyze costs and profits in previously unattainable detail, have benefited most directly from these innovations. But the biggest windfall is the large volume of high-precision data it generates, and this information may serve as the basis for improving the entire food marketing system.

Electronic price scanners using the universal product code were first introduced in 1974. It is likely that half of all grocery items were scanned in 1986.[41] For food retailers, the system promises the following types of advantages:

- direct savings through reduced checkout time (by 40 percent) and error rates;
- an ability to make rapid price changes (some stores are moving to electronic price indicators on shelf);
- improved coupon management (in 1983 customers redeemed 5.6 billion coupons worth $2 billion; an estimated 20 percent of coupons are processed in error[42]);
- reduced error rates in billing and ordering (at $11 to $18 per adjustment, price-related errors on about half of the invoices issued by food manufacturers impose annual costs conservatively estimated to total $100 million[43]); and
- precise identification of the effect of advertising campaigns and changes in store format and product placement.

The systems may eventually make it easier for firms to provide the government with requested information. If customers begin to pay for food with credit cards or direct debit cards, sales can also be linked with demographic and income characteristics with great (some would say Orwellian) precision.

For food manufacturers, many of whom purchase scanning data from supermarkets, the information is used to guide marketing strategies, identify new market niches, and evaluate potential changes in products that will boost sales. And for food wholesalers, some of whom use in-house computers to evaluate the efficiency of their operations, feedback on storage and distribution costs may spawn measures to improve efficiency.

Perhaps most importantly, the systems allow a detailed performance evaluation of the thousands of products on their shelves. These evaluations can provide estimates on the real cost of selling each item, preferred stocking patterns, and even information about which warehouse to use as a supplier. At present, few retailers take advantage of the potential to guide merchandise strategies.[44] A more recent development is the Universal Communication Standard (UCS), with which food marketing firms can substitute computer-to-computer communication ("electronic data interchange") for paper-based exchanges of invoices, purchase orders, and reams of other information generated throughout the system.

41 P.R. Kaufman, op. cit., footnote 31, pp. 26-27.

42 H. Monat, "Misredemption of Coupons: A New Solution', " Trim, Inc, Los Angeles, CA, 1984.

43 Ronald Cotterill, "Effects of Electronic Information Technology on Employment in the Food Manufacturing and Food Distribution Industries," contract report prepared for the Office of Technology Assessment, 1985.

44 Food Marketing Institute, "Retailer Applications of Scanning *Data*," 1985, cited in C.E. Morris, "Supermarkets: Super Data," *Food Engineering,* May 1986, p. 120; and Food Marketing Institute, "Statement of Food Marketing Institute before the Bureau of Competition, Federal Trade Commission." Milwaukee, WI, Sept. 11, 1984, cited in B. Marion, cd., op. cit., footnote 21.

Now in the early stages of adoption, the UCS, which is a set of protocols that allow one firm's computer to send information to the computer of another, should streamline distribution and marketing functions. It should also eliminate redundant clerical tasks, and some of the duties of the manufacturer's sales force.

In all, the communication network is estimated to offer annual savings of $196 million to $324 million (1979 dollars), assuming the technology is used by the 10,000 largest firms in the food marketing system. Most of the savings would result from reductions in clerical staffs, inventories, and waste and spoilage. Moreover, the network can accelerate recalls of tainted food items, as firms now have the capability to track items throughout the marketing system and, sometimes, back to the farm.

The impact of the communication network on competition is not clear at present. It is clearly possible that large, sophisticated firms will be able to make more effective use of the analytical power of the equipment because of greater access to national data bases and because they can afford to invest in market analysis. They could also carefully monitor regional price competition and quickly cross-subsidize products to beat smaller competitors. Electronic versions of price fixing are possible.

On the other hand, the networks make it possible for large firms to keep track of larger numbers of products and suppliers. This may make it easier for small producers to sell through large stores.

HEALTH[45]

Prospects

The high cost and complexity of new health care technologies have been largely responsible for the massive reorganization of the Nation's health care network that has occurred since the end of the Second World War. Experiments in management and cost containment have proliferated. During the next two decades, the system operating to provide health care could take any of several different courses. They include:

- *A system where institutional incentives throughout the economy are clearly linked to providing the best possible health outcomes at the lowest cost.* This means a system capable of making an even-handed assessment of investments in different kinds of measures to promote health or prevent illness (including investments in air and water quality and occupational safety, and advice on diet, exercise, and other aspects of lifestyle), and clinical treatment of illness when it occurs.
- *A system where a patient's care is diverse and flexible, and can be integrated in* a way *that ensures optimum health care.* This involves a mixture of home care, treatment by specialized clinics, and local out-patient services with highly sophisticated medical centers in a way that is sensitive to the needs and desires of individual patients.
- *A system that provides timely and accurate records on the effectiveness of alternative treatment strategies.*
- *A system which attempts to contain increases in health costs resulting from a growing elderly population needing medical care, and a growing array of expensive new medical producures and equipment with increasingly baroque regulations.*
- *A system that provides an enormous range in health care quality depending on the patient's ability to pay, permitting only the most affluent to enjoy real choice about courses of treatment.*

Again, these alternatives are not mutually exclusive. They depend heavily on public decisions.

Structure and Performance

About 1 dollar in 10 in the U.S. economy is spent on the Health amenity, either by individuals or the government. This figure does not include spending aimed at improving health, such as investment in environmental protection or safety, healthy food, or

45 Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Health," sector study, Washington, DC, 1987.

fitness. More than half of all value-added in health care enterprises remains in the hands of the Social Service sector, with the rest being spent on such things as hospital construction, purchases of medical equipment, and supplies from High and Medium Wage Manufacturing firms. Purchased Transactional Activities (such as insurance and legal fees) account for nearly 16 percent of Health costs (see figure 6-2). Within the health care enterprises themselves, however, production recipes are heavily dependent on labor; nearly three-quarters of the value of the output of such firms is derived from value-added, most of which is in the form of employee compensation.

Factors Forcing Change

Until the 1950s, the structure of the Nation's health care system was relatively easy to understand. The system was highly fragmented, highly individualistic, and free of anything but self-regulation by professional societies like the American Medical Association (AMA), which guarded their prerogatives jealously. The courts ruled that anti-trust regulation could not be applied to these organizations since they were "professional societies."[46]

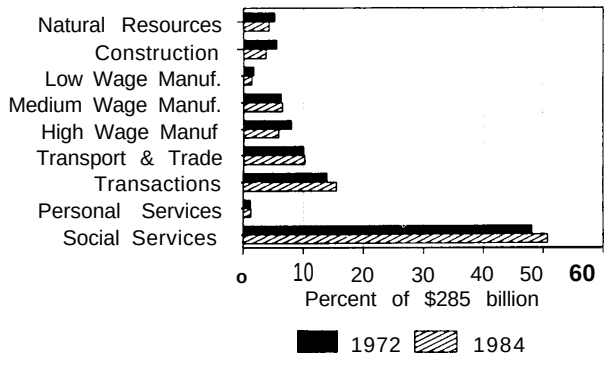
Individual physicians treated most patients in a private practice and resorted to relatively small community hospitals (nearly always operated as not-for-profit organizations) for difficult surgery and some specialized assistance. In extreme cases, they might have turned to a larger hospital in a major urban center. The range of treatment was limited; the family physician played a central role. Most people paid for health care in cash. In 1950, two-thirds of the bill was paid directly by the recipient of the service.

Explosive growth in the scope and cost of medical services occurred following World War 11, and a complex tangle of programs was put in place to regulate them. Rapidly advancing medical technology opened a wide range of therapeutic options with proven value. The high cost of these opportunities required new approaches to financing. The Hill-Burton program initiated in 1946 encouraged hospital construction. Health care for the needy and the elderly was greatly expanded under the Medicare and Medicaid Acts of 1965 (although gaping holes remain in the coverage). Private insurance programs grew rapidly, encouraged in part by Internal Revenue Service (IRS) rulings that employer contributions for health insurance were not taxable as employee income.[47] The public and private insurance systems operated in a way that almost completely insulated the payer and provider from estimates of cost, since they reimbursed the provider for virtually any measure taken. By 1982, 73 percent of all health bills were paid by government agencies or private insurance companies.[48]

There has also been rapid growth in both the number of cases treated and the intensity of care provided. Between 1960 and 1982, the number of physicians per capita grew 46 percent; the annual number of graduates in medicine grew 128 percent; the annual number of nurses graduated grew 146 percent; and the number of community hospital beds per capita grew 22 percent.[49] Hospital costs grew from 25 percent of health expenditures in 1940 to 40 percent

[46] Clark Havinghurst, "The Contributions of Antitrust Law to a Procompetitive Health Policy," in Jack A. Meyer, cd., *Market Reforms in Health Care* (Washington, DC: American Enterprise Institute, 1983).

Figure 6-2.-Value-Added To Meet Demand for Health ($285 billion* in 1984)



● Constant 1980 dollars

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4)

[47] Alan Enthoven estimates that revenue loss to government because of non-taxation of employer contributions to health insurance and medical expense deduction is as large as the Federal contribution to Medicaid and almost half the size of Medicare. See Alexander M. Capron, "Allocating Finite Resources: Questions of Equity and Access," in M.E. Lewin, ed., *The Health Policy Agenda: Some Critical Questions,* (Washington, DC: American Enterprise Institute, 1985).

[48] U.S. Department of Health and Human Services, *Health: United States* (Washington, DC: U.S. Government Printing Office, December 1985).

[49] Ibid.

in 1980. Using a relatively narrow definition of health care spending, health costs grew from 6.1 percent of the U.S. gross national product (GNP) in 1965 to 9.8 percent in 1981.

The reasons for this growth are difficult to disentangle. Costs increased both because more people had access to the health care system and because advances in medical science increased the range of treatment. Rapid technical advances continued to drive the price of "recommended practice" to ever higher levels. Decisions about "how much is enough health care" became critical. Professional review organizations presided over the processes used to designate treatments as "prevailing professional custom and practice."[50]

As the complexity of the system grew, so too did the range of possible mistakes. Among other things, it was no longer possible to assume that a physician, competent at the time of original certification, would be competent in the revolutionary changes sweeping the medical field.[51] Consumers, increasingly aware of the range of their choices, began to question decisions made in their name. The result was regulation by tort law in the form of malpractice litigation. The issue of "prevailing professional custom and practice" came under courtroom examination, with the perverse effect that physicians were forced to include costly procedures even when there was only a small chance that the patient would benefit. Though the courtroom was a poor place to negotiate the issue of "how much is enough, " it took on this role by default. This helped transform a decentralized and diverse system.[52]

During the 1970s, renewed interest in public health issues accompanied the explosive growth in clinical medicine. The National Highway Traffic Safety Administration and the Environmental Protection Agency began operation in 1970; the Consumer Product Safety Commission in 1972; the Mining Enforcement and Safety Administration, the Drug Enforcement Administration, and the Occupational Safety and Health Administration in 1973; and the Nuclear Regulatory Administration in 1975.[53] Capital spending for air and water pollution abatement rose from $700 million in 1965 (about 1 percent of total plant and equipment investment) to a peak of nearly *$5* billion in 1975(4 percent of total new plant and equipment) (all in 1972 dollars). The Surgeon General's office became more aggressive in forcing the country to recognize the dangers of smoking.

As medical costs reached 10 percent of GNP and health care enterprises grew to the size of major national corporations, it was no longer possible to maintain the fiction that the industry could be governed by the camaraderie of professional organizations. Taxpayers complained about the growing costs of Federal and State programs. Employers found that their contributions for health insurance co-payments had risen from 2.2 percent of wages in 1970 to 5.3 percent in 1984.[54] There was concern that an inefficient national health system was placing an intolerable burden on the costs of American products. There was also a reaction to the enormous costs of pollution abatement.

Attempts to make the health care delivery behave more like an ordinary market by creating a more perfect match between the interests of patients and the interests of privately owned firms in freely operating markets have proven to be extraordinarily difficult. For reasons discussed in the Health section of chapter 3, individuals face enormous problems in making informed choices about appropriate levels of health care. Even experts disagree about appropriate levels. Attempts to introduce greater market freedom have come to be coupled with extensive and complex regulations governing both price and practices. The result has been a system that is at once more free and more heavily regulated than the one it replaced. Federal payments, for example, are now governed by a precise schedule of hospital fees for "diagnostic groups" and plans are underway to regulate physician fees. Private insurers are negotiating with "preferred providers" for health care. At the same time, a 1984 survey of 1,115 firms indi-

50 C. Havinghurst, "Decentralizing Decision Making: Private Contract vs. Professional Norms," in Jack A. Meyer, cd., op. cit., footnote 46, p. 24.

51 Regulation of one's collegues requires enormous fortitude, and there is every indication that it has not proven very effective. A peer review undertaken by the American Medical Association indicated that as many as 10 percent of active physicians were so impaired that they presented a danger to their patients. See The New *York Times,* June 4, 1984, p. A17.

52 C. Havinghurst, op. cit., footnote 50.

53 S. Breyer, Regulation and *Its Reform* (Cambridge, MA: Harvard University Press, 1982).

54 Employee Benefit Research Institute, "Private Expenditures to Contain Health Care Expenditures," EBRI Issue Brief No. 55, Washington, DC, June 1986.

cated that 97 percent were taking specific steps to reduce health care costs.[55]

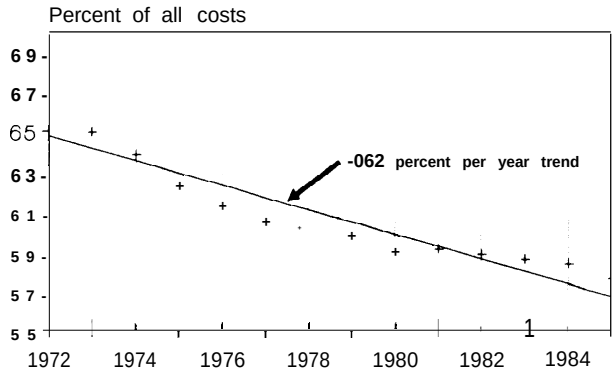
Network Components

The structure of the health industry has become increasingly complex in recent years, responding to the explosion of new technologies, to new professional specialties, and to the radical changes in the financial rules under which the health system operates. In general, the effect has been a proliferation of specialized treatment facilities, reduced use of hospitals, and increased use of out-patient treatment. Use of capital equipment has steadily increased. As in other service-oriented sectors, however, human skills are increasingly accompanied by sophisticated equipment. Figure 6-3 illustrates how labor costs have declined as a fraction of all hospital costs during the past 15 years. The decline is surprisingly unaffected by the radical changes in health care financing.

The drive toward efficiency has forced increases in the size of both hospital establishments and groups of physicians surrounded by a complex constellation of supporting organizations like testing laboratories, dialysis centers, hospices, nursing homes, and home health care providers. Patterns of ownership are in flux, as some of these specialized facilities are owned by large firms while many are independent.

[55] The Wyatt Co., "1984 Group Benefits Survey," Washington, DC, 1984.

Figure 6-3.-Direct and Indirect Labor Costs as a Percent of All Community Hospital Costs



SOURCE: American Hospital Association, *Hospital Statistics,* Chicago, IL, 1986 edition.

Changes in the financial system have also resulted in a movement toward private rather than public ownership. Even publicly owned facilities are managed more like private firms.

While there are differences in the quality of health care delivered in different parts of the country, the opportunities for health care businesses obviously follow population movements and provide employment and investment opportunities around the country. The rapidly growing areas of the south and west have furnished particularly attractive opportunities to health care enterprises well matched to the new financial rules. The increasing size of hospitals has reduced easy access to these facilities, but a variety of outpatient clinics, "urgi-centers," "doc-in-a-box," and other health facilities have proliferated in suburban areas. Rural areas are most likely to suffer a decline in health care access. At issue is whether the benefits of economies of scale in large facilities outweigh the benefits of short travel times to smaller facilities.

Although the effect of the changes just described on the quality of care delivered has proven difficult to measure over the entire Health network, the following examination of individual components reveals some interesting trends.

Physicians.-Cost containment by insurance programs, an actual decline in use of physician services resulting in part from rising prices,[56] and a potential "surplus" of physicians are in the process of restructuring the series of independent enterprises that were once at the center of medical practice in the United States. As a result, competition has begun to play a major role. The AMA's resistance to advertising has faded to a prohibition against "deceptive practices" and "creation of unjustified expectations."[57] Physician offices have extended their office hours, and some even make house calls. The most dramatic effect of competition, however, has been to force independent physicians into group

56 Between 1976 and 1981, the average number of yearly physician visits per person declined from 4.9 to 4.6 while physicians in office-based practice rose 33.3 percent. See U.S. Department of Health and Human Services, National Center for Health Services Research, "Contacts with Physicians in Ambulatory Settings: Rates of Use Expenditures and Sources of Payment," Data Preview 16, DHHS Publication PHS 83-3361, Washington, DC, 1983.

57 Robert M. Veatch, "Ethical Dilemma of For-Profit Enterprises in Health Care," in Bradford H. Gray, cd., *The New Health Care for Profit* (Washington, DC: National Academy Press, 1983), p. 128.

practices. Instead of moving from medical school into lucrative private practices, an increasing number of certified physicians are finding that they must accept corporate employment paying $35,000 to $40,000 per year.[58]

Aside from private practice, the different ways that physicians are now organized include:

- **Preferred Provider Organizations (PPOs) and Individual Group Practices.** The PPOs are loosely knit groups of private practitioners and hospitals that contract with employers and insurers to provide care at a discount, ranging from 5 to 30 percent on physician fees and 7 to 15 percent on hospital fees.[59] Physicians are typically paid on a salary basis. It is difficult to determine whether cost savings are real,[60] but the introduction of price competition undoubtedly puts pressure on prices. Between December 1984 and June 1985, enrollment in PPOs was estimated to have increased from 1.3 to 5.8 million.[61]
- **Health Maintenance Organizations (HMOs).** HMOs began with the encouragement of the HMO Act of 1973, which required businesses with 25 or more employees to offer an option for HMO care. HMOs have managed to replace professionally dictated standards with their own. Although Federal subsidies have stopped, HMOs have grown rapidly. Between 1981 and 1985, enrollees increased from 10.3 to 18.9 million, and membership may reach 40 to 50 million by 1990. The geographic pattern of their growth has, however, been uneven, and they have begun to dominate the practice of medicine in some parts of the country-in some large metropolitan areas 75 percent or more of all doctors participate in HMOs. HMOs are most active in urbanized areas of Hawaii, Minnesota, California, and Oregon, and are least important in rural areas in Mississippi, Montana, and Wyoming.[62] Most are new; in 1983, only half had been in business for more than 5 years.[63]

HMOs are organized using an entirely new principle in medical finance: they are self insuring. Patients pay a flat fee and rely on the HMO bureaucracy to provide needed treatment. This principle, coupled with the fact that the organizations can employ professional business managers to replace physician-dominated management of traditional health facilities, allows them to consider costs and benefits from a unique perspective. Not only do they create a unique regulatory environment from which to view alternative procedures, they create a unique bureaucratic environment for the physicians employed. There have been suggestions that one of the explanations for the lower rates of aggressive treatment administered at HMOs is that they do not attract the kind of personalities that practice aggressive medicine, and do not provide the kind of peer support for such actions that might be available in other kinds of practices.[64]

While data is ambiguous, HMOs appear to be able to provide health care at lower cost. Estimates indicate that HMOs can offer a wide range of services at prices 10 to 40 percent lower than fee-for-service expenses, even though the HMO patients receive as much ambulatory service (4.42 physician visits v. 4.19 fee-for-service).[65] HMO hospital admission rates were 40 percent lower than fee-for-service rates, while hospital stays averaged the same length. In 1981, average number of hospital days per thousand population for all payers was 1,316—for HMO members, it was 458. This could not entirely be

58 Eli Ginzberg, "The Destabilization of Health Care, " New England *Journal of Medicine, vol. 315, No. 12, Sep. 18, 1986,* pp. 757-760.

59 D. Ermann and J. Gabel, "Preferred Provider Organizations: performance Problems and Promise," Health *Affairs, vol. 4, No. 1,* spring 1985, pp. 24-40.

60 U.S. Congress, General Accounting Office, "Constraining National Health Expenditures: Achieving Quality Care at an Affordable Cost," GAO/HRD-85-105, Sept. 30, 1985; and U.S. Congress, Office of Technology Assessment, *Payment for Physician Services: Strategies for* Medicine, OTA-H-294 (Washington, DC: U.S. Government Printing Office, February 1986).

61 "PPO Enrollment Jumps Dramatically in 1985," *Hospital Week, vol. 21, No. 40,* October 1985, p. 1.

62 Grady Wells, "Healthy Growth for HMOS," *American Demographics,* vol. 6, No. 3, March 1984, pp. 34-37, 46-47.

63 N. Baker, J. McGee, and M. Shadle, "HMO Status Report, 1982-1983," Interstudy, Exelsiour, MN, August 1984.

64 C. Havinghurst, op. cit., footnote 50.

65 Employee Benefit Research Institute, Op. cit., footnote 54; H.S. Luft, "How Do Health Maintenance Organizations Achieve their 'Savings'?" New *England Journal of Medicine, vol. 298, 1978,* pp. 1336-1343; and W.G. Manning et al., "A Controlled Trial of the Effect of a Prepaid Group Practice on Use of Services," New *England Journal of Medicine, vol. 310, 1984, pp. 1050-1510.*

explained by the difference in ages between HMO enrollees and other patients.[66]

Not surprisingly, HMOs initially faced great skepticism from both the public and physicians, but this resistance appears to be fading in the face of a growing consensus about the need for cost containment.[67]

Hospitals. -Spending for hospital care has increased rapidly, because (1) hospital use was encouraged (sometimes required) by most public and private insurance programs, and (2) hospital construction was encouraged by the Hill-Burton Act. There is evidence that these factors led to overuse of hospitals. For example, a study which reviewed 1,132 records of patients admitted to hospitals concluded that only 60 percent of the admissions were appropriate; 23 percent were judged to be "inappropriate" in that the examiners could determine "no positive benefit" from treatment in the hospital setting, and 17 percent of these could have been avoided with ambulatory surgery.[68] An independent study found that 19 percent of hospital admissions and 27 percent of hospital days were inappropriate.[69] A study of laboratory tests indicated that 47 percent of the tests performed in a teaching hospital could have been eliminated without any apparent loss in the quality of patient care.[70]

While such conclusions are controversial, cost reduction programs have put unrelenting pressure on hospital systems to reduce expenses, by increasing efficiency and—to an extent that is difficult to determine—by eliminating implicit cross-subsidies that had the effect of supporting teaching, research, and care for the indigent by overcharging patients able to pay.

Recent trends in hospital care include:

- The numbers of full-time in-patients, the rate of hospital admissions, and admission rates for the elderly all fell sharply in 1985. Average hospital stays were 7.7 days in 1975 and 7.1 days in 1985;[71] hospital occupancy rates fell from 80 percent in 1970 to 69 percent in 1985.[72] This alone led to great pressures to close inefficient facilities.

  Industry studies assert that changes in insurance coverage provided by Deere & Co. of Illinois resulted in a 21 percent decline in hospital days per 1,000 beneficiaries over a period of 36 months; a major insurance company reported savings of $523 per patient in 1981 all because of ambulatory surgery and pre-admission testing.[73]
- Although in-patient costs are still growing, the rate of growth has slowed considerably and the average length of a hospital stay has been reduced.[74] In-patient expenses per capita increased 12.6 percent between 1976 and 1982, but only 4.5 percent per year after 1983.
- Competitive pressure has forced hospitals into horizontal integration (in the form of hospital chains) and other services, such as clinics, nursing homes, and ambulance companies, into vertical integration. Some have even diversified into real estate and resort management.[75] An increasing fraction of hospitals are being operated as parts of chains rather than as independent community-based facilities.

  Between 1975 and 1982, multi-hospital systems increased their share of all community hospitals from 25 to 33 percent.[76] Ownership of multi-hospital chains is dominated by five large companies that own 6 percent of all U.S. acute-care beds, and nearly 50 percent of all for-profit

[66] R.J. Arnold, L.W. Debrock, and J.W. Pollard, "Do HMOs Produce Specific Services More Efficiently?" *Inquiry*, No. 21, 1984, pp. 243-253.

[67] C. Havinghurst, op. cit., foOtnOte 50, p. 30.

[68] A.L. Siu et al., "Inappropriate Use of Hospitals in a Randomized Trial of Health Insurance Plans," New England *Journal of* Medicine, vol. 315, No. 20, Nov. 13, 1986, pp. 1259-1266. This study examined records from Seattle, Dayton, Fichburg and Franklin Counties in Massachusetts, and Charleston and Georgetown Counties in South Carolina. Upper income (> $61,000 family income) families and families on Medicare were excluded.

[69] J.D. Restuccia et a]., "The Appropriateness of Hospital Use," *Health Affairs, vol. 3, No. 2,* summer 1984, pp. 130-138.

[70] A.R. Martin et al., "A Trial of Two Strategies to Modify the Test Ordering Behavior of Medical Residents," New *England Journal of Medicine,* vol. 303, 1980, pp. 1330-1336.

[71] American Hospital Association, *Hospital* Statistics: *1986* (Chicago, IL: American Hospital Association, 1986), p. xvii. There were actually 8 percent *fewer* people in hospitals in 1985 than there were in 1975.

[72] Ibid., p. 2.

[73] R. Kauer, "Deer & Company: Utilization Review, " Health Systems Management Center, Case Western Reserve University, under contract with the Business Round Table Health Initiative Task Force, 1983; and Employee Benefit Research Institute, op. cit., footnote 54.

[74] Medicare Prospective Payment and the American Health Care System: Report to the Congress," February 1986.

[75] L. Punch, "Contract Management Companies Manage Growth Rate of 13.3 percent, " *Modern Health Care, vol. 14,* August 1984, pp. 45-52.

[76] D. Ermann, and J. Gabel, "Multihospital Systems: issues and Empirical Findings," *Health Affairs, vol. 3, No. 1,* spring 1984, pp. 50-64.

beds. The number of beds owned by these firms grew from 29,000 in 1976 to 62,000 in 1982. Their holdings are concentrated in the South and West, where hospital construction was most rapid during the past two decades.[77]

While scale economies have encouraged horizontal integration, there has been some vertical disintegration as hospitals have elected to contract for specialized services (housekeeping, food services, emergency services, plant operations and maintenance, records keeping, billing, and collection).[78]

- The average numbers of beds per hospital has also risen. In some cases this has led to economies of scale. The number of hospitals with fewer than 100 beds fell 8 percent between 1975 and 1985, while hospitals with more than 300 beds increased their share from 45.8 percent of all beds to 47.8 percent.[79]
- An increasing number of hospital patients are now treated privately, and more hospitals are privately owned. Public facilities faced enormous difficulties because of competitive pressures and the increasing difficulty of obtaining funding from philanthropic or public funds.[80] In many cases, costs may have been difficult to contain because of the large number of indigent patients. Between 1975 and 1985, the number of beds in investor-owned facilities increased from 7.7 to 10.3 percent of non-Federal hospitals.[81] Even not-for-profit hospitals are hiring private hospital firms to manage their operations, From 1970 to 1981, hospitals operated under contract management increased from 14 to 497.[82]
- Cost containment in standard hospitals, coupled with growing consumer interest, has spawned rapid growth in specialty hospitals. More than one-third of all private hospitals now specialize in psychiatric care, alcohol and drug abuse, physical rehabilitation, or the care of women.[83]

Clinics.—Free-standing clinics and sophisticated services offered in physician group practices are introducing new competition for hospitals. There were 1,800 to 2,000 such centers in 1983,[84] approximately 23 percent of which were controlled by three companics.[85] Technology now allows many procedures to be conducted out of hospitals and many insurers encourage the use of the less expensive clinics, where for some procedures rates average 55 percent less than hospital in-patient rates and 18 percent less than hospital out-patient rates.[86] Many of these centers are owned by individual physicians or partnerships, but in some cases hospital chains are diversifying to own smaller facilities themselves.

Support Facilities.—Expanded options for care have produced many specialized organizations designed to serve specific market niches. For example, there are now 1,200 centers that provide dialysis and many clinical laboratories that conduct medical tests. Because medical science has improved diagnosis faster than treatment there has been a growing demand for hospices, where patients with known but essentially untreatable illnesses can be made comfortable. There were 1,345 hospices in 1984, increasing at a rate of 1 per day.

Similarly, the rapid growth in the ranks of the elderly, and the failure of medicine to provide cures for the chronic illnesses of old age, has led to an expansion of nursing homes. This trend has been accentuated by the number of women wishing to remain in the work force, who are therefore unprepared to care for an aging parent.

The costs of these facilities, about half of which are paid by Medicaid funds, already represent nearly 10 percent of all health expenditures. This expense has led a number of States to take draconian actions to block further cost increases. The number of nursing home beds grew 3.7 percent annually between 1971 and 1976 but growth slowed to an annual rate of 2.4 percent between 1976 and 1982 in spite of a 4.5 percent annual increase in the number of persons over 85. By 1984, nine States ordered a halt to nursing home construction, and others were limit-

77 R. B. Siegrist, Jr., "Wall Street and the For-Profit Hospital Management Companies, " in Bradford H. Gray, cd., op. cit., footnote 57.

78 In 1983, growth rates in contractual services ranged from 18 to 200 percent. See L. Punch, op. cit., footnote 75.

79 *Hospital Statistics: 1986,* op. cit., footnote 71, P. xvii.

80 Ibid.

81 Ibid., pp. 3-4.

82 J.W. Salmon, "organizing Medical Care for Profit," in J.B. McKinlay, cd., *Issues in the Political Economy of Health Care (New* York, NY: Tavistock Publications, 1984).

83 M. Freudenheim, "Specialty Health Care Booms, " *The New York Times, Nov. 25, 1987,* p. D1.

84 G. Richards, "FECs Pose Competition for Hospital EDs," *Hospitals,* Mar. 16, 1984, pp. 72-82; and "National FEC Group Changes Name," Oct. 1, 1984, p. 22.

85 H.J. Henderson, "Surgery Centers Double," *Modern Health* Care, vol. 15, June 7, 1985, pp. 148-150.

86 C. Ansberry, "outpatient Surgery Rises as Firms Push to Reduce Health-Care Costs," *The Wall Street Journal,* Feb. 20, 1985.

ing approvals to retirement housing and life care.[87] Levels of service vary enormously depending on the policies in individual States. There were 94 nursing home beds per 1,000 elderly in Wisconsin in 1980, and 22 per 1,000 in Florida.

Most nursing homes are now in small private chains of 2 to 7 facilities with interlocking ownerships, but concentration is increasing. The five largest investor-owned chains increased their share of beds from 64 to 73 percent between 1982 and 1983.[88] While most facilities do not provide much more than routine convalescent care (two-thirds of all jobs are for orderlies, therapy assistance, food service, laundry, and housekeeping), a number have begun to offer a series of diversified services. Some are specializing in areas like physical and respiratory therapy, home health care, adult day care, residential retirement, and life care.[89] All are seeking to increase service for patients covered by private rather than public insurance.

Home Health Care.— Home health care has increased dramatically as regulatory programs reduce the frequency and length of hospital stays, transferring health care costs to the home (usually to women, see note 111, p. 391). A growing number of home health care services are now covered under public and private insurance. Medicare reimbursements for home health care grew 376 percent between 1976 and 1983.[90]

In response to growing demand, a variety of new technologies have been developed that permit an increasing range of treatment at home. For example, technology now permits oxygen therapy for emphysema and IV-nutritional therapy to be conducted at home more cheaply than in the hospital. The implantable pump is an example of a highly sophisticated device that, like the implantable heart pacemaker, makes it possible for the patient to carry a sophisticated piece of equipment inside the body cavity and to become completely ambulatory. There will soon be a version that can be reprogrammed by a physician, and eventually through sensors in the body itself. About 15,000 implantable pumps are now in place, primarily for delivering chemotherapy for liver cancer, morphine for intractable pain, and insulin for diabetics. The manufacturer estimates that costs, including the initial cost for surgical implantation, would be $17,000 for one year of treatment with the implantable pump—as opposed to $65,000 for one year of conventional therapy.[91]

Technology also makes it possible for comparatively small firms to maintain the sophisticated record keeping needed in modern medicine. Comparatively inexpensive systems can maintain financial records, personnel and payroll records, records of billable activities, and the voluminous forms required by the Health Care Finance Agency .[92]

Less complex equipment is available without prescription at retail stores. There has been a sharp increase in sales of incontinence products, cardiac monitoring equipment, diabetes therapy products, home nutrition products, kits for colon disease, and infections.[93] Monoclinal antibodies have made it possible to offer a wide variety of sophisticated diagnostic kits to the home market and there is a large market for herpes virus testing and home screening for pregnancy, ovulation, venereal disease, and strep infections. If they are properly used, these systems can also reduce health care costs.

A number of small agencies have grown up to serve the exploding need for home health care services. What was once a not-for-profit service has become a profitable enterprise. Investor-owned agencies increased share of home health care from 5.0 percent in 1978 to 26.7 percent in 1984. Most firms are small (averaging 45 employees) and depend heavily on Medicare. Services provided range from housekeeping to training family members in the operation of complex home care equipment.

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[87] K.A. Fackelmann, "Nursing Home Crunch to Hit Hospitals Soon," *Modern Health Care, vol. 14, Nov. 15, 1984,* pp. 42-46.

[88] B.C. Vladeck, *Unloving Care* (New York, NY: Basic Books, 1980), and L. Punch, "Chains Expand Their Operations, Expecting Prospective Pay *Boom, "Modern Health Care, vol. 14,* May 1984, pp. 131-140.

[89] A. Renschler, "Testimony Before the Subcommittee on Aging," U.S. Senate, Committee on Labor and Human Resources, pp. 79-86, 1983; and P.G. Hollie, "Nursing Homes Seek Affluent," The New York Times, PP. 31, 33, Sept. 15. 1984.

[90] U.S. Senate, Special Committee on Aging, "Medicare and the Health Costs of Older Americans: The Extent and Effects of Cost Sharing," Washington DC, April 1984.

[91] "Implantable Drug Infusion Pump," *Issues in Health Care Technology*, vol 5, No. 2, pp. 1-3, 1982; and "Johns Hopkins/NASA/Industry-Developed Implantable Infusion Pump," Blue Sheet, Johns Hopkins University, Baltimore, MD. Mar. 7. 1984.

[92] M.A. Beachler, "What a Computer Can Do for a Home Health Agency," *Caring, vol.* VI, No. 6, June 1987, p. 5.

[93] B. Edmondson, "The Market for Medical Self-Care," *American Demographics, No. 51,* pp. 35-37.

Drug stores and other retail outlets have become more efficient in their ability to serve home health care needs. There has been rapid growth in over-the-counter sales of drugs (9 percent annually since 1972). Computers operated by retail pharmacists can now keep track of patients' records, and help to identify possible adverse drug combinations. Retail operations have also become more efficient in inventory control, ordering, billing, and invoicing.

Measuring Productivity

How well does each component of the complex Health network do its job, and how well does the system operate as a whole? The increasing complexity in the health care system has made the second question more important than at anytime in the past. Answering this question involves addressing several other issues:

- What is known about the factors contributing to the incidence of disease, the methods available for reducing risk factors, and the way investments in prevention compare with investments in treatment?
- What is known about the costs and benefits of alternative methods of delivering medical care?
- Is society allocating its resources to different classes of individuals equitably and in a way most likely to minimize costs?

The retrospective system of payment that prevailed in public and private insurance until recently encouraged procedures that exceeded any reasonable estimate of benefit, and in some cases may actually have encouraged practices that entailed more risk than benefit. These procedures continue even under the current payment system, as witnessed by the case of fetal monitoring—a technique shown to be of no benefit and some risk in most cases.[94]

Disagreements, or lack of information about the relative effectiveness and costs of different courses of medical treatment, lead to wide variations in the way medicine is practiced around the country.[95] For example:

- In Maine, the probability that a woman has a hysterectomy is 20 percent in some markets and 70 percent in others.[96]
- Table 6-4 summarizes a recent study that revealed enormous differences in the rates at which different procedures were performed in hospitals around the country. The differences are extremely large even for costly and dangerous procedures, like coronary-artery bypass surgery where rates differed by a factor of 3.1 in the facilities studied. Unfortunately the authors of the study had no basis on which to estimate whether the high rates were too high or the low rates too low: "the available data do not allow us to explain the wide variations we have observed. In addition, we cannot establish the 'correct' use rates from these data."[97]

The rules governing the financing of a health care organization may influence the kind of care provided. Patients of physicians who owned X-ray equipment, for example, are more likely to receive an X-ray and less likely to see a radiologist than those of physicians who did not.[98] In a recent experiment, a series of case histories involving heart problems was reviewed by cardiologists with no personal interest in the cases. Physicians in independent fee-for-service practices were significantly more likely to recommend tests and surgery than those working for prepaid group practice.[99] However, the rules governing the allocation of costs between patient and insurance company do not seem to have a significant effect either on the total cost of health care, or on the priority with which funds are spent.

New Technologies and System Integration

Emerging information technologies offer great potential for achieving a new kind of integration in the

94 R. Neutra et al., "Effect of Fetal Monitoring on Neonatal Death Rates," *New England Journal of Medicine, vol. 299,* Aug. 17,1978, pp. 324-326.

95 J. E. Wennberg, J.P. Bunker, and B. Barnes, "The Need for Assessing the Outcome of Common Clinical Practices," *Annual Review of Public Health, vol. 1, 1980,* pp. 277-295.

96 J.E. Wennberg, "Variations: A Proposal for Action," *Health Affairs, pp. 7-32.*

97 M.R. Chassin et al., "Variations in the Use of Medical and Surgical Services by the Medicare Population," New *England Journal of Medicine, vol. 314, 1986,* pp. 285-290.

98 A.W. Childs and E.D. Hunter, "Non-medical Factors Influencing the Use of Diagnostic X-ray by Physicians," *Medical Care, vol.* 10, No. 4, July/August 1972, pp. 323-335.

99 M.A. Hlatky, E. Botvinick, and B. Brundage, "A Controlled Comparison of Cardiac Diagnostic Test Use in a Health Maintenance Organization," paper presented at annual meeting of the Robert Wood Johnson Clinical Scholars, San Antonio, TX, Nov. 11-14, 1981.

Table 6-4.—Variations in the Use of Medical and Surgical Services

Procedure	Coefficient of variation	Highest/lowest rate ratio
Injection of hemorrhoids	0.79	**26.0**
Hip arthroplasty	0.69	**11.4**
Destruction of benign skin lesion	0.67	**8.0**
Skin biopsy	0.58	**4.8**
Humeral fracture repair	0.51	**7.9**
Total knee replacement	0.47	**6.0**
Lumbar sympathectomy	0.44	**4.0**
Coronary-artery bypass surgery	0.41	**3.1**
Carotid endarterectomy	0.39	**4.0**
Hiatus hernia repair	0.38	**5.9**
Excision of malignant skin lesion	0.37	**3.3**
Coronary angiography	0.32	**2.3**
Excision of benign breast lesion	0.31	**2.2**
Craniotomy	0.31	**2.6**
Total hip replacement	0.31	**3.0**
Arterial grafts of lower extremities	0.28	**3.5**
Cones' fracture repair	0.25	**2.3**
Bronchoscopy	0,21	**2.2**
Appendectomy	0.19	**2.2**
Abdominal aortic aneurysm repair	0,19	**2.2**
Mastectomy	0.17	**2.7**
Diagnostic upper gastrointestinal endoscopy	0.16	**1.6**
Colectomy	0.15	**1.6**
Prostatectomy	0.12	**1.7**
Lens extraction	0.11	**1.5**

SOURCE: M.R. Chaasin et. al., ''Variations in the Use of Medical and Surgical Services by the Medicare Population:" New *England Journal of Medicine, vol. 314, 1988, pp. 285-290.*

Nation's health care system that would reduce costs and improve the quality of services rendered. In many cases, new devices can contribute a qualitatively new service; in others, they can so improve the speed and accuracy of procedures that their costs maybe reduced to a point where they are offered routinely. For example, computer aided diagnostic and treatment systems can provide systematic seeond opinions for complex decisions. Such devices are already available for general abdominal pain, lung and thyroid diseases, glaucoma, cancer, and even neurological and psychiatric problems. These systems are unlikely to displace a physician's judgmerit, but at a minimum they can play a role in eliminating simple mistakes.

Computers and communication equipment can also play a powerful role in rationalizing the management of different parts of the health care system, as they have in other business enterprises. For hospitals, record keeping is a major expense that has grown rapidly with the introduction of complex cost containment reporting requirements. New information technology can have a dramatic impact on the efficiency with which records are maintained. Automated ordering and invoicing systems can control overhead while ensuring that adequate supplies of a large number of items are in stock without maintaining large inventories.

Information technologies can also improve the quality of clinical medicine by coordinating information about individual cases and maintaining patient records in away that makes it easy to review alternative programs of therapy. In this way, physicians can benefit from the collective knowledge of case histories instead of relying on their own experience and that of their immediate colleagues, as is the case today.

Hospital investment in information-processing equipment has been spectacular. Information system costs have now grown to 2 percent of the overall hospital budget, second only to investments in the hospital building itself. At present 60 percent of system capacity is used for billing and collections, 22 percent for in-patient care, 13 percent for ordering tests and drugs, and 5 percent for management information.[100] Many more applications are expected soon and equipment purchases are expected to in-

[100] ''HospitalSystems' Expenditures Skyrocket" Hospitals, April 1, 1984, p.39.

crease by a factor of four between 1984 and 1990. Applications range from improved software for interpreting data from CAT, MRI (magnetic resonance imaging), X-ray, and other diagnostic equipment; advanced systems for designing and operating prosthetics (like artificial joints and limbs); improved reaord keeping that may combine efficient bookkeeping with an intelligence capable of detecting obvious errors; and improved telemetry for connecting homes and ambulances to professional facilities.

HOUSING[101]

Prospects

The U.S. housing construction industry has been called the "industry that capitalism forgot." Compared with other manufacturing enterprises, the industry is fragmented and decentralized, with little investment in plant improvement, new equipment, or permanent staffing. It conducts virtually no research on either its products or the techniques by which products are assembled. Innovation has resulted almost entirely from component and equipment suppliers.

Productivity in the construction industry as a whole appears to be falling. Few builders have adopted the optimum engineering techniques, innovations in basic materials and structural designs, or performance analyses which have been applied to nearly all major products manufactured by other U.S. industries. A typical home, for example, has about 15,000 parts-approximately the same number as an automobile—but is assembled almost entirely by hand at the construction site.

The construction industry may be on the brink of a major change as modern production technology and the threat of imports force basic changes in the industry's products, in its production process, and in the way its goods are marketed:

. The industry could turn increasingly to factory assembly of products and components. These production facilities could be efficient, flexible, and enjoy the productivity increases that are being obtained in other manufacturing enterprises. Field assembly could be rapid, with entire homes assembled in a day. Increased investment in research could lead to major improvements in housing and other construction products. Housing could be made more comfortable and less expensive to operate, using new technologies ranging from advanced windows to efficient appliances. Homes could be sold through outlets that would permit prospective clients to participate in the design of a new house, or to be given a video tour of existing structures.
- The industry could remain largely unchanged, with productivity declining. 'Housing prices could rise with respect to other amenities. The Nation could be burdened with poorly constructed products that would become an increasing burden if energy prices rise during the next few decades. Foreign suppliers could provide increasing amounts of the value-added through components (e.g., major appliances and fittings), construction equipment (everything from hand tools to heavy construction equipment for tunneling), and licenses. Americans could find themselves assembling foreign products with foreign tools and adding little value other than site preparation.

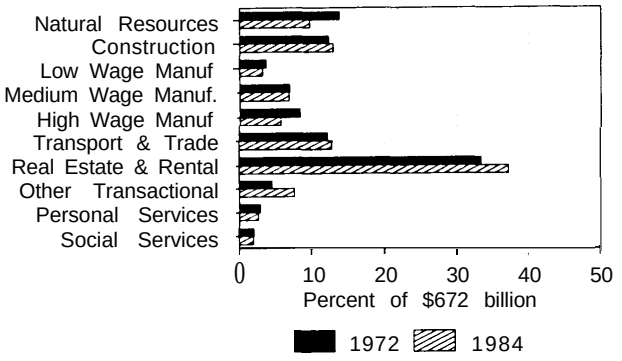
Housing and other types of construction operate with relatively few direct government regulations, other than the highly fragmented set of building codes typically operated at the local level. Compared with the extensive public support for research in the farming industries, total public spending on housing research is negligible. With 9 million people, Sweden supports more research on home construction than the United States; virtually all U.S. housing research is supported by the U.S. Department of Energy.

Structure and Performance

A diverse collection of enterprises combines to provide Americans with comfortable homes. Of the funds spent on the Housing amenity, however, one-third of the value-added ends up in the real estate

[101] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Construction," sector study, 1987.

Figure 6-4.-Value-Added To Meet Demand for Housing ($672 billion* in 1984)



● Constant 1980 dollars

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

industry (see figure 6-4), most in the form of direct returns to capital invested by homeowners or other investors. Since these costs result from factors largely unrelated to the structure of production, they are not examined here. There is little opportunity to change land costs, or the cost of home financing, through changes in production recipes in construction. Price changes in these areas result from a variety of factors discussed at some length in chapter 3.

Approximately 16 percent of the spending for Housing results in value-added in the manufacturing firms that produce appliances, furniture, and housing components for housing (as well as value--added generated indirectly by suppliers of these firms; the system for producing these products is discussed more fully in the last section of this chapter). About 10 percent of the value-added in Housing goes for energy or raw materials.

Only about 13 percent of all the value-added in the U.S. economy resulting from Housing ends up in the Construction sector. Most of this results directly from home construction, but some arises from the need to construct facilities that provide energy for housing and from other indirect effects. Housing provides by far the largest market for Construction activities, accounting for almost 48 percent of value-added in that sector.

For convenience, the industry that meets intermediate demands for construction (dams, harbors, bridges, roads, sewers, hospitals, and office buildings) will also be examined in this section.[102] The network of industries associated with this kind of construction includes architecture, engineering, field erection, component production, maintenance, and repair.

Factors Forcing Change

There are several reasons for the lack of progress in the U.S. housing construction industry. The most important is undoubtedly the enormous uncertainty ties in demand. Demand for construction business can change by as much as 50 percent in one year. Most firms achieve the flexibility required under these circumstances by minimizing use of permanent staff and long-term capital investments. The ratio of capital to labor in construction, after increasing by 4.2 percent per year between 1950 and 1968, declined by 0.8 percent per year during the early 1970s.[103]

The industry is highly fragmented and decentralized. While some vertical integration exists, most projects involve teams assembled from different parts of a network. Most construction firms are relatively small; of the 558,000 U.S. construction firms in 1982, only 10 percent had more than 19 employees.[104] There are few barriers to entry, particularly for homebuilders. Less than 8 percent of homebuilders have annual sales of over $1 million.

This fragmentation is encouraged in part by the fragmented form of regulation governing the industry. The homebuilding industry is regulated almost entirely at the State and local level. Currently, local governments apply several thousand major and minor variations of four model codes. There are at least as many inspection systems, accounting for differences in building code interpretations and varying degrees of enforcement. The various fire safety codes

102 As defined by the U.S. Office of Management and Budget (OMB), the construction industry actually consists of many different subindustries: Standard industrial Classification (SIC) code numbers 15, "general building contractors and operative builders"; 16, "heavy construction general contractors"; and 17, "special trade contractors. " In addition, "subdividers and developers," a subdivision of real estate (SIC code 65), is included in statistics on the construction industry.

103 H. Kemble Stokes, Jr., "An Examination of Productivity Decline in the Construction Industry," *The* Review *of* Economics *and Statistics,* vol. 63, No. 4, November 1981, pp. 495-502.

104 U.S. Small Business Administration, *The State of Small Business,* 1985 (Washington, DC: U.S. Government Printing Office, 1985), Table A1.21.

and inspections systems that relate to buildings compound this regulatory complexity. Enforcement systems also vary, both among and within States. This complex system presents problems for large U.S. homebuilders. The producer must satisfy hundreds if not thousands of building codes and inspection systems in order to serve the national market and still abide by the law. In addition to creating difficulties for large firms attempting to ship products to many different locations,[105] this array of State and local building codes and differing inspection practices can present obstacles to technological innovation.

Many of the features that have led to the existing industrial structure are changing. The construction industries in Japan and Sweden have moved rapidly to substitute factory construction for on-site hand labor. In Sweden, over 90 percent of new homes are made in factories.[106] In Japan, homebuilding is moving into the hands of large firms (e.g., Matsushita and Sekisui Chemicals) with a large capital base and a large investment in research engineering.[107]

Factory assembly offers a number of potential advantages. The factory permits greater quality control, greater use of modern fabrication equipment, and better working conditions. A factory-assembled home can be erected quickly on a site, minimizing construction loans and disruptions due to poor weather and offers the potential for greater flexibility of design. All of these advantages are moot, of course, if fluctuating demand leaves the equipment idle.

In the United States there has been a partial movement toward factory construction. Most U.S. factory construction, however, is essentially hand-assembly indoors. Very little capital equipment is used. In addition to the problem faced by fluctuating demand, factory-based homebuilding firms face an important marketing barrier in the United States. While factory construction is associated with "brand name" reliability and quality in places like Japan and Sweden, it is associated with cheap "pre-fab" and mobile homes in the United States.

Intermediate Demand for Construction

The rapid growth of service-related industries and the comparative decline of employment and investment in manufacturing and natural resource activity are both reflected in shifting patterns of intermediate demand for construction. Buildings taken as a whole have retained a surprisingly constant share of all investment in structures during the past 35 years, capturing approximately 70 percent of all pub lic and private investment in structures. The rapid fluctuations in demand for new residential construction are compensated partly by activity associated with renovation and remodeling, and partly by the fact that changing demand for non-residential building construction does not respond as rapidly to the changes in interest rates and other factors that lead to collapsing markets for new homes.

There have, however, been significant shifts in the composition of non-residential building construction. Rapid growth in service employment has meant that between 1976 and 1985, commercial building space and government offices grew from about 56 to 70 percent of all investment in buildings. During the same period, hospitals and educational facilities fell from 21 to 12 percent of building investment. Investment in industrial buildings fell from a peak of nearly 25 percent of all building activity in 1979 to 15 percent in 1985.

There has been a striking decline in the share of construction work slated for highways, sewers, water projects, and other infrastructure investments (see figure 6-5). This decline has continued in spite of a significant rise in investment in highway construction between 1982 and 1986 (outlined in the Transportation discussion of this chapter). Declining investments in new electric generating facilities, new pipelines, and other energy-related projects counted as "structures" led to a sharp decline in energy-related construction work in the 1980s.

Network Components

Heavy Construction.—Most major civil engineering projects, power plants, and large office complexes are constructed by relatively large builder/

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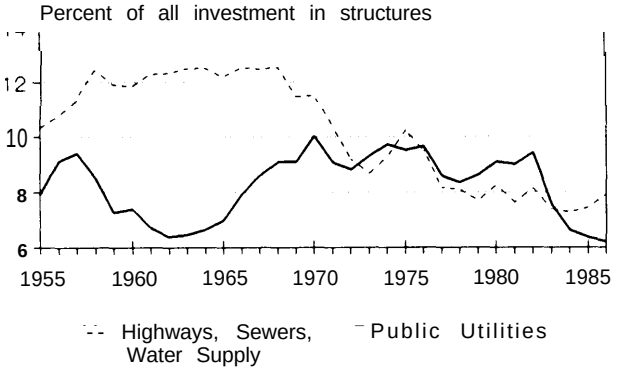
105 U.S. Congress, Office of Technology Assessment, Technology, *Trade, and the U.S. Residential Construction Industry-Special Report, OTA-TET-315* (Washington, DC: U.S. Government Printing Office, September 1986), p. 70.

106 L. Schipper, A. Meyers, and H. Kelly, *Coming in From the Cold: Energy Efficient Housing in Sweden* (Cabin John, MD: Seven Locks Press, 1986).

107 James McKeller, "Industrialized Housing: The Japanese Experience," Alberta Department of Housing, Alberta, Canada, December 1985, p. 81.

Figure 6-5.-Investments in Infrastructure (percent of all structures in constant 1982 dollars)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.5.

developers or general contractors. The top firms generate more than $1 billion in annual revenue and account for 40 percent of domestic contracts. However, many of these large firms have faced serious financial difficulties in recent years, due to the decline of large domestic projects; receipts for the largest companies fell by 30 percent between 1981 and 1983.

Although some firms have offset losses through foreign contracts, competition has grown for major international projects. Foreign firms have captured markets that were once the domain of U.S. giants. The problems of the U.S. nuclear industry, for example, have eroded the position of such major American companies like Bechtel in international markets. At the same time, Japanese, French, and West German firms–many of which began with American licenses—capture increasing shares. Many foreign firms offer advantages that the U.S. firms cannot match such as discounts on materials such as steel and concrete as part of a government-sponsored package that includes design and engineering.

Home Builders.-The homebuilding industry includes many small firms, but larger companies have begun to dominate housing output. In 1986, for example, homebuilders with annual volume greater than 100 units produced 67 percent of domestic units—up from 7 percent in 1959.[108] Moreover, the share of major firms has grown over the past two decades, reflecting trends in the industry as a whole.

Most homebuilding enterprises in the United States continue to operate on a small scale. A National Association of Home Builders (NAHB) survey conducted in 1979 showed that 46.7 percent of NAHB's member firms were run by either the principal or the sole owner, while only 8.1 percent had a salaried executive. The average U.S. builder produces 5 to 10 units per year. Most homebuilders serve specific local markets; less than 15 percent of all homebuilders do business outside of their home State.[109] These firms move rapidly into other lines of work during periods of low housing demand. In the "bad years" of 1967, 1974, and 1975, nearly 20 percent of all NAHB members switched to other businesses.

Even the comparatively large firms that build homes or home components in factories—which average 320 homes per year[110]—are not large by the standards of most manufacturing facilities.

Subcontracting to specialized firms accounts for a growing share of construction activity. In 1976, 58 percent of U.S. homebuilders contracted over three-quarters of their construction activities, as opposed to one-third in 1969. Firms reporting that subcontracts accounted for less than one-quarter of their work fell from 19 to 10 percent during the same period. Over 90 percent of all industry receipts were paid to subcontractors in 1977.[111]

Market concentration has increased in both conventional and factory-based construction. The top 100 production builders now control about 25 percent of the market, up from 17.3 percent in 1978.[112] The top 25 "manufactured" (mobile) home producers controlled 74 percent of the total market in 1983. Concentration in the metal buildings industry is particularly high, with the top 30 companies controlling over 95 percent of the market.

108 National Association of Home Builders, "Housing Focus," news release, Washington, DC, November 1987.

109 F.T. Ventre, "on the Blackness of Kettles: Inter-Industry Comparisons in Rates of Technological Innovation," *Policy* Sciences, vol. 11, 1980, pp. 309-328.

110 Renee Mathieu, "The Prefabricated Housing Industries in the United States, Sweden and Japan," *Construction Review, vol. 33,* July-August, 1987, p. 20.

111 U.S. Department of Commerce, Bureau of the Census, 1977 Census of Construction *Industries*, Washington, DC, April 1980.

112 *Automation in Housing* and Manufactured Home Dealer, various issues.

Remodelers.—The remodeling and reconstruction industry has even greater diversity and flexibility than producers of new structures. Traditionally, many firms have worked in both areas, partly to protect themselves against market fluctuations, Newer firms, however, often specialize in renovation, even going so far as to specify types of structures. NAHB finds that the largest and smallest construction firms tend to limit their work to new structures, while many intermediate size firms engage in both new construction and remodeling.

The renovation industry is becoming an increasingly distinct business specialty. Over 90 percent of all NAHB members that do remodeling have ceased all other operations. The use of specialized subcontractors has also increased, particularly when renovation is undertaken to improve energy efficiency or safety; this generally involves electrical and plumbing experts. Renovation places a high premium on worker skills, since unexpected developments often accompany the opening of older structures for repair.

Investment in building improvements, additions, alterations, and replacements represent a growing share of construction activity. A survey by the 600 largest U.S. construction firms put reconstruction at approximately 40 percent of total construction activity in 1984 and 1985; that figure was 26 percent in 1979. Disagreement about the potential future growth of the renovation market arises from a poor understanding of its framework. Traditionally, rehabilitation rates have been highest during slack periods in the new construction market, but this pattern may be changing.[113] Differences between the cost of new construction and the cost of extensive renovations have decreased. One cause of high renovation and rehabilitation costs is the inherent uncertainty in entering an older structure. As a result, most renovation contracts are negotiated, and are not subject to competitive bidding. This reduces pressure to reduce costs or improve efficiency.

Accelerated depreciation of new structures often favors new construction over renovation. Nevertheless, tax credits for historic preservation and other indirect subsidies for renovation can encourage renovations in certain areas. Renovated commercial properties may rent for less than new structures.

Measuring Productivity

Inadequate funding for construction research and the inability of industry firms to make permanent investments in people or equipment explain much of the stagnant or falling productivity in the U.S. construction industry. A number of other explanations have been offered as well:

- deflators may fail to account for changes in construction quality (like the obvious improvement in energy efficiency offered by new homes);
- repair and maintenance work may be underreported;
- off-site assembly of components may shift high-productivity activity into manufacturing industries and out of the construction industry, leaving comparatively unproductive site-work in construction; and
- there has been comparatively rapid growth in young, non-union construction workers during the past decade.[114]

The pace at which innovation is accepted by local codes provides a good measure of rates of change in the industry. A study of 14 technologies (including non-metalic electric cable and wood roof trusses) showed that 20 years typically passed between the time when 10 percent of all codes accepted the change and 90 percent accepted the change.[115]

Builders, whose financial position makes it difficult for them to tolerate mistakes, are extremely sensitive to possible negative consumer reaction. Unions have also resisted change; their effect has been to slow the introduction of innovations.

New *Technologies and System Integration*

New construction technologies and higher energy costs have already had a noticeable effect in changing the nature of the structures themselves—how buildings are manufactured, and how they may be adapted for differing conditions and uses. Often

113 Duane 'r. McGough, "Additions to the Housing Supply by Means other than New Construction," U.S. Department of Housing and Urban Development, Office of Policy Development and Research, Washington, DC, December 1982.

114 *Technology, Trade, and the U.S. Residential Construction Industry*, op. cit., footnote 105, pp. 31-33.

115 Ventre, op. cit., footnote 109, p. 319.

buildings can only be made to operate efficiently when the construction and future operating costs are considered as an integrated design problem. Institutional problems and the lack of research targeted at net building design and performance (particularly for residences) has limited progress. Often the cheapest way to reduce the heating or air-conditioning costs of a building involves good basic design.

New computer-based systems can improve the productivity of building design and analysis in a number of ways. They can rapidly convert concepts to drawings, drawings to analysis, and can combine these steps in order to estimate initial and operating costs. Such systems might be used to prepare both working sketches and detailed drawings. For example, a draftsman could call a computer file with routine building components at a moment's notice, thus bypassing the tedious aspects of drafting. Price lists could be included, allowing for instantaneous projection of the cost of various design alternatives. Computer assisted design systems could aid the designer by removing many of the barriers between inspiration and execution, and could improve client-designer communication, allowing for more design and investment flexibility.

New information systems can also influence the relationship between consumers and designers. Advanced systems can allow for a computer-based "tour" of building interiors and exteriors, serving as the basis for a computer-based structural analysis, a study of lighting, or an assessment of energy consumption. Japanese housing producers sell factory built homes through retail outlets and "show rooms," much like automobile dealerships in downtown locations. Some make use of computer assisted displays that permit customers to design their own products. [116] While there has not been extensive use of such technology in the United States, important suppliers of housing products have begun to experiment with new communication technologies. Sears Roebuck &Co. has developed an interactive video system which allows customers to browse through 11,000 types of curtains, blinds, and shutters and to receive decorating tips.[117]

New technologies could reduce the cost of modifying designs while preventing errors in areas unaffected by the change. The risks of trying a new idea would be reduced, because a concept would be transferred to drawings and analyzed without a major investment in time or money. Automated design systems coupled with communication systems could facilitate the performance of geographically dispersed teams, allowing clients, architects, engineers, and construction firms to cooperate during the entire implementation process. Computer based technologies could also improve the system of competitive bidding; they might quicken the initial bid application, reduce the uncertainties associated with bidding, and decrease the burdens associated with analysis. Design flexibility is not limited to commercial structures. Prospective homebuyers can now plot their own floor spaces, or compare the appearance of different interior and exterior wall coverings. [118]

If computer assisted design represents the first major revolution in building design, factory production of structures and components is the first in assembly. History is littered with predictions of an end to site construction and the development of an industry that would resemble more conventional manufacturing enterprises,[119] making it easy to be cynical about new claims. However, there have been recent gains in factory-based construction of homes and small commercial structures. Though data sources differ, it appears that as many as one-half of the homes built in the United States today involve at least some factory construction. The other half employ such factory-built components as roof trusses, pre-hung windows and doors, and "wet-cores" (bathroom and kitchen modules).

Assembly techniques for building components have also changed. Various new products are used

[116] See *Technology, Trade, and the U.S. Residential Construction Industry,* **op. cit., footnote 105, p. 45.**

[117] L. Therrien, "Birth of a Salesman: How Video is Revving Up Retailing," *Business* **Week, No. 3015, Sept. 7, 1987, p. 109.**

[118] U.S. Congress, Office of Technology Assessment, "Technology and the Future of the U.S. Construction Industry-Proceedings of the Panel on Technical Change and the U.S. Building Construction Industry" (Washington, DC: American Institute of Architects Press, 1986).

[119] A 1930s commission organized for President Roosevelt made this claim, which led to significant investment in factory-based home construction by a number of steel and aluminum companies; however, these groups never captured more than 2 percent of the market. President Truman appointed a "housing expediter," who was to solve the post-war housing shortage through increased factory production. Only a fraction of the goal was achieved. Under the Johnson Administration, George Romney rekindled the dream with "Operation Breakthrough," but this also failed to reach its initial goal. See *Technology, Trade, and the U.S. Residential Construction Industry*, **op. cit., footnote 105, pp. 23-26.**

for insulating materials, floor coverings, exterior wall surfaces, glazing, and floors. Technology has challenged conventional notions about how to provide basic structural support, and optimum design engineering has refined conventional designs. Truss systems can vastly reduce the cost of large, unsupported spans. There is even a possibility that active controls can be installed in structures to adjust for the dynamics of wind loadings. And new adhesive materials have been introduced to facilitate a wide range of construction from decorative paneling to exterior sheathing.

Roofing has always necessitated much site labor, and most client complaints result from imperfections in roof assembly. New techniques can produce roofing sections with standing-seam rib panels, joined mechanically by semi-automated equipment. Some U.S. firms have developed a self-propelled "roof runner" to do the mechanical crimping. And over 90 percent of all roof trusses are now built in factories; inexpensive computers can design trusses in all but the smallest facilities. Software serves most common applications, allowing for flexibility in design at no additional cost to the builder.

In addition, concrete structural units can be manufactured in factories and trucked to building sites. Several firms now sell low-rise office buildings, which can be erected in a single day, to clients ranging from retail operations and banks to schools, These structures can be disassembled on the completion of their useful life.

Structures using metal frames and sheathing offer clear opportunities for mechanization, since conventional metal fabrication tools can serve this purpose. Metal-framed housing has never made significant inroads into U.S. markets, due more to market conservatism than to factors of cost or performance. These structures are designed, engineered, and manufactured under computer control. Computers also monitor inventories and material flows, which is critical to an industry where success depends on the ability to deliver products quickly.

Technical change has also affected field erection techniques, particularly for commercial structures. Computer assisted operations have been introduced into equipment for uses ranging from earth-handling to erection, and fully robotic systems will arrive soon. Computer assisted equipment serves to replace people in high-risk situations while improving precision. For example, crane operations account for a significant fraction of all construction accidents. Automated systems can alleviate this factor. Control equipment "remembers" both critical lift heights and swing envelope restrictions.

New technology has not facilitated a large increase in the productivity of renovation or retrofit operations. This work often involves "gut" renovations, where interior work resembles new construction and new materials and assembly techniques. Renovation costs have been reduced by surface wiring for wall mounting, flat-wiring that can run under rugs, modular furniture, modular wall partitions, lighting systems attached to movable partitions, and new types of scaffolding. There is controversy over whether the result is attractive office space.

Diagnostic equipment has been developed to help pinpoint defects in older buildings. Infrared cameras can locate heat leaks, and pressurization devices can indicate sources of unwanted air infiltration. Because facades of certain buildings—especially in older cities like Chicago and New York—have fallen to the street, renovation must now address issues of public health and safety. For example, X-ray, video, and other diagnostic equipment are employed to spot defects; nuclear scanning, capacitance testing, and other techniques are now used to locate sources of roof cladding defects.

It is entirely possible that the forces that reshaped the construction industry abroad will also revolutionize the U.S. construction industry. The construction firm of the future may resemble that of conventional manufacturing industries in terms of method and application of research, product assembly, and worker skill levels. Large firms with a high level of technical sophistication are capturing a larger share of markets in areas that were once the domain of smaller companies, creating an industry with a national rather than regional scope. And technology can alter the seasonal nature of construction employment: "flexible factories" that serve changing markets can replace a "flexible workforce,"

TRANSPORTATION[120]

Prospects

Emerging production networks and American lifestyles depend on a flexibile and responsive transportation system, tailored to individuals and comparatively small shipments. These demands have the potential to reshape the network of businesses that provides transportation for U.S. consumers and businesses:

- Personal transportation systems could be rebuilt around personal vehicles, and guideways (highways, and rail lines) could be tailored to provide fast, safe transportation. Pedestrian and mass transportation systems could play small but critical roles in high density areas. Freight movement could exploit the power of new communication systems to ensure fast, reliable delivery of comparatively small shipments.
- Congestion and a deteriorating highway infrastructure could limit growth of mobility and limit the growth of dynamic production networks based on "just in time" integration of large and small producers, in different parts of the country or different parts of a given metropolitan area. Destructive competition could lead to a decline in safety.

Public regulation of transportation has sharply declined in the past decade. Government influence over the future structure of the system can be critical. Public decisions about research priorities, construction of new highways and other facilities, and regulation of safety will play a decisive role.

Structure and Performance

The production recipe for the transportation system involves a complex amalgam of private and public spending. With the exception of rail, most guideways are purchased at public expense (primarily through user fees) while equipment is privately owned. Moreover, a significant amount of transportation is purchased as an intermediate good by businesses, rather than being purchased directly by individuals or the government. The purchases involved in transportation include:

- equipment—automobiles, trucks, railroad rolling stock, and aircraft (the manufacture of vehicles falls almost entirely into the High Wage Manufacturing sector, and is discussed in the final section of this chapter);
- guideways (the businesses that build these facilities are included with the Construction sector, and are addressed in the Construction analysis of the Housing discussion);
- control and communication networks-dispatch systems and air traffic control (some of these are discussed in the section on Personal Business and Communication);
- terminals and transfer facilities—parking spaces, airports, rail yards, ports, harbors, and warehouses;
- vehicle maintenance facilities;
- fuel purchases, insurance, and associated supplies (the production of automobile insurance is also examined as part of Personal Business and Communication); and
- packaging and containers—standardized bulk containers for rail and truck or shipping as well as product packaging (packaging technology is discussed in the section on Food).

The discussion in this chapter will deal primarily with the provision of transportation services.

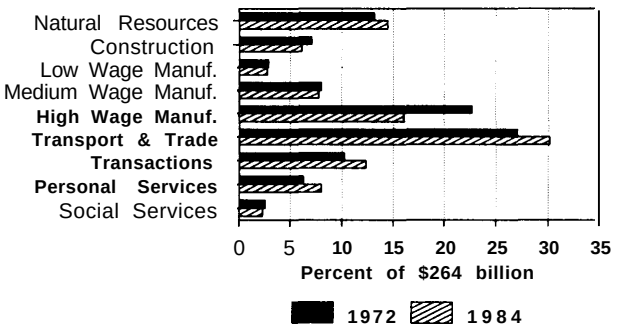
The network of value-added generated by consumer and government purchases directly related to the Transportation amenity is dominated by transportation services (30 percent), purchases of vehicles (High Wage Manufacturing captures 16 percent), and Natural Resource enterprises providing energy for vehicles and materials needed for vehicle and highway construction (see figure 6-6).

Factors Forcing Change

The Nation's recipe for delivering transportation services is comparatively stable, in part because the enormous capital investment in equipment and guideways makes change difficult. Technology has a com-

120 Much of this section is drawn from U.S. Congress, Office of Technology Assessment, "Transportation, " sector study, Washington, DC, 1987.

Figure 6-6.-Value-Added To Meet Demand for Transportation
($264 **biiiion in 1984)**



● Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

paratively small direct effect on transportation recipes. Nonetheless, rapid changes in the nature of demand for personal and business transport, the potential for rapid increases in fuel prices, and growing congestion in critical bottleneck areas (such as busy airports and crowded suburban highways) have created significant pressure for change. Public decisions about highway construction, airports, air-traffic control systems, and the implementation of regulations will necessarily play a key role in the performance of the transportation system emerging over the next two decades.

The Nation's transportation system depends almost entirely on liquid fuels—primarily fuels derived from petroleum. There is almost universal agreement that the price of petroleum will rise sharply during the next two decades. Optimists hope that the rise will be gradual enough to allow private markets to make a graceful adjustment to a new fuel source. Others fear that the rise may come rapidly in response to a crisis in the Middle East or elsewhere.

The price of petroleum in the United States now reflects the operation of comparatively free world markets. The United States has opted to use regulations rather than fuel prices as an inducement to increase fuel economy in automobiles. These regulations proved impossible to maintain when low fuel prices gave consumers a message that fuel was inexpensive and plentiful while regulations demanded parsimony. Many other developed nations, however, place a $1 to $2 per-gallon tax on petroleum fuel, giving consumers a strong incentive to find substitutes. This was originally done because driving was taxed as a "luxury" like alcohol and cigarettes; it now reflects the high national cost associated with heavy petroleum dependence that is not included in market-based fuel prices.

Changing regulations in the past decade have begun to reshape the Nation's transportation system. Air, truck, rail, and bus transportation systems were all once heavily controlled by Federal regulation. Most of these regulations have been either eliminated or substantially modified in the past decade. The full impact of these changes has yet to be felt, but they appear to have increased the overall efficiency of transportation in the sense that the new system offers more choice in quality and cost of service. There is, of course, continuing controversy about whether deregulated airlines are safe, whether drivers for small trucking firms are as safe as those working for larger firms, and whether consolidation and mergers occurring throughout the industry will lead to lower prices and more choice or the converse.

The critical issue of licensing truck drivers remains one of State discretion. Concern about safety has led to proposals that more classes of driver licenses be introduced, and that State licensing be either coordinated or replaced by a national framework in cases where driver responsibility is critical. Transportation of hazardous materials is an example.[121]

One trend that deserves special attention is greater use of "intermodalism," in which different transportation modes are combined to provide a transport (rather than road or rail) service in a way that minimizes costs. Examples are the park-and-ride lots that allow commuters to transfer from private autos to a bus or train, joint airfare-car rental discount packages, and the sale of airport-to-downtown limousine service tickets on the aircraft.

Intermediate Demand for Transportation

Business Travel.—As the number of white collar jobs has increased, business demand for the transportation of people has grown more rapidly than that for freight. While statistics are poor, it appears that

121 U.S. Congress, office of Technology Assessment, Transportation of *Hazardous Materials, OTA-SET-304* (Washington, DC: U.S. Government Printing Office, July 1986),

about one-third of all intra-city travel is for business and therefore must be considered as "intermediate" and not final demand.[122] There are, of course, many ambiguities in this accounting since most people pay for their own trip to work while the employer typically picks up the price of parking (a not inconsiderable expense hidden in the cost of commercial and industrial structures).

Since the businesses that require significant personal travel are growing rapidly, personal travel would seem to be a growing part of the "recipe" for American production. On the other hand, modern communications can substitute electronic for personal contact. Telephones, computer communications, and eventually high-quality video conferencing could replace much business travel. But will this occur? The signals are mixed. The introduction of the telephone put more people in contact with one another and actually increased, rather than decreased, the need to travel.[123] Newer forms of communication may have the same effect.

Freight.—Changes in economic structure are reshaping demand for freight services in a variety of ways. Perhaps most fundamentally, the economy is becoming less intensive in its use of materials. The consumption of steel, cement, paper, and a variety of chemicals appears to have peaked. A variety of factors are involved:

- more efficient use of materials in manufacturing,
- a shift toward light-weight materials (e.g., substitution of plastic for steel in automobiles and of light packaging material for metal cans),
- recycling of existing materials,
- development of materials with longer useful lives, and
- a movement toward an economy dependent on high-value information and products-with a high value per unit weight[124]

As a result of these changes, freight traffic (measured in tons shipped per dollar of GNP) has fallen by 40 percent since 1950. At the same time, however, bulk commodities are being shipped further. Manufacturing centers appear to have moved away from sources of raw materials, sources of bulk materials close to population centers have been exhausted, and some regions appear to have specialized in the production of raw materials. More than 20 percent of all domestic U.S. energy resources, for example, are now shipped from Alaska. Rapid growth in exports of bulk farm materials and coal have added to demands for long-distance freight movement. Intercity tonnage increased 60 percent between 1950 and 1983 while intercity ton-miles increased 100 percent—the same rate as GNP—implying an increase in average haul length of over 30 percent.

Increasing interest in better inventory control and integration of geographically dispersed production centers has placed a premium on fast, reliable delivery of relatively small shipments. While there may bean upper limit to the tons of material per person that an economy needs to move, there is no apparent limit to the amount of value per pound that can be added by sophisticated production. Increasing the value per unit weight of goods, coupled with production systems that are paying close attention to inventory controls, is requiring higher quality from transportation services.

Demand for freight transport has also changed, as manufacturing in the United States is becoming more geographically dispersed and is moving from urban to suburban and rural areas. Changes in the location of population centers, retail outlets, and production centers have increased the market for relatively short-haul collector/distributor freight shipments within urban areas.

All these effects translate into a growing demand for quality—speed, reliability, and security—and for batch rather than volume shipments. In the past decade, this has resulted in rapid expansion of truck and air shipments at the expense of rail shipment and Great Lakes waterways. Trucks appear to be the vehicle of choice for most high-value shipments, Trucking accounted for 37 percent of total intercity tonnage in 1982, up from 26 percent in 1950. Railroads have countered by introducing containers and vehicles that can operate on both rails and highways, which offer greater flexibility and reliability. While only about 4 million tons of material are shipped

[122] U.S. Department of Commerce, Bureau of Economic Analysis, "Input-Output accounts," *Survey of Current Business,* various issues.
[123] Herbert S. Dordick, "What 'Home Work' Means to Large Organizations, Home Workers and Home Builders," *Land Development Studies, vol.* 3, 1986; and 1. de Sola Pool (cd.), *The Social Impact of the Telephone* (Cambridge, MA: The MIT Press, 1977).
[124] R.o. Larson, M.H. Ross, and R.H. Williams, "Beyond the Era of Materials," Scientific *American, vol. 254, No. 6,* June 1986, p. 34.

by air, air freight grew by a factor of 10 between 1950 and 1982.

Measuring Productivity

Given the qualitative changes occurring in the nature of demand for transportation, it is increasingly difficult to develop an acceptable measure of performance. Measured in terms of the average price of a ton-mile and a passenger-mile, the Nation's transportation system has shown steady improvement. Some of the price reductions may be the result of the changing mix of services demanded, since the price of public transportation and freight services has grown more rapidly than average. Such price indices can be misleading, however, because they span a period when deregulation radically changed the price structure of many transportation services—particularly air fares, as survey techniques may not accurately reflect the real impact of discount fare structures that have become the norm rather than the exception.

Price per pound is, however, only one element of service competition. If efficiency is measured in terms of average speed, the record is not particularly distinguished. Although highway speed restrictions limit trucking performance, problems of track quality and yard efficiencies have limited the average speed of the U.S. rail system.

Increased competition has made the U.S. transportation system more flexible and dynamic. Some of this flexibility has been achieved at the cost of stable, well paid jobs in the industry (see ch. 12). At the same time, outmoded work rules continue to present problems in established industries like railroads. A journey from Chicago to Los Angeles, for example, can require nearly 20 crew changes. Real efficiency improvements will require innovations in labor-management relations as well as new technology.

The indications are that the U.S. freight transportation system can adjust to changing economic conditions, patterns of demand, and input costs more rapidly than in the past. Some of this new flexibility has been achieved by improved communication and computation technology, equipment changes, and new management strategies made possible by deregulation.

Scale **and** Scope.-Major changes have occurred in the way that industry firms are organized. The deregulation of air travel following the 1978 Airline Deregulation Act has introduced much confusion as the industry struggles to rebuild itself around a new set of rules. There has been much controversy over the extent to which regulation of safety can be separated from regulation of fares and other features of air travel. The efficiency of "hub" systems seems to have been revealed by new regulatory freedom. The new public rule scheme has also revealed the subsidies inherent in regulation, resulting in higher fares to certain locations (typically smaller towns) and lower fares on heavily traveled routes.

Nonetheless, shadows of former regulations are still visible in the air transport system:

- The two airline reservation systems whose development was, in effect, subsidized by regulated fares on all flights are privately owned. Development of a competing system is virtually impossible.
- Many airports are largely owned by one or two carriers. American Airlines controls 63 percent of the traffic from Dallas-Fort Worth International Airport. Northwest controls 81 percent of the flights from Minneapolis-St Paul and 64 percent of the flights leaving Detroit. U.S. Air controls 84 percent of the Pittsburgh market.[125]
- Landing and takeoff rights during peak times at congested airports are not available on the open market. They can be bought only by purchasing an entire airline.
- A series of mergers and acquisitions has significantly increased the concentration of the airline industry. In 1986, 12 major carriers controlled 85.5 percent of air travel while in September 1987, 8 airlines account for 94 percent.[126]

All of this suggests that deregulation may result in less competition and not more.

Deregulation has had a major impact on the rail industry as well. Many feel that the rule changes helped improve efficiency by concentrating traffic on a smaller number of routes, and by permitting greater economies of scale in functions such as bill-

[125] A. Salpukas, "Air Fare Increase Worry Regulators," *The New York Times*, Sept. 9, 1987, p. D5.
[126] Ibid.

ing, invoicing, and routine management. [127] The Railroad Revitalization and Recovery Act of 1976 and the Staggers Rail Act of 1980 liberalized merger policy and made it easier for railroads to demonstrate unprofitability of a line. The result was a dramatic decrease in the number of miles in the system.

A new element of flexibility in pricing was also introduced by deregulation. While average annual rail freight costs outstripped the overall U.S. GNP price index (or deflator) between 1975 and 1982, growth in freight costs since that time has been less than two-thirds that of GNP.[128] Special prices can now be arranged to reduce the need for empty cars in backshipment. For example, Union Pacific has introduced a reduced rate for hauling fertilizer for Cargill north along the Mississippi in grain cars that would otherwise have traveled empty. The rates are designed to be competitive with barges. Such a strategy would have been virtually impossible without regulatory changes.

The Motor Carrier Act of 1980 greatly eased entry into trucking, and relaxed regulations governing rates and service offerings. The effect on the industry was dramatic. The number of trucking firms increased from 18,000 in 1980 to nearly 30,000 in 1983. Profit margins and returns on equity have fallen rapidly; indeed, the rapid rise in the number of firms has been partially offset by the nearly 6,500 business failures occurring since 1978.[129] While average profitability for the industry has fallen below traditional levels, profits have improved for some specialized carriers, particularly larger firms.[130]

The market for trucking seems to be bifurcating. Economies of scale and scope appear important in the "less-than-truckload" (LTL) market, and this business is increasingly dominated by comparatively few carriers—the top 10 LTL shippers control 60 percent of all U.S. LTL shipments and 90 percent of all LTL profits.[131] These economies result in part because firms large enough to operate sophisticated, computer-based communication and dispatch systems have more flexibility and operate more economically. On the other hand, there appears to be cut-throat competition among small shippers and owner-operators in the truckload market; most of the industry turnover has occurred among truckload shippers.[132]

A competitive market may favor larger shippers who have greater market power, higher volume, and more continuity. Some case studies indicate that small firms lost ground in service and rates in Minnesota and Florida.[133] On the other hand, volume discounts are generally not large, and can be given to brokers and shippers' agents who can pass the savings through to smaller shippers.

The problem of "captive shippers" also appears to have grown since deregulation. A growing fraction of bulk shippers are tied to a single railroad for at least a part of their route. This presents real dangers of monopoly pricing and reduces incentives for improvements.[134]

Geographic Effects.—Small cities with air fares implicitly subsidized by more lucrative air routes have faced increasing prices or less frequent air service. Bus service and short-haul air service has filled many of the gaps.

While statistics are not available to confirm the point, it appears that deregulation has not led to a decline in the freight transportation services available for most communities; service from small shippers actually appears to have improved. Competition opened a number of options for remote shippers and often reduced prices. On the other hand, over 240 locations had their scheduled bus service reduced by more than 50 percent in the three months following bus deregulation in 1982 (the Bus Regulatory Reform Act).

New Technologies and System Integration

A number of trends in the Nation's transportation system are almost certain to continue for a genera-

[127] "Transportation," **op. cit., footnote 120.**

128 BU.S. Bureau of the Census, Statistical *Abstract of the United States: 1987* **(107th** cd.), **Washington, DC, 1987, table 699, p. 1053.**

129 Chris Welles, "Is Deregulation **Working?"** *Business Week, No. 2078,* **Dec.** *22, 1986,* p. *52.*

130 W. Legg, *Financial Analysis of the Motor Carrier Industry, 1985* (Baltimore, MD: Alex Brown, 1986).

[131] Chris Welles, **op. cit., footnote** 129.

132 I'bid.

[133] **"Transportation," op. cit., footnote 120.**

134 See Mary H. Cooper, "Economic Deregulation," *Congressional Quarterly's Editorial Research Reports, vol. 2, No. 3,* **July 24, 1987; Theodore Keeler,** *Railroads, Freight and Public Policy* **(Washington DC: The Brookings Institution, 1983).**

tion. They include:

- increasing geographic integration of production within the United States;
- increasing demand for fast, reliable shipments of relatively small batches;
- no significant growth in demand for commodity shipments; and
- continued increases in energy efficiency and labor productivity in rail and air transport.

Personal Travel

The key question for the future of business travel is whether new forms of communication will substitute for physical presence. The answer depends more on psychological attitudes than economics, since it is less expensive to use the telephone than to travel. It is difficult to explain why the physical presence of another individual is felt to be critical to certain kinds of discussions. The need to read gestures, expressions, and other nonverbal communications must have deep psychological roots. Activities that require sensitive discussions, such as personnel evaluations, student tutorials, or delicate contract negotiations, appear to require physical presence while contact such as the exchange of routine business information, is acceptably conducted by mail or telephone. There are, on the other hand, situations where individuals prefer to avoid the "presence" of another individual, prefering the relative anonymity of mail or a message service.[135] The range of alternatives between meetings and mail will continue to increase-the result of new communication technologies that can create a series of "niche" markets offering different levels of contact.

Unfortunately, little is known about the demand for these kinds of services. Such information may develop only after the technology has been in place long enough for society to adjust to its capabilities. It took a generation for individuals to feel comfortable with the telephone.

A number of studies of office location have examined the reasons behind decisions to locate offices in city centers.[136] According to some observers, the need for physical presence in communication is highest for headquarters operations and lowest for back offices that undertake functions like billing and payroll.

Aircraft efficiency has been improved, through both increased load factors and the addition of highly efficient wide-bodied jet aircraft. The gains following energy price increases were dramatic. Commercial aircraft achieved 17 passenger miles per gallon in 1973 and approximately 30 in 1986.*[137] The new wide-bodied jets are capable of significant improvements; the Boeing 757 averaged 40 passenger miles per gallon in 1985, and the 767 averaged just over 35 in 1984.[138] Improved air traffic control can also reduce fuel use, by optimizing descent and climbout procedures and by reducing delays. In 1986, the Airline Transport Association estimated that $2 billion in operating costs were lost due to landing and take-off delays resulting from air traffic control problems. These costs do not include the value of the 1 million passenger hours per year lost due to the delays.[139]

Video conferences have been on the horizon since the 1960s, but their cost (still about $1,000 per hour for a coast-to-coast communication) has been prohibitive. In addition, the conferences can usually only be held in specialized facilities. Few individuals value the characteristic of talking to a moving image enough to pay much for the privilege.[140] A significant market could appear if the price of video transmission was drastically reduced and the process made more convenient; 84 percent of Fortune 500 companies have either installed a videoconference facility or plan to do so in the near future. There were 575 installed teleconferencing rooms in place in 1981—4,000 may now be in place.[141]

Freight

The costs and system-wide performance of the transportation system have been improved by a va-

135 R. Johansen, J. Vallee, and K. Spangler, *Electroric Meetings: Technical Alternatives and Social Choices* (Reading, MA: Addison Wesley, 1979).

136 See J. Thomas Black et al. (eds.), *The Changing Office Workplace* (Washington, DC: The Urban Land Institute, 1986).

137 Unpublished data provided by the Federal Aviation Administration.

138 Ibid.

139 Airline Transport Association, "Discount Fares Save Airline Passengers $3 billion in *1986*," press release, Washington, DC, 1987.

140 R. Johansen, J. Vallee, and K. Spangler, op. cit., footnote 138; and A. Reid, "Comparing Telephone with Face-to-Face Contact," in 1. de Sola Pool (cd.), op. cit., footnote 123, pp. 386-415.

141 For more on recent developments in teleconferencing by U.S. businesses, see *Fortune,* Aug. 5, 1985, p. 63, and May 2, 1983, p. 295.

riety of new technologies, many of which were encouraged by changes in regulation. Railroads have been able to achieve significant cost reductions through the use of integral "unit trains" for coal, farm products, phosphates, and other chemicals. Performance was further improved using more specialized cars, consolidated yards, mechanized "hump" yards, and weigh-in-motion systems. The integral trains can move more quickly through yards and loading facilities. The "tare," or empty weight of freight cars, has been reduced through greater use of aluminum. A variety of improvements in trucks—center sills, load dumping systems, drawbars, couplers, wheel slip controls, and multiple unit controls—have improved system performance. Automated sensors now inspect for wheel cracks, and car identification is facilitated with bar-coding. Computer-based dispatching, scheduling, and control systems can improve reliability and timeliness.

The efficiencies of bulk truck hauling have been improved largely through a steady increase in the size and weight of trucks permitted on the highways. In 1974, Congress raised maximum permissible gross vehicle weight on the interstate highway system from 73,280 pounds to 80,000 pounds, though States were allowed to retain lower, "grandfathered" weight limits. The Surface Transportation Act of 1982 made Federal standards preempt State limitations on truck sizes and permitted double trailers on all interstates. These changes may have increased labor productivity in freight transport along some corridors, but the trade-offs remain highly controversial.

The efficiency of barge traffic has also improved due to economies of scale. There has been a steady growth in the size of barges and Great Lakes freighters, made possible by lock enlargements funded primarily by the Federal government. Specialized barges have been introduced that permit high maneuverability in congested areas like the upper Mississippi River.

Pipelines offer great economies for bulk movement. New, larger diameter pipes are now possible because of new technologies. The 36 "-diameter Alaska oil pipeline is an example. The performance of pipelines is further improved using better compression systems, pumping systems, and sensors tied to computers that increase effective capacity.

A variety of innovations has improved the system for moving standardized containers from ships to specialized flat-cars and trucks. Entire truck trailers are also carried on freight cars. The transfer of containers is being steadily improved with specialized terminals, automated loading systems, and standardization.

Another class of innovation helps different branches of transportation offer a joint service-intermodalism. For example, the Railroader and Railmaster systems use vehicles with both rubber and metal wheels that can operate on either rails or highways. The vehicles are about 1,500 pounds heavier than standard truck trailers, but are much lighter than standard rail cars. The small performance sacrifice in relatively short highway hauls is more than offset by the advantages offered when these vehicles are used on rails.

Specialized truck dispatching firms have sprung up to provide coordination and status information on material being trucked within the large, fragmented network of intramodel and intermodel carriers. This service would not have been possible without the widespread implementation of computers necessary for controlling, tracking, and Scheduling.[142] Only through such a system can the small truckers compete on a nationwide basis with the large corporations. Information services have, as a result, become a critical part of the production recipe for freight transport.

Energy price increases during the 1970s led to a variety of innovations in the transportation system. If the transportation system of 1981 had operated with 1974 energy efficiency, fuel consumption would have been 15.3 percent higher. But energy efficiency is affected as much by the choice of transportation mode and system efficiency as it is by the performance of vehicles. The shift from rail to truck transport, for example, significantly reduced the energy efficiency of the system, since rail transport is three to four times more energy efficient than trucking.

A variety of technical improvements can improve the energy efficiency of freight transport. In trucks, use of radial tires, aerodynamic body shapes (including the now familiar flanges on the cab roofs of many

142 Thomas S. **Gray, "The Effects of Trucking Deregulation on the U.S. Economy: 1980-1985," presented at the Third Creativity, Innovation, and Entrepreneurship Symposium, Framington, MA, May 1986.**

intercity trucks), low-weight materials, and diesel engines can improve energy efficiency. Further improvements include the use of both double-wide tires and engine additions taking advantage of exhaust energy. The average efficiency of trucks can probably be improved by at least 30 percent using technology now on the shelf.

It offends common sense to believe that a system using a single person to move a truck trailer across the country can compete with a system using two people to move hundreds of trailers via rail, and rail enjoys markets for commodity and container shipments greater than 600 miles. Trucks tend to compete in long-haul markets primarily when high quality (e.g., timely) service is required or when rail service is not otherwise adequate. Some analysts believe that railroads can never cover the real opportunity costs of their real estate and operating costs carrying anything but commodities hauled on relatively high density routes. It may well be that rail lines and rail yards are a poor use of a unique resource: long rights of way extending into the hearts of virtually every major city in the United States.

To some extent, of course, the balance between rail and trucking will be a public and not a private decision. Rail lines must be maintained entirely by private funds, while some of the cost of public highways is subsidized by taxpayers rather than user fees.

CLOTHING AND PERSONAL CARE[143]

The system of businesses that combine to bring clothing to American markets provides a particularly clear example of the way changes in the warp and the weft of business networks can affect the costs and quality of products delivered, as well as the fate of individual industries that form parts of the network. This discussion will cover the network of businesses that convert fiber to finished apparel offered for retail sale. Clothing and related products represents the bulk of the economic activity in this amenity group.

Prospects

The apparel production system could follow one of several radically different paths during the next two decades:

- The industry could be transformed by technology and innovative management strategies. It could develop an ability to respond quickly to emerging tastes and new developments in production. It could rely heavily on skilled labor and programmable equipment instead of large numbers of low-paid workers. It could tie producers and retail operations together in a tightly integrated network. An ability to tailor products to specific tastes and sizes without significant increases in price would, in effect, complete a cycle that began when the industrial revolution replaced tailor-made apparel with mass production.
- The manufacturing part of the network could be gutted by imports, leaving a domestic industry consisting primarily of transportation, whole sale, and retail operations. It is likely that a small fashion industry would survive and that domestic producers of high volume commodities (like bed sheets) would continue, although the equipment to produce the materials might be imported. Markets for industrial fabrics could be tied heavily to the fate of manufacturing elsewhere in the economy. Without enforcement of wage and hour regulations, there could be rapid growth of "underground assembly" through employment of illegal aliens at subminimum wages.

There may be no middle ground between these scenarios. Given the pace of change in global textile and apparel production, the direction that the U.S. industry will take should soon become clear. At present, signs can be read that point in both directions. The makers of textile machinery in the United States have failed to keep pace with the world state-of the-art. Imports are cutting deeply into domestic apparel businesses. A decline in these industries cuts deeply into prospects for growth in textile and fiber production.

[143]Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in* Progress-Special Report, OTA-TET-332 (Washington, DC: U.S. Government Printing Office, April 1987).

On the other hand, there has been active movement in the development of tightly integrated production networks, use of flexible production equipment by textile firms (though much of it is purchased from foreign suppliers), and a renaissance in the development of technology for apparel assembly.

With the exception of comparatively heavy trade protection, the rules governing the domestic operation of textile and apparel production are almost entirely those of freely operating markets. Structural changes in this ancient business, however, can be heavily influenced by custom, and tradition. Public support for research has been minimal, but Federal regulations may have inadvertently had a major effect on industry structure through rules restricting worker exposure to fibers that caused "brown lung." These rules may have played a critical role in stimulating private investment in new, highly productive textile equipment.[144]

Many of these basic rules are in a state of flux. A small Federal investment in new apparel production equipment has proven highly successful. Disparate elements of textile and apparel networks have formed a new series of trade councils to develop standards, communication protocols, and universal product codes.

Structure and Performance

The production and sale of clothing has been divided into sharply defined operations for generations. Firms that produce man-made or natural fibers supply material to yarn producers, which in turn sell to weaving or knitting facilities. There has also been rapid growth in production of nonwoven fabrics like felt or medical gowns. Fabric is sold to a finisher and then to a garment manufacturer. There, jobbers oversee the movement of products from one processor to another, supplying a finished product to cutters or retailers and maintaining product supplies for spot markets.

The cultures of each of these sectors are different, and almost tribal. Producers of man-made fibers are typically enormous, sophisticated chemical industries like E.I. du Pont de Nemours & Co. Textile production typically occurs in the southeastern United States, in comparatively small businesses often owned by old families. Apparel production is generally an elaborate network of small businesses in the northeast, and more recently by networks of firms using inexpensive American and Mexican workers in southern California. Retail merchants are almost a completely independent "tribe." Many rely heavily on foreign supply, and their interests may diverge sharply from many domestic manufacturers.

While there has been some horizontal and vertical integration, movement has been slow and uneven. Distinct patterns are difficult to identify. In some areas, a period of expansion and mergers was reversed when firms that had diversified returned to narrower specialties. Some concentration has occured in cotton weaving and man-made fiber weaving—the two largest sectors of the textile industry. In the early 1950s the leaders of the textile industry, particularly Burlington Industries and Milliken, moved to vertically integrate the textile product from fiber to finishing; apparel production, however, remains highly competitive and fragmented. Of the more than 200 apparel companies in the United States, less than 1 percent have sales over $100 million per year. While there has been some vertical integration in apparel retailing, most efforts to combine functions have proven unsuccessful. The 1980s saw growth in both large "discount" and relatively small and expensive outlets.

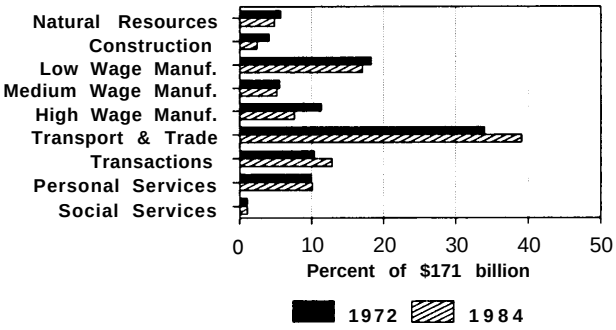
The system that starts with raw materials and ends with apparel offered for sale in retail stores involves virtually every part of the economy. In 1984, only about 17 percent of value-added generated by spending on the Clothing and Personal Care amenity ended up in businesses directly associated with the production of cloth or apparel. Nearly 40 percent appeared as value-added in transportation, wholesale, or retail activity; 13 percent wound up in the hands of transactional businesses (see figure 6-7).

New Technologies and System Integration

Technologies are improving both individual steps in the process used to convert fiber into retail products, and the efficiency of the overall system.

[144] Ruth Ruttenberg, "Compliance with the OSHA Cotton Dust Rule: The Role of Productivity Improving Technology," contract report prepared for the Office of Technology Assessment, March 1983.

Figure 6-7.-Value-Added To Meet Demand for Clothing and Personal Care ($171 billion* in 1984)



● Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

Technical improvements in individual processes include:

- the substitution of synthetic for natural fibers, and an increase in the strength and consistent quality of yarns of all types;
- the introduction of programmable, "shuttle-less" looms and other devices that improve the efficiency of winding and weaving, and of new equipment for producing non-woven fabric;
- computer-assisted garment design;
- numerically directed cutters, including laser cutters, that reduce waste when patterns are cut from cloth and make it possible to produce comparatively small batches of patterns economically;
- automatic sewing systems that can assemble components (like sleeves or trouser legs) using robotic handlers;
- price code scanners that enable retailers to improve inventory control and reordering.

While each of these innovations can, and have, increased productivity in individual businesses, their most important contribution may appear in the way they can be tied together to build a system for delivering apparel to consumers that is more efficient *taken* as a *whole.*

Improved information flows and responsive batch production are key to what the industry calls a "Quick Response" strategy. The key is holding inventories low and avoiding overstocking while still ensuring that retailers stock what customers want to buy. Accomplishing this will require fundamental changes in the way information flows between the different components of the fiber-textile-apparel-retail chain, and an associated revolution in the style of production. In many ways, the institutional difficulties that must be confronted in implementing such a system pose a greater barrier than the technical problems.

Efficient transportation will also play a key role. Currently, it can take up to 2 months for a product to get from an apparel plant to the sales floor. Initial experiments with Quick Response have shortened this time span considerably, using United Parcel Service for rapid deliveries.[145] Textile suppliers are now able to communicate with large apparel companies with such precision that apparel firms can obtain reliable information about the time and size of delivery, as well as the color and location of fabric within a truck. This permits apparel producers to integrate deliveries closely into their plans, and allows them to avoid costly and lengthy inventories of materials delivered. The Levi Strauss Co. estimates that their new communication system by *itself* saves as much as 10 cents per square yard of material.[146]

The system-wide productivity gains made possible by new communication technologies and flexible production technologies are difficult to measure using conventional methods. There is a certain irony in this, since the consumer obviously measures the performance directly in the price and characteristics of products offered for sale. The dilemma of measurement lies partly in the fact that the productivity of individual businesses may actually appear to decline while the productivity of the system as a whole increases. It is possible to describe the areas where system-wide benefits can be expected even when it is difficult to develop precise measurements:

- The enormous inventories carried by textile mills, apparel manufacturers, and retailers can be reduced. On average, it takes roughly 65 weeks for fiber to move from a manufacturing plant to the customer's hand. The material is in processing for only 15 out of these 65 weeks; the remaining 50 weeks are spent in inventory.[147] The cost of this inventory alone represents

145 Kurt Salmon Associates, Inc., "Crafted With Pride in U.S.A. council, Inc., Quick Response Program Report," June 11, 1986.

146 R.E. Cotton, "QR's Bottom Line," *Apparel Industry Magazine,* July 1986, pp. 26-31.

147 Sig Scheier, "QR to Consumer Demand Vital, Hinerfeld Warns," Daily News Record, Oct. 9, 1985, p. 11.

6.4 percent of retail sales. With good management, it should be possible to reduce inventories by 25 to 50 percent.[148] Proper inventory control can increase sales per square foot, ensuring that the assortment on the selling floor matches proven market demand for styles, colors, and sizes.

- It should be possible to reduce incidents of forced markdowns that result from orders for goods that fail to sell as expected. Forced markdowns have grown by 50 percent during the past decade, and the National Mass Retail Institute estimates that total losses may be as high as 15 percent of retail sales.[149] Forecasting failures are due in large part to the long, 65 week cycle (requiring that most initial orders for seasonal products be placed more than a year before the products are sold). With Quick Response it may be possible to reduce initial order times to 2 or 3 months, and reorder cycle times to a few weeks. Accordingly, the need for long range, imprecise forecasting is greatly reduced.
- Tightly integrated networks can result in cost savings in situations where business is lost because a customer cannot find apparel in the desired style or size when the store is out of stock. Quick Response systems permit smaller initial orders, allowing stores to reorder more of a product that proves popular. The product can then be in stock at full price during the selling season.

  Estimating the magnitude of "stock out" losses is a difficult task, since many consumers who fail to find what they want simply leave a retail store without registering their disappointment. Industry estimates suggest that losses from stockouts are about 8 percent of apparel sales,[150] though field experiments with Quick Response systems suggest that this may be an underestimate. Quick Response reordering systems for sales of basic men's slacks have increased inventory turnover at the astonishing rate of 30 percent, with a comparable increase in gross margins on inventory.[151] A stock count in an experimental installation indicated that while 29 percent of items checked were out of stock before the program began, only 17 percent were out of stock after the Quick Response system was initiated. Retail stores can offer a greater variety of products without a significant increase in inventory through the ability to replenish stocks quickly.
- Responsive networks can also reduce costs and paperwork associated with such overhead operations as billing, invoicing, and inventory controls. Improved information flows and standardized reporting systems can greatly reduce handling and processing costs, such as quality control audits, hanging and premarking of merchandise, and time spent handling and counting deliveries. Perhaps most importantly, four networks that link different parts of the fiber-to-finished product chain more effectively have been created within the last 2 years: the Fabric and Supplier Linkage Council (FASLINC), the Textile and Apparel Linkage Council (TALC), the Sundries and Apparel Findings Council (SAFLINC), and The Voluntary Interindustry Communications Standards (WCS).
- Finally, productivity gains can be realized within the apparel production facility through the use of off-the-shelf equipment, and better management practices can facilitate integration with the overall system. Moving away from the "progressive bundle" system—a process driven by repetition of standardized tasks, which may have been cost-effective in an environment where response time and inventory control was not critical—to a modern "unit production" system can reduce processing times of 4 to 6 weeks to 1 or 2 days.[152] Computer-controlled cutting techniques can reduce material losses by 2 to 3 percent and can take 1 to 2 weeks out of planning, while reducing the number of parts that are cut simultaneously by 30 to 50 percent.[153]

A conservative estimate of the savings that can be realized from a relatively straightforward implementation of Quick Response technologies indicates that the industry could have saved $12.5 billion in 1984.[154] The cost of apparel could be reduced by one-

[148] Robert M. Frazier, "Quick Response," presentation made at DUPAATCH, Sept. 13, 1985.

[149] Ibid.

[150] Ibid.

[151] "Quick Response Pilot Program Update," Crafted *Wisth Pride,* Jan. 1987.

152 R.E. Cotton, op. cit., footnote 146.

153 Frazier, op. cit., footnote 148.

154 Peter N. Butenhoff, "U.S. Apparel Competitiveness," paper Presented to OTA by E.I. du Pont de Nemours & Co., June 1986.

eighth. These savings are realized by the system acting as a whole, and would not be possible through improvements occurring only in component businesses.

Most of the savings result from better matching of production to patterns of consumer purchasing because it would allow re-ordering popular items. Inventory costs could be reduced or merchants could maintain a wider selection of items by simply keeping fewer of each style and size in stock at any given time. All of this, of course, depends on close integration of all parts of the design and planning cycle. It requires flexibility in the production of cloth, flexibility in apparel assembly, and flexibility in the transportation network. It also requires relatively short-batch runs.

Where could the technology lead? There appears to be no technical reason why the planning/production cycle could not be reduced to a few days for a wide range of fabrics and designs. Computer displays capable of combining real images of an individual with a synthetic image of different kinds of clothing are already in experimental use in expensive retail outlets. In principle, these systems could be combined with a file maintained on the individual's measurements, producing clothing tailor-made to individual specifications. Assuming rapid delivery services, the garment could be available in 2 to 3 days.

Highly responsive networks are likely to be built largely of comparatively small establishments connected together by a well managed communication and transportation system. It is not at all obvious that these systems would operate more or less efficiently given greater horizontal or vertical integration of management. The standards, agreed protocols, and flexible contracting arrangements may well be preferred to a formal bureaucratic management scheme. A considerable amount of experimentation will be needed before a preferred management strategy emerges.

EDUCATION[155]

Prospects

The Nation's educational enterprises appear to be on the edge of a major reform. There may be no area where changing patterns of demand and the challenges of new technology are creating greater pressure for change. Real economic growth depends as never before on the skills of people in a wide range of occupations. The essential elements of flexibility and adaptability depend not only on knowledge of a particular skill, but on the ability to identify opportunities, to work together, and to acquire new skills efficiently. At the same time, new technology makes it possible to think about major changes in the productivity of learning. Technology has created an unprecedented power to bring practical problems into the classroom environment, adapt instruction to individual needs, and integrate teaching and learning into the work environment so that information and instruction is available when and where it is most essential.

Taken together, the need for change and the power of the new technology can reshape the way instruction is delivered, where it is delivered, and when it is delivered in a person's career. As in all of the other cases examined in this analysis, the network of activities that produce education in the United States are unlikely to show real productivity gains unless basic changes are made in the way the system operates as a whole.

The choices in education are particularly critical and stark:

- A system could be developed that makes learning more efficient and more fun, and that allows teachers to spend more time as tutors and coaches and less in routine tasks. Education could be tailored to individual styles of learning and adapted to strengths and weaknesses in a person's talents and background. instruction could be available throughout a person's career, empowering individuals to adapt and grow in a dynamic economy.
- A system could be developed that would lead to greater centralization, mechanical and imper-

155 Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Education," sector study, Washington, DC, 1987.

sonal instruction, and uniformity imposed by a perception of scale economies. National regulations could choke individualism, and the dominance of a small number of product suppliers could limit real choice and flexibility. Rigid control could be maintained over a student's course of instruction.

Increased use of capital equipment could lead to major changes in the structure of the Nation's educational system. The process of education could become separated into more differentiated components, coming to resemble other information-intensive enterprises. The development and maintenance of hardware and software for education and training could become an important specialty, and a variety of other specialties could develop. The size and location of institutions could change if technology allows decentralization without sacrificing quality. Instructional activities could be integrated more formally into all business enterprises.

Unlike many other production networks, the future structure of the Nation's educational establishment is primarily the responsibility of public decisions. Some way must be found to combine the need for enterprise and diversity with the need to find resources adequate to the major development efforts that will be needed.

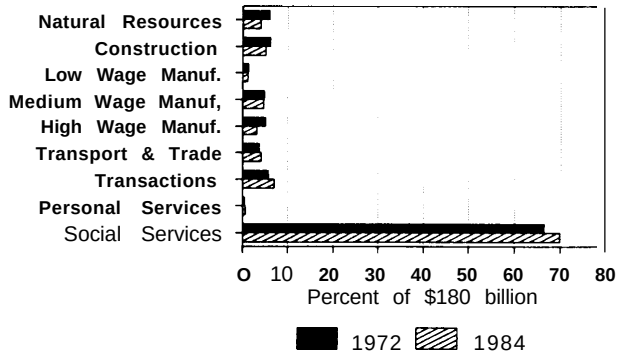
Structure and Performance

The network of operations leading to educational services remains astonishingly unchanged by the forces that have reshaped other parts of the economy engaged in the transfer of information. Personnel costs—primarily for teachers—and the cost of buying and operating buildings constitute about three-quarters of all costs related to business activity associated with the Education amenity (see figure 6-8).

Intermediate Demand for Education

The value of a well-educated and well-trained work force is probably the most important input purchased by most businesses, but this input is virtually impossible to measure.[156] During the 1970s, when comparatively well educated members of the baby boom generation were entering the work force and replacing people with lower levels of education, there was some speculation that America had overinvested in education. This argument held that education served primarily to help get preference in hiring but did little to actually contribute to performance once on the job.[157] Given the problems of measurement, such disputes are difficult to resolve with precision. Recent data demonstrate strong links between education, income, and an ability to avoid unemployment (see ch. 11).

Figure 6-8.-Value-Added To Meet Demand for Education ($180 billion* in 1984)



● Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

American businesses are making heavy investments in education. The total cost of corporate training is probably in the range of $30 billion to $200 billion (see notes to table 3-26). Precise levels are impossible to gauge, since the vast majority of employee learning comes from watching peers, reading manuals, and other informal routes.[158] Unfortunately, as with investment in research, investment in training is often reduced when it may be needed most—when business cycles turn down.[159]

156 Several attempts have been made in this area. Among the first were T.W. Schultz, Investing in *Human* Capital (New York, NY: The Free Press, 1971); G. Becker, *Human Capita/* (Chicago, IL: University of Chicago Press, 1975); and T.W. Schultz, Investing *in People: The Economics of Population Quality* (Berkeley, CA: University of California Press, 1981).

157 I. Berg, Education *and Jobs: The Great Training Robbery* (New York, NY: Prager, 1970); A. Weiss, "A Sorting-Cum Learning Model of Education," *Journal of Political Economy,* June 1983, pp. 420-442; and R.B. Freeman, *The Over-Educated American (New* York, NY: Academic Press, 1976).

158 one estimate suggests that informal training represents *80* to *90* percent of job related training. See S. Lusterman, *Trends in Corporate Education and Training(New* York, NY: The Conference Board, 1985),

159 M. Meyerson and R. Zemsky, *Training's Policies: Public and Private Reinforcement for the American Economy,* (Philadelphia, PA: University of Pennsylvania Press, 1985), cited in F.D. Fisher, "Redefining Training: An American Perspective," presented to the "Computer Assisted Approaches to Training, Foundations of Industry's Future" conference, May 25, 1987, Lugano, Switzerland.

Few firms have any clear view of what their real training costs are. The costs of staff training maybe included as general administration expenses, rather than as "training" or "education." Even where training costs are identified separately they may include only teaching and equipment costs, rather than the costs of an employee's time and other factors that may be much greater than training costs measured directly. The life insurance industry was recently astonished to find that it costs an average of $125,000 to place an agent in the field—the Massachusetts Mutual Life Insurance Company for example, pays trainees during the full 2 to 3 years it took them to be self-supporting through commissions even though, on average, only one out of four entrants managed to become an agent. [160]

The Federal government also invests heavily in training. About 20 percent of the active military is either being taught or engaged in teaching.[161] The U.S. Department of Defense spent $13.4 billion on training in 1984, providing the equivalent of 250,000 full-time students. The Office of Personnel Management estimates that more than 500,000 students per year are trained elsewhere in the Federal government (not a full-time equivalent estimate) at a cost of about $371 million, excluding the wages of the employees being instructed.[162]

While the costs of training are difficult to measure, it is even more difficult to measure the losses resulting from inadequate training. There is obviously a high social cost when adults are unemployed or underemployed because of inadequate training.[163] Direct costs are also large. Chrysler Corporation estimates that it saved $1.3 million by training workers about the dangers of hazardous substances in the workplace.[164] Poor training may have been a contributing factor in the Three Mile Island disaster.[165] Nearly one-quarter of Army and Air Force budgets go for maintenance. These two services probably spend as much to maintain as to purchase electronic equipment. Largely because of poor training, between 9 and 32 percent of all person-hours spent in maintenance was wasted (depending on the type of maintenance problem), and between 4 and 43 percent of all parts removed as defective were not defective. 166

An even greater implied cost of poor training, of course, can result if a company's employees are not able to adapt to new production systems or new management strategies. Defining the kinds of skills needed for this ability poses a tremendous challenge. Without greater effort to define them, however, there is a danger that the Nation's educational system will have difficulty aiming at the proper target. Any system forced to consider productivity gains is guided in powerful ways by what can be measured. A basic grasp of skills in language, mathematics, and science is clearly essential; box 6-B provides a hypothetical list of other qualitative skills likely to be critical for future employment opportunities.

New *Technologies and System Integration*

A number of new information technologies are being developed with the potential to change the nature of human communication in fundamental ways by vastly reducing the cost of storing, manipulating, and communicating information. It may soon be possible to manipulate images and sounds as easily as the printed word. This means being able to break some of the barriers of abstraction that separate "scholarship" from the world people see, hear, and understand. Modern information technology also has the power to give participants more active control and greater choice without necessarily adding significantly to costs.

These innovations can radically change the performance and structure of the educational system.

160 Life insurance Management Research Association, Hartford, CT, 1986, reported by Jane Curtis, Director of Field Development, Massachusetts Mutual Life Insurance Co., private communication, November 1987.

161 Sar A. Levitan and Karen Alderman, *Warriors at Work: The Volunteer Armed Forces* (Beverly Hills, CA: Sage, 1977).

162 Training Magazine, October 1984.

163 See U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment: Reemploying Displaced Adults,* OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986).

164 R. Neff, "Videos are Starring in More and More Training programs," *Business Week, No. 3015,* Sept. 7, 1987, p. 108.

165 The President's Commission on the Accident at Three *Mile* Island, "The Role of the Managing Utility and its Suppliers," staff report, Washington, DC, October 1979.

166 J. Orlansky and J. String, "The Performance of Maintenance Technicians on the Job," IDA paper P-1597, Institute for Defense Analysis, Alexandria, VA, 1981.

Box 6-B.–A New Set of Job Skills

Skills of Problem Recognition and Definition:
—recognizing a problem that is not clearly presented
—defining the problem in a way that permits clear analysis and action
—tolerating ambiguity

Handling Evidence:
—collecting and evaluating evidence
—working with insufficient information
—working with excessive information

Analytical Skills:
—brainstorming
—hypothesizing counter-arguments
—using analogies

Skills of Implementation:
—recognizing the limitation of available resources
—recognizing the feed-back of a proposed solution to the system
—the ability to recover from mistakes

Human Relations:
—negotiation and conflict resolution
—colaboration in problem solving

Learning Skills:
—the **ability to identify the limits** of your own knowledge
—the ability to ask pertinent questions
—the ability to penetrate poor documentation
—the ability to identify sources of information (documents and people)

SOURCE: Based largely on Francis D. Fisher, "Redefining Training: An American Perspective," presented to the 'Computer Assisted Approaches to Training, Foundations of Industry's Future" conference, May 25, 1987, Lugano, Switzerland.

The new generation of technologies, built on relatively inexpensive equipment, are qualitatively different from the film strips, television shows, and other techniques that have been used in limited ways to augment instruction in the past. They represent something fundamentally new. In principle, new information technologies can actively engage students or groups of students, and can shape instructional programs to idiosyncratic styles of learning, individual interests, and individual assets and strengths.

The Potential for Change

In order to understand the potential for change in a sector where productivity and structure have been static, it is necessary to begin by demonstrating that real change is attainable. The following discussion identifies several areas where progress is clearly possible.

Improved Understanding of the Learning Process.-There is much room for improvement in what we know about how learning takes place and about the efficiencies of different learning techniques for different people. This is true both for formal classroom instruction and for skills acquired informally at home or on the job. Informal learning on the job can take a variety of forms. It can mean a worker on a shop floor struggling with the documentation for a new machine tool, a secretary puzzling over new word processing software, or an employee in the "back office" of an insurance firm learning how to underwrite a new type of policy. Clearly, sailors, physicians, and carpenters approach problems in different ways. Each profession, however, combines formal knowledge and formal reasoning from abstract principles with experience and a reservoir of anecdotal evidence.

Failure to understand the learning process obviously means that there are few good guidelines for improving its productivity. Most formal training by corporations is practically identical to instruction delivered in standard classroom settings. But a sensitive understanding of learning pathologies is required to teach adults who enter retraining with an enormous variety of backgrounds. The efficiency of instruction is obviously improved where it is possible to discover what people do not know, and why they fail to understand important topics.

The new field of "learning pathology" is beginning to discover why students fail to understand some topics. Analyzing errors made by elementary school students, John Seeley Brown of Xerox found 150 distinguishable patterns of errors in simple subtraction problems. There is obvious merit in finding a way to focus on a student's real problem (perhaps a failure to understand the meaning of the number zero) rather than repeating an entire lesson.

Many basic issues in pedagogy would have needed to be addressed even if new demands had not been placed on the Nation's educational system. New technologies make the issues impossible to avoid.

Research on advanced computer designs may provide some serendipitous help. There are powerful connections between research on human learning and research on productive designs for information technology. The study of "artificial intelligence," for example, addresses basic problems in inference and tries to understand how "experts" think about complex problems. The results of such efforts are likely to influence strategies in teaching before they lead to significant changes in the design of computers.[167]

John Henry Martin's "Writing to Read" program, developed with IBM support, is a basic innovation in pedagogy stimulated in part by an analysis of how best to integrate computers into classrooms.[168] The basic idea is to shrink the distance between the rich tools of spoken language of pre-school children and the limits of written language that are available to students entering kindergarten or first grade. It is done by teaching students to decode spoken words using 44 phonemes, and then asking then to use these codes to write stories that use their entire vocabulary. The computer helps primarily by making it easier for students to form letters and by making the task more fun.

The **Ability To Teach Individuals, Not Aver=** ages.-Earlier discussions have provided examples of the way modern production equipment makes it easier to serve niche rather than mass markets. The American system of education, however, continues to deliver a relatively uniform level of instruction with a rigidly proscribed conception of what is to be learned.

New technology can help teachers design programs of instruction suited to individual tastes and talents. Some students learn faster from text, some from lectures, some from repetition, and some from visualizations or examples drawn from areas of personal interest. Technology would not, of course, sub stitute for a good teacher—but it could provide an invaluable tool for helping teachers tailor instruction to the needs and talents of many individual students. This is obviously difficult in a standard classroom setting. It is possible to imagine an "expert system" of the kind available to physicians, designed to diagnose the source of a specific learning problem or to construct a program of instruction most likely to interest a specific student.

Technology also has the potential to monitor the progress of individual students in a way that rivals the attention of an individual tutor. It can ensure that the pace of instruction does not outpace a student's understanding. Using a series of built-in tests, it can ensure that each student has mastered a subject before being forced onward. It can also permit the student to take "curiosity excursions" into areas that may not be of general interest. And it can facilitate a detailed diagnosis of the sources of a student's misunderstanding and habitual errors.

From the student's perspective, the power inherent in new technology means more control over the pace of learning and less repetition of things already understood. It means not being embarrassed to acknowledge what is not understood. It means the freedom to have fun by building a program of instruction around a set of interesting problems. It means the security of building new knowledge on a base of information that is familiar.

The Ability To Simulate.—There is also much to be learned about the role that games play in learning. In traditional societies, where children could see much of the work done by adults, play mimicked life. Skills learned in playing at hunting or at household tasks translated gracefully into the practical world. In contrast, contemporary society places enormous barriers between the world of adults and the world of children. Few children have a clear sense of their parent's work life; classrooms seldom provide good tools for understanding the work environment. In principle, simulations can mix work with instruction and instruction with play in entirely new ways. The interest and entertainment of an interactive spy adventure can be used to teach map reading, geometry, or chemistry.

After centuries without practical alternatives, people have become accustomed to think about communication in terms of words and books. New visual technologies, however, can provide a means of communication that is in many areas more powerful than language. Leaving aside the question of whether language and grammar are an integral part of human intelligence, it is obvious that words in a geography

167 w. K. Estes and A. Newell, *Research Briefings, 1983,* briefing panel on Cognitive Science and Artificial Intelligence, Committee on Science, Engineering and Public Policy, National Academy of Sciences (Washington, DC: National Academy Press, 1983).

168 John Henry Martin, *Writing to Read (New* York, NY: Warner Books, 1986), Alice Kelly and Sophia Kelly, private communication.

text are a poor substitute for a visit to Brazil and that a flight manual is a poor substitute for a turn at the controls of an F-16. The emerging generation of information technology has been used to create flight simulators capable of producing an experience so faithful to reality that even seasoned pilots are able to benefit. This power to imitate reality can have a helpful role in education.

Much of modern history is available to us in the form of film or television images and sound recordings. These images and sound recordings are arguably responsible for some of our history. The radio clearly helped Franklin D. Roosevelt gain the presidency and strongly influenced the way he communicated with the public as president. Television helped Ronald Reagan in much the same way. Yet the capacity for managing images (particularly moving images) has never been developed with the same facility as that for sorting and analyzing words on paper. Pictures are a "second class" resource in any library. Technology now emerging can change this status by making it nearly as easy to retrieve, make, and modify images as words. Simulations can also help where student motivation depends on a belief that knowledge will provide power for solving real problems.

Simulations can take a wide variety of forms:

- The Defense Department has a long and successful record of using simulations to train pilots, tank drivers, TOW missile crews, maintenance personnel, and a variety of other specialists. [169]
- Goodyear successfully used simulators to train repair crews in the use of multimeters and oscilloscopes. [170]
- Simulators have been used to train welders who use light-pens instead of welding rods. This equipment can determine such factors as the beginning and ending points of the weld made and whether the simulated rod is moved at the proper rate.
- Medical technicians can be trained to identify tumors on displays of actual Magnetic Resonance Imagery (MRI) or Computer Assisted Tomography (CAT) images, Simulations can reproduce medical emergencies demanding immediate responses and analysis for physicians in emergency rooms.
- Insurance sales personnel can be confronted with a variety of potential customers using video representations of consumer types. The agents' responses are videotaped and played back so that students can judge their own responses and ask for expert advice. This experience is so compelling that many students elect to drop out rather than continue training. There are obvious advantages for both the student and the company if the student's incompatibility with the job is identified early.[171]
- A new data compression technology developed by the David Sarnoff Laboratory allows a student to simulate a walk through the Mayan city of Palenque using data stored on a standard 5" compact disk. The system permits the student to go virtually anywhere at the site, stop, and look around a 360 degree vista. It is possible to take pictures of sites for further study.[172]
- A variety of chemistry laboratory experiments have been simulated using video representations which could be controlled by computer.[173] These simulations are obviously safer than actual experiments.

Communication v. Isolation in the Learning Process. -In the abstract, computer-based instruction often evokes an image of passive, hollow-eyed students staring at flickering screens in great windowless halls, or small cubicles. This would be a disastrous outcome given the desirability of allowing students to learn from each other and work as parts of dynamic groups. While it is obviously possible to use computer-based instruction in nightmarish ways, new instructional technology appears to open op-

169 J. Orlansky, "The Cost Effectiveness of Military Training," in *Proceedings of the Symposium on the Military Value and Cost-*Effectiveness of Training, NATO headquarters, Defense Research Group on the Defense Applications of Research (DS/A/DR(85)167), Brussels, Belgium, January 1985 (evaluations of the program are reported later in this section).

170 S. Holzberger, "Goodyear Tire Compares ITC ACTIV With Traditional Training Methods," *The Videodisc Monitor,* March 1987, pp. *14-15.*

171 Jane Curtis, op. cit., footnote 160.

172 The system was developed with the assistance of the Bank Street College. Mike Tinker, David Sarnoff Laboratory, private communication, December 1987.

173 Oone test found no measurable difference between the test results of students working with the computer system alone and students in real laboratories. See S.G. Smith, L.L Jones, and M.L Waugh, "Production and Evaluation of Interactive Videodisc Lessons in Laboratory Instruction," *Journal of Computer-Based Instruction, vol. 13, No. 4,* pp. 117-121, autumn 1986.

portunities for mixing isolated study with work as a part of a group. It seems possible to use the equipment to improve communication on many levels: between teachers and students, among students, between schools and the body of knowledge and specialized expertise outside of the school system, between schools and parents, and among the teachers within the system.

Giving students an avenue to participate in different kinds of social groups is an important contribution of the school system.[174] The ability to collaborate with individuals having different kinds of skills and different viewpoints, to perform effectively as part of a heterogeneous society in a variety of circumstances, and to debate effectively about a disputed point are all important skills both on and off the job. The goal may be one of having students "learning around the computer" as opposed to learning with the computer: "when several students work together at a computer display two things happen: learning becomes more of a social activity than in the usual school environment and an impressive amount of peer learning takes place. ''175

The potential for teaching groups has obvious advantages in corporate and government training programs, but documentation is rare. The U.S. Army has found that one of the most valuable uses of its new M-1 tank simulator was the way it permitted a team of tanks to practice working together in difficult tactical situations. It is critical that members of a tank battalion learn to work together, to trust each other, and to adapt quickly in unexpected situations, since group maneuvers are extraordinarily difficult to undertake in the field.

Informal observation suggests that adults can be made more comfortable in reentering a classroom environment if they are paired with another person of similar skills. The partners can help each other, and if baffled are less restrained in asking the instructor a question. They assume that if their confusion is shared, they should not be ashamed.[176]

It is fair to ask whether the new strategies proposed for "learning around a computer" represent an improvement over the existing system. Appearances to the contrary, the standard classroom instructional techniques prove to be highly impersonal. Collaboration is discouraged in virtually all cases-it is often considered "cheating." Companies have complained that formal instruction methods result in students who want to solve problems in isolation, unable to benefit from group discussions. [177]

One observer has found that "88 percent of all instructional time in the high school involves only two methods: telling, lecturing, and questioning the total group and monitoring some form of seatwork."[178] Similarly, about 70 percent of the student's time in elementary school was spent listening to lectures; the figures were 77 percent in junior high and 76 percent in high school. The lectures in this investigation typically presumed student passivity. Barely 5 percent of instructional time was designed to create student anticipation of a need to respond, and when a response was required it was often a simple recall of fact. The overall strategy of interaction was summarized as follows:

> **First,** the vehicle for teaching and learning is the total group. Second, the teacher is the strategic, pivotal figure in this group. Third, the norms governing the group derive primarily from what is required to maintain the teacher's strategic role. Fourth, the emotional tone is neither harsh and punitive nor warm and joyful; it might be described more accurately as flat. '79

The passivity just described scarcely portrays a situation characterized by a great deal of communication within the schools themselves, either between students and teachers or among peer groups of students or teachers. There is also is little communication with the world beyond the school door, or between schools and parents. And with the exception of major universities, most teaching material does not reflect recent progress in research. Available mechanisms for upgrading teachers' skills are seldom adequate; textbooks remain the main source of substantive communication with external research, yet texts for courses taught in primary and

[174] George Leonard, Education *and Ecstasy* (Berkeley, CA: North Atlantic, 1987).
[175] Margaret Cox, cited in "Education," op. cit., footnote 155.
[176] Virginia Nelms, IfBM Corp., private communication, December 1987.
[177] w. Glasser, Control Theory (New York, NY: Harper & Row, 1985); and Judith Resnick, "Learning in School and Out," *The* Educational *Researcher, vol. 16, No. 9,* December 1987.
[178] John I. Goodlad, A Place Called *School (New* York, NY: McGraw Hill, 1984), p. 12.
[179] Ibid.

secondary schools are infrequently revised. School texts in Texas, for example, despite being updated every eight years, have become out-dated in important areas.[180] While universities are designed to forge good links between instructors and advanced research, these links are growing weaker. Some faculty members are forced to take on heavy teaching loads in order to keep college costs down, while others are engaging in proprietary research that cannot be shared with students.

Improving Productivity

The challenge of measuring productivity in education was discussed at some length in chapter 3. The difficulty results from both an inability to measure net investments in education from the many contributing sources, and an inability to develop acceptable measures of educational quality. Problems of measurement are, if anything, becoming more difficult. The flexible skills now needed by the U.S. work force defy easy documentation.

Many attempts have been made to link student performance to teaching salaries or per-capita spending. Correlations are difficult to establish when adjustments are made to correct for the income and educational levels of families.[181] Students with strong family support for education have tended to do well in virtually all circumstances; [182] strong correlations have also been found between the performance of a teacher's students and subjective evaluations of the teacher made by supervisors. [183]

The failure to find correlations between spending and progress obviously does not mean that greater investment cannot lead to greater results. It does suggest that much remains to be learned about the efficiency of different strategies for teaching and learning.

Against this background, estimates of improvements in educational productivity must be treated with caution. Quantitative estimates of productivity change resulting from new technology are particularly difficult to document because of the poverty of information on experimental programs. Experiments with documented results have typically used primitive computer-based teaching technologies that were available only for short periods of time—none involved the kinds of fundamental reform outlined above. Many systems entering the market have not been well designed or tested. As a result, it is not clear whether tests of effectiveness are measuring the quality of the software or the inherent power of the new technology.

In spite of these limitations, significant improvements in teaching and learning can be documented.[184] An exhaustive survey of Defense Department experience with training is summarized in table 6-5. Information on flight training is well documented because of its long history. The Defense Department has spent over $1.2 billion on flight trainers; the cost of operating a trainer ranges from 2 percent of flight costs for a B-52G to 50 percent for an AH-ls. The amount of savings depends heavily on what is being learned. For some types of training, simulators have proven useless or worse. In other cases, an hour on a trainer was twice as effective as an hour in actual flight. [185] On average, each hour spent on a simulator was equal to 0.48 hours of actual flying experience. The simulator, of course, could provide experiences that would be dangerous or even impossible to rehearse in a real aircraft.

Extensive studies are also available for computer assisted training in maintenance. In 12 of 13 examinations, students trained with a simulator achieved the same or better test scores than those trained with actual equipment. Students using simulators, however, required 20 to 50 percent less time to learn their tasks, and 90 percent of the students questioned preferred simulators to conventional training (instructors gave mixed reviews).[186]

A key question, of course, is whether the quality of the training received is as good as conventional methods. Are the topics learned retained longer? Are they more easily transferred to practical applications? Such questions are virtually impossible to address

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180 See Billy Reagan and Patricia Sturdivant in "Education," Op. cit., footnote 155.

181 E. Hanushek, "Throwing Money at Schools," *Journal Of Policy Analysis Management,* fall 1981, pp. 19-41.

182 J.S. Coleman et al., *Equality of Education/ Opportunity* (Washington, DC: U.S. Government Printing Office, 1966).

183 D. Armor et al., *Analysis of the School Preferred Reading program in Selected Los Angeles Schools* (Santa Monica, CA: The Rand Corporation, 1976).

184 See *Technology and Structural Unemployment,* op. cit., footnote 163; and Richard E. Clark, "Reconsidering Research on Learning from Media," *Review of Educational Research,* winter 1983, vol. 53, No. 4, pp. 445-459.

185 J. Orlansky, op. cit., footnote 169, P. 9.

186 Ibid., p. 28.

Table 6=5.—Measured Effects of Defense Department Flight Simulators, Computer-Based Instruction, and Maintenance Simulators

Factor	Flight simulators	Maintenance simulators	Computer-based instruction
Student time savings	50 percent	20-50 percent	30 percent
Acquisition cost savings	30-65 percent	20-60 percent	NA
Operating cost savings	8 percent	50 percent	NA
Life-cycle cost savings	65 percent	40 percent	NA
Amortization	2 years	4 years	NA

NA = not applicable.

SOURCE: J. Orlansky, "The Cost Effectiveness of Military Train ing," in Proceedings *of the Symposium on the Military Value and Cost-Effectiveness of Training,* NATO headquarters, Defense Research Group on the Defense Applications of Research, (DS/A/DR(65)167), Brussels, Belgium, January 1965.

with existing data. Evaluations conducted in the past decade necessarily combine results of well designed and poorly designed programs (by comparison, imagine an evaluation of automobiles conducted in 1910). The available evidence, however, seems to suggest that computer based instruction is at least as good, if not slightly better, than conventional methods ranked on the basis of quality (most evidence is anecdotal, and is limited by the fact that the state-of-the-art in instructional software and hardware is changing at breathtaking rates):

- A review of 24 evaluations of educational technology found that new technologies could cut learning time by 25 percent, as compared to conventional instruction; 5 of the 24 were in basic education and the rest in specialized technical subjects.[187]
- The Adult Basic Literacy Education (ABLE) in Central Piedmont Community College in Charlotte, NC, found that the average student needed only 21 hours to gain one grade level in reading and math, whereas the average time had been 150 hours.
- A review of 28 studies of newly introduced videodisk training systems used by corporations and the military found that achievement was improved in over 60 percent of the cases reported, user attitudes were improved in 56 percent, and training time was reduced in 80 percent (20 percent of the cases reported mixed results).[188]
- IBM's "Writing to Read" program, described earlier, has consistently shown an ability to increase learning rates of kindergartners and first graders. An advanced system designed to teach literacy skills to adults has consistently shown an ability to increase measured grade levels by 2 to 3 years during a 20-week course.[189]
- A number of specific applications have proven highly effective: Federal Express has reported a 50 percent increase in the learning rates of agents in training; McDonnell Aircraft has reported a 33 percent increase in efficiency in teaching computer-aided design drafting; and the University of West Florida has reported a 24 percent increase in speed in teaching new health workers.[190] The Massachusetts Mutual Life Insurance Company's system claims to have reduced learning time by as much as 50 percent.[191]

There is also clear evidence that students enjoy the experience of working with technology in the course of learning. For example, in a basic education program in Great Neck, NY, 98 percent of the students said that they enjoyed studying with a computer and were particularly impressed by the clear explanations and immediate feedback provided. Three-quarters said that they would like to spend more time on a computer while only 5 percent asked for less.[192]

187 Chen-Lin, C. Kulik, James A. Kulick, and Barbara J. Shwalb, "Effectiveness of Computer-Based Adult Education," Center for Research on Learning and Teaching, University of Michigan, presentation to the American Educational Research Association meeting, Chicago, IL, March 1985.

188 J. Bosco, "An Analysis of Evaluations of Interactive Video," *Educational Technology,* May 1986, pp. 7-17.

189 "Literacy Program is a Revelation for Non-Reading Adults," *Technological Horizons in Education, vol. 15, No. 2,* September 1987. pp. 81-82.

190 J.W. Nelson, "Evaluation Data on Successful Applications of Technology Based Training Systems," U.S. Department of Commerce, Washington, DC, October 1987.

191 v. Nelms, op. cit., footnote 176.

192 Norman D. Kurland & Associates, "The Role of Technology in the Education, Training, and Retraining of Adult Workers," contract report prepared for the Office of Technology Assessment, Oct. 5, 1984.

Structural Effects

Most enterprises where information technology has the potential to make significant changes in productivity have found that the potential cannot be achieved without basic changes in management. Education is unlikely to be an exception. A real improvement in the productivity of the Nation's educational system will require asking basic, blunt questions about what is being learned, how it is being learned, when it is being learned, where it is being learned, and why it is being learned. There is growing sentiment that a fundamental review is in order (see box 6-C). At issue is whether institutional mechanisms needed to conduct research and to test results are adequate.

Few educational institutions are organized in a way that allows real attention to productivity improvement. School decisions are often highly fragmented and politicized. School systems typically resist proposals for reform; university instructors are among the most recalcitrant. This has both healthy and unhealthy results. Teachers tend rightly to be skeptical about any new "grand scheme" for reform—particularly so in reacting to claims that technology can provide good pedagogy. They require convincing proof that schemes proposed for using technology can be an advantage for their students.[193] Skepticism is justified since, as might be expected, some of the computer based instruction packages offered initially were poorly designed.

The incentive systems governing educational investment in private industry are fundamentally different from those governing education in traditional school settings. In a corporate setting or the military, where students are paid for their time as well as the teacher, it is obvious that the productivity of a student's time is worth more than teacher productivity by a factor roughly equal to the student-teacher ratio. In most public school settings, however, the perceived cost of a student's time is zero. Organizations that pay the salaries of both teachers and students appear to be far more likely to investigate innovations in teaching techniques than those for whom the cost of a student's time is zero.

In fact, privately funded training has changed the structure of education more rapidly than public institutions. Interviews with 218 large U.S. companies have found that 60 percent of these firms have made significant changes in training methods and training technology over the past decade.[194] They reported extensive use of television, computers, live videotape playback, and satellite television networks. One company used satellites to tie 67 of its locations together so that training in sales and servicing could take place without extensive travel. The Defense De-

Box 6-C.–Some Views on Technology and Structural Change in Education

"The introduction of a substantial amount of information technology into conventional classrooms as they operate today will, in my belief, produce only marginal improvement in educational effectiveness. It will take substantial institutional changes to bring about the improvement that we are seeking; the school environment must be altered to provide motivation, self-paced progress, and integration of out-of-school learning experiences. It will also be necessary for parents to develop new expectations for their children's education."

Lewis Branscomb
Harvard University
(formerly of IBM)

"1 am **persuaded that the existing K-12 school bureaucracy is having its last hurrah, and that designing new models** for education that serve all Americans is of vital importance. A fundamental shift in the nature of the education system is not only possible, but essential. "

Theodore Sizer
Chairman, Department of Education
Brown University

"If technology cannot be used to bring about a radical restructuring of how we teach, then its effect will be nil,"

"We should not flinch from the fact that we are talking about a revolution in education. "

Richard M. Cyert, President
Carnegie Mellon University

SOURCE: U .% Congress, Office of Technology Assessment, "Education," sector study, Washington, DC, 1987

[193] See Education, op. cit., footnote 155.

194 Seymour Lusterman, op. cit., footnote 158, p. v.

partment has also invested heavily in advanced instructional technology.[195]

Measured by the zeal with which they are purchasing computers, public school systems appear to be moving rapidly toward greater use of instructional technology. While barely 10 percent of U.S. elementary schools had computers in 1981, more than 90 percent had them in 1986. Nearly all American high schools had computers in 1986. The schools now average one computer for every 37 students.[196]

It is more difficult to determine whether the new information technology is leading to significant changes in the productivity of learning and teaching. Most equipment appears to be used in relatively straightforward ways. Less than one-fifth of all applications are used for purposes other than "drill and practice," teaching computer programming, or word processing.[197]

Scale **and** Scope. -Will the increased use of capital equipment make schools and training more like an undifferentiated commodity, or more closely adapted to individual needs? Both directions are technically possible. Properly used, the technology could be used to encourage questioning and to explore alternatives. A system that frees teachers to spend more time with individual students could make teaching and learning less and not more mechanical. The high cost of producing software systems for new technologies could, however, lead to the replacement of individual authors and teaching styles with teaching approaches developed by bureaucracies or large teams of people.[198] There is also a risk that inflexible and unimaginative software could crush the spirit of inquiry and reward unquestioning obedience to the "one right way" accepted by a machine.

Judgments about whether technology will increase or decrease flexibility and change the desirable scale of educational operations are made difficult because so little is known about the flexibility of the existing system of education. At first blush, the system appears to be highly decentralized and capable of tailoring instruction to individual needs. But closer examination seems to indicate that decentralization has created stunning uniformity. A survey of 1,000 classrooms across the United States found unexpected uniformity in what was being taught, in how it was being taught, and in the texts from which it was taught.[199] From most points of view, there has been relatively little change over time in the nature or content of instruction in elementary and secondary schools, or in the time spent in school. This uniformity is encouraged by the use of textbooks written to satisfy a broad market.

If the decentralized system is to be effective in providing instruction tailored to individuals, teachers must have some way to keep track of the progress of individual students, and to identify individual sources of confusion and individual receptivity to different pedagogical strategies. Teachers report that it is virtually impossible to accomplish this for 20 to 40 students at a time in a classroom, or for 100 or more students during a day. The pacing of instruction must be keyed to the teacher's sense of the average progress of a class—something that is inevitably a crude compromise even for the most talented instructor. One observer has argued that most teachers stop when from 30 to 50 percent of a class understand about 80 percent of what they need to know to master a subject.[200] As a result, few students completely understand the subject before they are forced to go forward. Similarly, another study has indicated that an average of 20 percent of the students experienced difficulty understanding the teacher's comments or directions at any given time.[201]

No comparable study has been conducted in colleges and universities. College and university education in the United States is also highly decentralized, But few institutions give any systematic thought to the productivity of teaching and learning on their own campuses, and the use of technol-

195 See J. Orlansky, op. cit., footnote 169. Defense Department budget documents cited in this report, which appeared in January of 1985, show $39 million spent for "education and training," $87 million for "human factors," $38 million for "manpower and training," and $227 million for "simulation and training devices. "

196 U.S. Congress, Office of Technology Assessment, "Trends and Status of Computers in Schools: Use in Chapter 1 Programs and Use with Limited English Proficient Students," staff paper, Washington, DC, Mar. 13, 1987.

197 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University, cited in Ibid.

198 Arthur Wirth, "The Violation of People at Work in Schools," working paper, Department of Education, Washington University, St. Louis, MO, 1987.

199 John I. Goodlad, op. cit., footnote 178, p. 112.

200 Benjamin Bloom, cited in John 1. Goodlad, op. cit., footnote 178.

201 John I. Goodlad, op. cit., footnote 178.

ogy is idiosyncratic. Many colleges employ technology not to individualize instruction but to permit students in "mass" lecture courses to see the instructor.

Geography.—New technology has the potential to reshape the landscape of education, primarily combining geographic decentralization with an increase in the scale or scope of management. The effect is more likely to be felt by universities offering courses for large numbers of students on one campus, but it could also reduce the size of large high schools or other facilities in urban areas. The key is an ability to deliver specialized courses without having a specialized instructor, library, and experimental apparatus at each location. It is clearly easier for people to continue to receive training and instruction throughout their careers if they do not need to physically move to where instruction is available.

Closed broadcast technology is already being used to deliver instruction to people watching in rooms supplied by their employers. Stanford University has a program where students in a corporate facility watch a videotaped lecture in the presence of another employee of the firm with professional credentials in the subject area, who answers questions during and after the viewing. The TAGER system in Dallas/Fort Worth ties together 17 universities with a closed-circuit network for graduate level engineering business and computer science. Rio Salado Community College in Phoenix, Arizona has no classrooms; the college uses public and commercial television, cable television, audio teleconferencing, slow-scan television, and videotape.[202]

The emerging generation of technology could obviously do more. It might even permit major universities to offer courses and degrees throughout the Nation, through what amounted to small franchise operations tied to the central campus by advanced communication systems.[203] While the prestige associated with ivy covered campuses will undoubtedly always play a major role in helping people make important contacts and obtain attractive jobs, the role of colleges in delivering practical training may well change. It is possible that improved teaching will make it possible to give people what amounts to a good junior-level training by the time they reach 18. It is also possible that employers will be increasingly interested in specialized training, with the understanding that new employees will need to be retrained every few years.

Under these circumstances, is it the role of a university to give the student an initial specialty with the assumption that subsequent specialties will be taught by employers? Should universities screen out individuals likely to fail in different occupations? Is the university's central role one of providing students with basic intellectual tools and a capacity for understanding their culture?

[202] R.J. Lewis, "Research Questions on the Impact of Computers in the Classroom," The Ontario Institute for Studies in Education, University of Toronto, Toronto, Canada, 1983.

[203] F. D. Fisher, "Higher Education Circa 2005," *Change,* January/February 1987, pp. 40-45.

PERSONAL BUSINESS AND COMMUNICATION[204]

Structure and Performance

The telephone, banking, insurance, legal, accounting, and other businesses that deliver communication and business services to individuals and businesses are at the core of the much discussed "information economy," and are most obviously affected by the capabilities of new information technology. Powerful and inexpensive computers, high-speed communication made possible by relatively low-cost microwave systems, satellite links, fiber optics, high-speed switches, the ability to store massive volumes of data in ways that permit easy access, and a variety of other new kinds of equipment have the potential to fundamentally reshape industries whose primary function was routine paper-pushing. They also have the potential to create entirely new lines of business in areas where services need to be tailored to specific applications. Indeed, a rise in consumer, government, and business demand for these "transactional" products has been responsible for a significant share of U.S. economic growth during the past 15 years.

[204] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Communications and Information," sector study, Washington, DC, 1987,

This technical revolution has, in turn, undermined (some would say overwhelmed) the regulatory apparatus that evolved over decades around older systems. Such pressures, combined with new attitudes toward market freedom, have weakened or eliminated many ancient regulatory constraints on telephone services, insurance, and banking. Intense competition for long-distance telephone service has replaced the heavily regulated AT&T monopoly. Insurance regulations implemented over generations for a wide range of purposes (primarily at the State level) are being reviewed and modified.[205] Taken together, changes in technology, demand, and regulation, and the intense competition engendered by these changes are in the process of revolutionizing some of the stodgiest enterprises in America—and some of the Nation's leading employers.

The rules governing the telecommunications and broadcasting industries have been radically reshaped by changes in regulatory policy during the past few years. The "Carterfone" decision, the "Modification of Final Judgment" (disbanding the Bell System), the Federal Communication Commission's deregulatory initiatives established in "Computer II," "Specialized Common Carrier," "Computer III," and other proceedings, have facilitated competition, innovation, and entry.

Clearly the cast of characters has expanded considerably. In addition to the components of the old Bell system, independent telephone companies, and other common carriers, financial service providers such as credit card companies, banks, brokerage firms, and insurance companies have invested heavily in national and international communication systems. Some of these enterprises have expanded their networks to offer investor and financial information for remote users. Citicorp is a leader in this kind of private networking by financial institutions. It uses two Westar V satellite transponders, is a digital termination system vendor, and plans to offer both information and network services nationally.

Railroads, as well as electric and gas utility companies, have long utilized private microwave facilities for command and control of their network operations. They own or control extensive rights-of-way, especially railroads with rights-of-way that connect urban centers and have been active in providing rights-of-way, by sale or joint venture for the construction of intercity coaxial or fiber optic transmission systems. GTE Sprint, the third largest interexchange common carrier, developed from Southern Pacific's private microwave network.

As the information processing and data transmission industries merge, integration by many manufacturers into at least some transmission markets is taking place. Mitel and American Satellite have formed a joint venture, EMX Telecom, to provide end-to-end telecommunications services. Finally many large firms are assessing the feasibility, for their private networks, of providing their own (Integrated Services Digital Network (ISDN) facilities–using T1 carrier circuits obtained from AT&T's competitors, satellite transponders, or excess capacity of other users' internal networks, rather than leasing lines from telephone companies.

While growing use of advanced computers and communication equipment has increased the capital invested by the network of businesses that delivers communication and business services such as legal help, financial services, insurance, and real estate, these businesses remain comparatively isolated from the rest of the economy. Of the value-added generated in serving consumer and government needs for the Personal Business and Communication amenity, 70 percent remains in the sector classified as Transactional Activities (see figure 6-9).

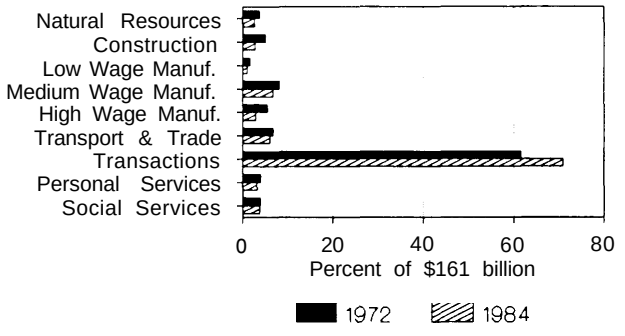
Information transactions are still dominated by human expenses and not equipment costs. The costs of a telephone call or a letter are irrelevant compared with the time spent preparing the material. The cost of using advanced databases is dominated by the personal costs needed from the producer to prepare the information and from the purchaser who retrieves and interprets it.

Prospects

Will all of the institutional shuffles just described result in real competition and flexibility in the Nation's information industry? The answer depends both on decisions made by regulatory authorities in

[205] Regulations in insurance cover consumer protection, licensing Of companies, restrictions on the types and quality of company investment, regulation of rates and advertising, limits on grounds for cancellation and non-renewal, provisions for minimum coverage, regulations on underwriting criteria, cost disclosures, unfair trade practices, and transactions between parent companies and affiliates.

Figure 6-9.-Value-Added To Meet Demand for Personal Business and Communication ($161 billion* in 1984)



•Constant 1980 dollars

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4)

the near future and on how formerly regulated companies survive the transition to competitive markets. Competition will also be heavily influenced by the way explicit and de *facto* standards are adopted throughout the industry. An open system, such as the architecture of the IBM personal computer and the MS-DOS operating system, clearly led to an explosion of hardware and software developments by firms of all sizes.

Regulation

Message Service and Information Processing.—The creation and maintenance of communication monopolies "regulated in the public interest" could be justified by arguing that the economies of scale possible under monopoly regulation can lead to prices so much lower than those likely to be available in a competitive environment that they offset any consumer advantage that may exist under competition. But while regulation can avoid a situation where a monopoly exploits its privileged position through excessive prices, it can seldom provide adequate incentives for the adoption of new, cost-saving products or services.

The logic of telephone regulation was undermined by technology in two principle ways. First, the clear "natural monopoly" advantages of economies of scale were undermined by the explosion of competing technologies for the provision of long-distance service. Relatively inexpensive microwave and satellite relay systems can now, for example, be operated by a variety of companies at prices competitive with AT&T. For some markets there is a debate about whether the provision of local area service, now restricted to the Bell Operating Companies, has also lost monopoly advantages.

Second, the logic of regulation collapsed because of the growing overlap between the provision of standard telephone service and activities involving the storage and processing of information where regulation was clearly unjustified. It became necessary to make painful distinctions between different types of advanced telephone equipment and a variety of "value-added" services such as computing and data services, protocol conversion (converting the language of one computer to a form where it can be interpreted by another), electronic mail, database services, electronic publishing, voice store and forward (a sophisticated "phone answering machine" that can store voice messages and permits intended recipients an opportunity to call into the system at any time and hear sorted messages), and alarm and telemetry services. It proved difficult to find a way to make adequate use of the Bell System Operating Companies' (components of the old AT&T system) enormous sophistication without allowing them to take unfair advantage of their regulated access to local telephone markets. At present, the Bell operating companies are allowed to provide some kinds of electronic information services (message storing and electronic advertising), but are still prevented from providing most long-distance services and making telephone equipment.[206]

The series of mergers and acquisitions in telecommunications has resulted in part from the decision to dismember the Bell system along market lines, instead of simply separating communication markets into a series of vertically integrated regional firms. It is possible that the latter choice would have resulted in more effective competition in end-to-end services and perhaps better international competition. The point may ultimately be moot, however, as an increasingly unregulated market moves rapidly to create end-to-end competition despite the original regulatory intent, and as restrictions on the Bell Operating Companies are removed.

[206] C. Sims, "Most Regulatory Curbs on 7 'Baby Bells' Kept," *The New York Times,* Sept. 11, 1987, p. D1.

By the end of this decade, the current telecommunications marketplace is likely to consist of select "tiers." A central sector will consist of fully integrated end-to-end suppliers who primarily employ their own facilities to offer users a complete "package" of services. Among the firms most likely to be major players in this sector are AT&T, the seven Bell Regional Holding Companies, and perhaps some of their larger competitors (MCI, GTE, United, and Continental). A second tier would consist of equipment and carriers' "carriers." For instance, the fiber optic networks will provide strong competition to AT&T in the carriers' carrier sector, while Northern Telecom and IBM/Rolm will be similarly successful in the network equipment and large private branch exchange (PBX) area. Industry "shakeouts" are currently underway in long-distance markets as well as in large switching equipment (especially digital), PBXs, and key sets.

Even within such an oligopolistic market structure, there will be many opportunities for firms to apply organizational advantages of large scale production and vertical integration. However, in each of the supply tiers, there may be problems of discrimination, cross-subsidy, and access to technical information. In sub-markets, particularly those of limited population and traffic density, supply will retain many monopolistic attributes. In central core areas, supply bottlenecks in local exchanges for basic service will remain and provide the most attractive area for application of structural separation. In other words, while the new regulatory environment for communications has opened opportunities for competition in areas traditionally controlled as "natural monopolies," it is likely that the industry will continue to be dominated by enormous firms that yield only a small fraction of their total business to companies serving relatively small niche markets.

In spite of rapid automation of many activities, the costs of human time and talent should continue to dominate the production recipe in communication and data processing. Given that a way is found to restructure management to take advantage of new information technology and overcome cultural barriers to new communication modes, this blunt fact will remain a significant economic constraint on the way new communication technologies are used. For example, the cost of message delivery primarily involves the time invested by the individuals sending and receiving the information.[207] Labor costs associated with management and the time spent reviewing data, for example, represent nearly 90 percent of the cost of database services, with capital costs of communication and computer equipment and the cost of communication services representing the rest (see table 6-6).

The cost of preparing a first-class letter in an ordinary business may be on the order of $20 to $30, while the cost of postage is only 25 cents. The cost of an average 10-minute long-distance business telephone call is $16.24, of which $8.97 is for communication services and the rest is the result of employee time.

Figure 6-10 illustrates the relationship between price and demand for different kinds of point-to-point communication services. Demand for mail has proven to be extremely inelastic, since mail delivered per person has continued to increase sharply even though real prices have increased.[208] The elasticity of demand for telephone service is negative. Long distance telephone demand appears to increase by 10 percent when prices fall by 10 percent (a price elasticity of-1 .0), while local telephone usage seems to increase by only 2 percent when prices fall by 10 percent (a price elasticity of -0.2).[209]

Broadcasting and Print Media.—Regulation of broadcasting and print media are discussed in the next section, which describes the network of busi-

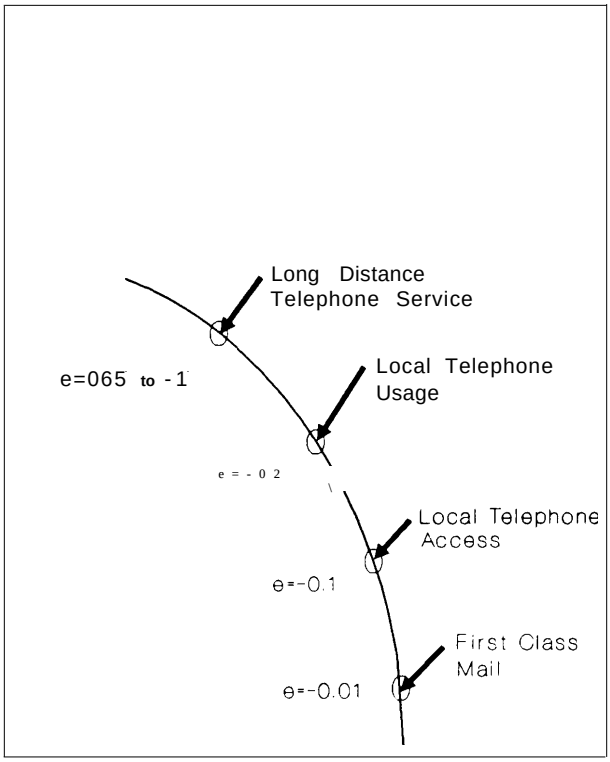
[207] 1. de Sola Pool et al., "Communications Flows—A Census in the United States and Japan," North Holland, Amsterdam, 1984.
[208] "Communications and Information," op. cit., footnote 204.
[209] Lester D. Taylor, *Telecommunications* Demand: *A Survey and a Critique* (Cambridge, MA: Ballinger Publishing), 1980.

Table 6-6.—Production Costs for a Database

Cost area	Percent of costs
Sales, marketing, and administration	45
Content acquisition	40-45
Data communications equipment, front-end processors, database storage	6
Communication services (local exchange, long-distance value added net or public switched)	7-8

SOURCE: Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone industry,* prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), based on Link Resources Corp., "Pricing and Marketing On-line Information Services, " 1988, pp. 17-18; Dun & Bradstreet; and other sources.

Figure 6-10.-Hypothetical Relationship Between Price and Quality of Message Services (e=price elasticity)



SOURCE: U.S. Congress, Office of Technology Assessment "Communications and Information," sector study, Washington, DC, 1987.

ness that provide the Recreation and Leisure amenity for Americans.

Information Processing. -Telecommunications and computers have traditionally been considered separate industries, partly because of legal constraints. AT&T was not permitted to sell or produce computers for anything other than use within the Bell system.[210] As telecommunications networks are, in an important sense, computers (or at least a primary example of the application of computers), this ban did not stop AT&T from emerging as a major presence in the industry.

The regulation of telecommunications also prevented computer companies from competing in the telecommunications arena. Nevertheless, the growth of distributed processing and computer terminals in the 1970s made computer communication dependent on facilities supplied by the regulated public telephone network. Frustration with certain parts of this system led to the development of alternative special networks for data even as the proliferation of computers in the office and factory led to the creation, by computer companies and others, of "Local Area Networks." Computer and telecommunications firms began to overlap and compete. There is growing demand for systems that combine voice and data communication.

The rules have changed. AT&T and IBM will compete in each other's traditional markets because regulators removed restrictions on AT&T's computer activities after the court-ordered Modification of Final Judgment,[211] and because several decades of regulatory changes have allowed more competition in the provision of communications equipment and services.

Intermediate Demand

Table 6-7 provides a crude review of the relationship between intermediate and final demand for information services in 1977. While the data are old (1977 was the last year for which detailed statistics are available on intermediate demand in the categories shown), the table provides some indication of the relationship between intermediate and final demand for information.

Some communication services have actually decreased as a fraction of all "intermediate demand" in the U.S. economy during the past few decades, in part because prices have fallen in many areas. Paper and publishing was 5.1 percent of all intermediate inputs in 1963 and 4.1 percent in 1977. Communication services decreased from 1.8 percent to 1.6 percent of intermediate demand during the same period.

Network Components

Insurance.[212]-Three features of the emerging U.S. insurance system deserve attention:

[210] This decree was issued in an antitrust case brought by the Justice Department to constrain this communications giant from dominating the nascent computer industry.

[211] This occurred as of Jan. 1, 1984, and technically, modified the 1956 Consent Decree.

[212] Much of this discussion is drawn from Barbara Baran, "Technological Innovation and Regulation: The Transformation of Regulation in the Insurance Industry," contract report prepared for the Office of Technology Assessment, Washington, DC, January 1985.

Table 6=7.—Demand for Information and Data Processing by Major User Group

	Percentages			
	Intermediate demand	Personal consumption	Government demand	Total use (1977 $ millions)
Communication services:				
Communications (except radio and TV broadcasting)	44	42	5	52,868
U.S. Post Office	72	21	7	12,935
Data processing servlces:				
Computer and data processing services	83	0	16	15,394
Information goods:				
Printing and publishing	52	32	12	31,849

NOTE: Percentages may not add to 100%, since total use also includes inventory changes and consumption of producer durable. These are quite small for the categories indicated here.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "1977 Input/Output Tables," Survey of *Current Business,* **vol. 64, No. 5, May 1964.**

1. a radical change in the way work is organized within the enterprises, which eliminates most routine clerical tasks and routine professional tasks (such as standard underwriting decisions);
2. fierce competition in areas traditionally enjoying protection for generations; and
3. a radical change in the geography of production, as some functions (such as central records keeping) become highly centralized and others (such as routine underwriting) are decentralized.

The increased range of services made possible by new technology are forcing consumers to ask penetrating questions about exactly what they are purchasing, and what features of the services they value. And the technology, combined with the new pressures of competition, is forcing producers to ask unprecedented questions about precisely how these services are provided. This has resulted in subtle but fundamental changes in how these enterprises go about delivering their services and frequently in basic changes in management practices and job descriptions throughout the enterprise.

Work Organization.—Insurance firms were among the first companies to make heavy use of computers, and at one time owned 16 percent of IBM's installed capacity. The computers were, however, used almost entirely to automate "back office" work like record entry and bookkeeping, and had virtually no influence on the way most work was managed. The industry is now undergoing a second and much more radical kind of automation, in which basic management strategies are coming under intense scrutiny and virtually every operation will be redefined. The primary motivations are product diversification, error reduction, improvements in service quality and speed, and the quest to be competitive; both the primary and second phases of this process are described in box 6-D.

There has been enormous institutional resistance to the implementation of such programs. The link to sales has proved to be particularly difficult to automate. Traditionally, most insurance was marketed through one of four mechanisms: independent agents and brokers, exclusive or "captive" agents, salaried employees or direct writers, or direct mail. Captive agencies and direct writers have moved to adopt new technology, while independents are moving comparatively slowly. Competitive pressure may force independents to move at a faster rate.

Competition.—Changing regulations, growing consumer sophistication, and new technology have combined to introduce ferocious competition in areas where the word was once considered impolite. Competition has grown around price, product innovation, and service quality. The "bundled" services of whole life, for example, are rapidly being separated into components: investment, risk-protection, and services. Unprecedented competition has emerged both in the provision of low-cost insurance "commodities," and in sophisticated financial and investment services. Banks and investment houses now offer money market funds and other services that often provide more attractive investment opportunities than life insurance. Between 1976 and 1980 premiums fell more than at any time since the turn of the century, and processing times have been greatly reduced.

Similar patterns prevail in commercial insurance. Corporate risk managers have increasingly compared the merits of commercial insurance with the merits of self-insurance or captive insurance companies that may provide equivalent risk coverage more efficiently. The "bundled" functions of property/casualty insur-

Box 6-D.—The First Phases of Automation

The first stage: Issuing a check

If a check had to be issued, first it was typed by a typist; then another clerical verified the amount; a third person audited the claim to insure that the doctor charged appropriately for the service provided; a fourth person actually "burst" the check [took apart the carbons]; and a fifth then put the check through the signing machine. Including supervisory oversight, between six and seven people were involved in this one procedure alone. Claims needed to be typed and retyped. Reports of several kinds needed to be prepared for accounting and management functions. Multiple copies of records prepared to update several files.

Back office "electronic sweatshops"

Data entry was typically separated in organizational terms, and often geographically, from middle management. Typically working in huge, open offices, workers were grouped by function: underwriters, raters, typists, file clerks. Clerical work was machine paced, and in some cases lines of text typed per hour were monitored by machine. Turnover rates for employees was very high. In 1979, a text processing center for Travelers insurance operated around the clock and turned out an average of 6,000 letters each week. It employed 35 typists, 11 of whom transcribed full-time and 27 part-time on a 6 PM to 10 PM shift each night or at peak hours to maintain a goal of 24 hour turnaround.

The second stage: Group Health underwriting

1. Commodity-like products (standard life insurance policies, group health, automobile and homeowner insurance, etc.) are offered through streamlined channels in which a highly skilled clerical employee or salesperson,[1] enters data directly into terminals linked to central data-processing facilities via the IIR/ACCORD network, IBM's IVANS [Insurance Value Added Network], or some other network. Skilled clericals, rather than professional claims examiners, are thus able to handle routine claims and order necessary inspection reports. Once entered, data that formerly needed to be typed and retyped need only be entered once. Information for claims, accounting and management reports, and other functions can be obtained from centralized data files that are automatically updated. The new systems are able to identify exceptional cases, presenting them to underwriters and claims examiners trained to handle cases that fit no standard role. The process is called "underwriting by exception," "pigeon-hole underwriting," or "computer assisted underwriting." A survey taken in the early 1980s found that firms making relatively straightforward investments in the automation of agent functions averaged a 70 percent increase in output in the first two years compared, with only a 17 percent increase in firms not investing in automation.[2] Regional offices can thereby be reshaped into multi-activity teams that combine typists, raters, and underwriters. Some 71 percent of property/casualty firms and 44 percent of life companies surveyed indicated that they instituted this form of organization.

2. Most forms of commercial insurance, and services for high-income individuals interested in sophisticated financial packages, cannot be automated in this way. Commercial insurance has necessarily continued to emphasize flexibility; highly sophisticated, tailored products; specialized services such as loss control engineering; and rapid claims handling. Competition in services of this kind requires agents close to the market. Computers are used to assist highly skilled professionals to tailor products for customers rapidly and to work through a variety of options.

SOURCE: **The Office, 1979, cited** in Barbara Baran, "Technological Innovation and Regulation: The Transformation of Regulation in the Insurance Industry, " contract report prepared for the Office of **Technology Assessment, Washington, DC, January 1985.**

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[1] Jobs created in systems like the one described here are so new that they have complex and obviously synthetic titles, like "para-technical, " "professional-clerical," "para-professional," or "skilled clerical."

[2] *National Underwriter,* May **13, 1983,** pp. **18-22**

ance (e.g., fire, workmen's compensation, auto liability, and auto physical damage) became unbundled and sold separately.

While regulations still place severe limits on interstate bank offerings and bank entry into insurance, the rules are constantly under assault. Many States now allow life insurers, for example, the option to forgo inefficient subsidiary systems as well as the freedom to widen their investment portfolios. Many insurance companies have been acquired outright by industrial or financial institutions such as ITT and American Express.

Scale and Scope.—Most of these changes work to the advantage of large firms. This encourages both horizontal and vertical integration of functions in firms that can take maximum advantage of the dynamic performance of new automation.

About 4,900 licensed insurance companies were operating in the United States in 1983, of which 60 percent were in property/casualty and 40 percent in life insurance. But a wave of mergers and acquisitions that started in the 1960s has begun to consolidate this diverse industry with astonishing speed. A recent study estimated that within the next two decades virtually all insurance would end up in the hands of 10 to 15 percent of companies now operating.[213] Large, multinational firms and increased government health coverage are expected to dominate most of the industry, leaving a modest number of market niches to specialty companies.[214] Concentration is likely to be particularly dramatic in the area of sales, where parent firms will attempt to invoke tighter control over distribution systems. Some concentration will also take place by integrating insurance and financial services. Citicorp, for example, has set up an insurance operation, and Prudential holdings now include a brokerage house and a bank.

Geography.–All of these developments have had contradictory effects on the geography of work. Some functions, like data storage and large-volume "number crunching," enjoy economies of scale or require integration of data files and are growing increasingly centralized. Others, typically those that benefit from rapid and flexible response to consumers, are becoming more decentralized.

In the 1960s, most large insurance organizations maintained numerous regional and branch offices as well as a network of field or sales offices. During the late 1960s and 1970s, many regional network offices were extended to "get operations closer to agents and customers." The second wave of automation technology, however, allowed data entry and other work to be accomplished efficiently in the field. This made it possible to return the functions of regional offices to home offices.

Large operations, primarily clerical, can now be located virtually anywhere. Under the first phase of automation (again see box 6-D) only highly standardized "back office" functions could be located in suburbs remote from corporate headquarters. But with new communication networks, entire integrated production and service facilities can be "burbed" to make them more accessible to a desirable labor pool: suburban housewives.

This centralizing force is offset by technology allowing much data entry, printing, and processing to be accomplished at the point of data generation—often in field offices. The portion of centralized data processing requiring large numbers of entry clerks and operators accomplishing routine tasks is often eliminated by work done on field terminals.

Banking.-Banking has undergone a similar transformation. Regulations that prevent interstate banking, and in States like Colorado even prevent branch banking, still impose major barriers to system integration and greatly restrict geographic centralization of operations. There is, however, enough flexibility in the system to permit a good deal of change. Pressures are being brought to bear to encourage further loosening of Federal and State controls on banking, while at the same time aggressive banks like Citicorp are finding increasingly sophisticated methods of exploiting loopholes in existing statutes. As a result, consumers face more choice, freedom, and risk than they have in the past.

Banks are making extensive use of electronic fund transfer systems that substitute for paperwork. The largest is the Fedwire system, operated by the 12

[213] Life Office Management Association, "Branch Office Clerical Salary Survey, " and "Management Salary Survey, " 1982, cited in B. Baran, op. cit., footnote 212.

[214] "Entering the 21st Century: An Insurance Forecast," focus on property/casualty, Florida Association of Insurance Agents, p. 161, cited in B. Baran, op. cit., footnote 212.

Federal reserve banks, which serves 7,000 institutions. Over $600 billion is transferred over the Fedwire and other systems on an average day. Electronic fund transfers have certain economies of scale and have been used primarily by larger banks, but the availability of low-cost microcomputers now allows many small banks to participate.

Automation can also make the sales portion of banking much more efficient. As in the case of insurance, sales appear to be splitting into two parts: the processing of relatively routine transactions (such as checking accounts, credit cards), and highly specialized financial services for affluent individuals and institutions. Automation can both facilitate the handling of the routine "commodity-like" functions and expand the capability and flexibility of the specialized services.

Automatic teller machines have begun to displace many routine teller functions. There were 13,000 automatic tellers operating in 1973 and 59,000 in 1985. By 1990, the industry expects to have 100,000 systems in place—some operating as national networks.

Consumer interest in new banking technologies has been limited. Home banking through personal computers enjoys only a small fraction of individual banking transactions, and sales have not moved much beyond the experimental stage. Barriers to further growth include the cost of home terminal equipment, software that is not completely transparent to non-experts, and relatively inflexible services.[215] A related innovation involves "point-of-sale" systems that permit retailers to debit a person's account automatically at the time of sale; a statewide, multi-bank system with 3,500 terminals is now being tested in Florida. Point-of-sales systems benefit the retailer by eliminating bad checks and invalid credit cards, and by speeding transfer of funds to the retailer's account. The advantages to the retailer are so great that it will probably be necessary to give customers a price break to encourage the use of point-of-sale systems.

It is not difficult to imagine a system that could allow an individual to pay bills, provide detailed analyses of an account's status at any time, sort transactions in ways that facilitate analysis of expenses like utility bills, or document payments for tax purposes. None of these functions would require communication speeds above those available through standard, unconditioned telephone lines.

Advertising. —The advertising industry occupies a unique role in the U.S. economy. Advertising is purchased almost entirely by businesses, and therefore must be considered an "intermediate" product, even though its primary function is to deliver information to consumers. Measured in direct terms, the industry contributes about 2 percent of value-added in the U.S. economy. Its influence over the structure of the U.S. economy is undoubtedly much greater than this modest figure would imply. Much of the information reaching consumers about products arrives through advertising. The firms purchasing advertising obviously feel that their money helps shape public response to their products.

The performance of the advertising industry is crucial to the operation of a dynamic economy. Interviews with producers suggest that an inability to advertise in a limited market is a greater barrier than an inability to produce a large number of specialized items at a competitive price. In the absence of specialist advertisers, therefore, there would be a bias towards mass rather than batch production.

Several recent changes, however, appear responsive to the new interest in identifying and reaching relatively small niche markets. The first involves the structure of the advertising industry itself. While recent movement appears to be away from the specialized creative "boutiques" and toward greater integration, the integrated firms operate on a very different philosophy than that of the "full service" agencies of the 1950s. The present firms seem to be largely orchestrating the activities of a number of subsidiaries that specialize in a narrowly defined areas. Some of these subsidiaries were profitable enterprises simply purchased by larger firms with a relatively well-defined shopping list. In other cases, larger firms explicitly set out to establish creative subsidiaries to meet client needs.

Activities in larger firms include regional and product specialization, and specialization in such strategies as direct marketing, public relations, sales promotion, package design, and corporate presentations. This range of activities allows them to combine the advantages of quasi-autonomous subsidiaries with the economies of "scope" deriving from unified man-

[215] Lucille S. Mayne, "Technological Change and competition in American Banking," *Technovation*, vol. 4, 1986, pp. 67-83.

agement. In principle, the "flexible oligopoly" that seems to be emerging permits the industry to bring a large variety of clients into contact with a large variety of audiences.

Secondly, changes in technology may make it easier to target relatively small audiences. Cable television, specialized magazines, and other new channels have fragmented advertising markets. Direct marketing has benefited from widespread use of credit cards and efficient local trucking.

Advanced printing machines can tailor magazine advertising to regional and perhaps eventually to individual interests. Envelope-stuffing devices are driven by computers, and mailings are carefully tailored and targetted to known individual profiles. The next logical step is finding a way to permit a customer more direct access to product information from a home information system. Systems like CompuServe, the home and corporate computer network, have a limited, if not devoted, clientele that consists largely of relatively affluent computer buffs, but it is not clear how such a system could be used for effective advertising. A customer going to a terminal with a particular purchasing decision in mind is different from one browsing through a magazine or watching a television show where product information is not the objective of reading or watching.

Geography.—While national agencies are still centered in New York and Los Angeles, there has been dramatic growth in firms located in such rapidly growing urban centers as Orlando, Dallas, and Houston. Some are independent, but many are subsidiaries of major firms that offer a full line of support. They provide intimate relationships with local producers and local markets.

When McCann-Erickson followed Standard Oil of New Jersey overseas in the 1920s, it was the exception and not the rule. But today, like so many other activities in the economy, the advertising industry has become an international enterprise. Advertising firms are playing a critical role in helping U.S. firms find markets abroad; an ability to maintain an effective foreign marketing operation has become almost essential for holding domestic accounts. Equally, U.S. firms have played a major role in helping foreign producers find a home in the U.S. markets. The sale of skilled services in marketing greatly facilitates international trade, with all the benefits and liabilities that this entails.

Understanding international market and having adequate access to foreign media has often involved combining forces with foreign firms. Of the 22 largest advertising agencies in the United States, 17 are multinationals. More than half of the income of several of the Nation's largest agencies currently comes from foreign revenues.

Information Processing and Communication

The patterns of institutional and geographic integration and disintegration described for virtually every sector of the economy depend critically on low cost information transmission and processing. It has, of course, always been difficult to identify the way information is "used" as an input by businesses, since information costs are typically buried in other accounts. But as businesses take more care to examine their consumption of information, it turns out that the cost of information is large, and consists mainly of hiring people and purchasing software rather than hardware costs.

Information-related investments continue to grow rapidly, if more slowly than computer manufacturers once anticipated. By 1986, information technology investments represented more than 30 percent of all business investment. Investments in information equipment did not slow significantly during the severe recessions of 1980 and 1982/83, when other capital spending was sharply reduced. While investments in hardware, such as computers and advanced telephone systems, are relatively easy to identify as "information" investments, most firms soon discover that the real costs of information processing are much larger than direct hardware costs.

Box 6-E provides a rough taxonomy of the functions provided by communications and information industries. The clean divisions illustrated in the table are not easy to identify in actual practice. Much data gathering, for example, now occurs automatically through the use of computers disguised as cash registers, automatic tellers, and terminals in travel agencies. Many "information" businesses provide more than one of these functions (some bundle them all as a service), but increasingly the traditional information industries are finding themselves suppliers

Box 6-E.–Components of the U.S. Communication Industry: Common Carriage and Substitute Services

Exchange service providers
- Bell operating companies
- Independent telephone companies
- Other common carriers
  - —Cellular
  - —Digital termination service
  - —Others

Interexchange carriers
- AT&T communications
- Satellite carriers
- International record carriers
- Bell operating companies
- Independent telephone companies

Carriers' carriers

Resellers, value-added networks, and information service providers

Media entities in common carridge (cable and broadcast companies)

Private and user-oriented systems
- Private systems
  - —Local and wide area networks
  - —Private microwave systems
  - —PBX systems
  - —Electronic funds transfer systems, etc.
- Shared Tenant Services
  - –Smart buildings
  - —Teleports

SOURCE: U S Congress, Office of Technology Assessment "Communications and Information," sector study, Washington, DC, 1987.

or components in elaborate networks owned and operated by businesses that do not consider themselves in the information business—witness the extensive communication networks in firms ranging from McDonalds to Citicorp to Federal Express.

Until recently, the industry was governed by several paradigms:

- A clean distinction existed between message service communications (mail, telephone, and telegraph), broadcast communications (radio, television, and publishing), and data processing.
- New technologies in communication would *add to* rather than *substitute for* existing channels.
- Point-to-point communication would need to be regulated because of the "natural monopoly" of the enterprises.
- Regulation would ensure that the telephone service was inexpensive and almost completely undifferentiated—the richest and the poorest Americans would have the same handset and talk over the same phone lines.
- With the exception of publishing, broadcast enterprises would need to be heavily regulated because of the scarcity of available broadcast frequencies.
- With the exception of books, broadcast information would be heavily (or entirely) sponsored by advertising rather than purchased by the ultimate consumer.
- Data processing would be a specialized service delivered primarily to industries with sophisticated information processing requirements.

Today, virtually all of these paradigms are collapsing under the combined pressures of a radically changed regulatory environment and new technology, which have created competition in price and quality of service and rapid differentiation of communication services. "Plain Old Telephone Service" (known in the industry as POTS) is rapidly becoming archaic, as both individual and business consumers are confronted with a variety of long-distance services (i.e., services offering different qualitative characteristics for the rate at which data can be transmitted, privately-owned switching systems within firms, and packet switching that can combine many relatively low-data rate services). Technology has introduced an enormous range of message delivery services competing with the market once limited by POTS, mail, and Telex/telegraph. Express mail, paging services, electronic mail, high-speed facsimile systems, and voice store and forward systems have opened a range of new market niches at a variety of prices (see table 6-8). The distinction between message and broadcast systems has become less distinct, since electronic message and voice forwarding systems can deliver messages from an individual to several different recipients simultaneously.

Acceptance of new technologies has been somewhat slower than expected, in part because the new communication techniques take time to insinuate themselves into the conventions of business in tradi-

tional organizations. The lack of an agreed communication standard has also presented problems.

Cellular radio and paging services are competing in markets once limited to mobile telephone, offshore radio, rural radio service, specialized mobile radio, air-ground radio telephone, and maritime mobile services. There were nearly 6 million pagers in use in 1986 and nationwide paging service is now available.[216]

Electronic mail is heavily used in manufacturing enterprises and large firms of all kinds. While only 17 percent of companies with sales less than $1 million used electronic mail, nearly 60 percent of firms with more than $1 billion in sales use electronic mail. The technology has the potential to replace much routine document and message transmission. As presently used, 55 percent of the information sent on electronic mail systems substitute for telephone calls, 10 percent for telex, and only 5 percent for first class mail, courier services, and other electronic transmission; 20 percent of the messages sent electronically appear to be new traffic generated by the technology.[217] Taken together, telex, facsimile, and electronic mail generated approximately $1.5 billion in revenues in 1984.[218]

It is difficult to estimate the extent to which electronic communication will substitute for print. At present, print is cheap, easy to transport, and offers the reader unmatched flexibility. But there is a high probability that some entirely new communication strategy may emerge. There is a growing market for electronic database services (e.g., Dow Jones and LEXIS) that substitute for conventional business information libraries or paper archives. The insurance, banking, and advertising networks described earlier maintain their own proprietary data banks. Manufacturing firms as well as architecture and engineering services are making increased use of drawings and specification files stored in electronic form.

Data communications still accounts for less than 10 percent of telephone company revenues, though data transmission is obviously a growing business. Approximately 13 million pages of information a day are sent through "packet switching" services that allow users to reduce telephone costs. The Federal government generates about 40 percent of this business.[219]

High-speed "dial up" packet switching from companies like Telenet, Tymnet, and Uninet has been available for some time and is used primarily for computer communications. The ISDN is an emerging concept for providing a standard for data and signaling over switched telephone circuits, which would evolve from existing international standards for digital voice communications. The International Organization for Standardization (ISO) is coordinating the work of 89 member nations on ISDN, while in the U.S. standards are being developed by the Consultative Committee on International Telephone and Telegraph (CCITT). As in the case of all standards, a premature choice can miss technical opportunities—but the lack of standardization can create such confusion that markets may materialize much more slowly than they should. Making no collective decision about standards does not mean that a standard will not be set. In the absence of a standard, a large public telephone company in Japan or Europe or a major corporation like IBM may set de-facto standards. AT&T, MCI, GTE, and each of the Bell Regional Holding Companies are presently conducting field trials of ISDN systems.[220] Japan and several European nations also have field trials underway.

Most high-speed channels require a "dedicated line" between senders and receivers, but advances in switching technology are now permitting what is called a "virtual private line" that allows a central office options for routing signals and can make more effective use of central office equipment. Advanced ISDN systems will permit users to select the kind of service required. They could, for example, purchase a high data rate line when massive data transmission rates are needed, and purchase lower speeds when these are needed.

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216 Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry*, prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), Table MB.2.

217 *EMMS: Electronic Mail and Micro Systems, vol. 10,* No. 5, Mar. 3, 1986, p. 3, cited in P. Huber, op. cit., footnote 216.

218 Robert Moran, The Eletronic *Mail Revolution."Implications for Users and Suppliers,* Business Communications Co., Inc., No. 63, May 1985.

219 P. Huber, op. cit., footnote 216.

220 John J. Keller, "Central Office Equipment Makers Preparing for Big Push," *Communications Week,* Mar. 17, 1986; and National Telecommunications and Information Administration, U.S. Department of Commerce, "Issues in Domestic Telecommunications: Directions for National Policy," NTIA Special Publication 85-16, Washington, DC, July 1985.

Techniques for purchasing data processing are becoming more complex as data processing costs of all kinds are dominated by the software and personnel operating the system (see table 6-8). In 1986, there were estimated to be about 3,000 databases, 1,400 producers, and 450 on-line services.[221] Demands for data are dominated by financial and credit services (see table 6-9).

Intermediate Demand for Information Processing.—Businesses use information services for a variety of functions, each of which lead to qualitatively different demands for products and services.

- Extremely large "number crunching" systems are required for an array of functions, including development of high-quality animations for film production, analysis of aerodynamic designs, weather forecasting, and the design of nuclear weapons. While most of these applications formerly were conducted in a "batch" mode submitted by the client to a computer center, applications are increasingly demanding "on-line" systems where an engineer or animator can view the results of a simulation immediately —often through a high-quality graphic representation.
- Process control systems, involving the operation of either a large chemical plant or an array of numerical machine tools, require fast communications and extremely high reliability.
- On-line processing for applications like banking, insurance, or airline reservations require communications, a connection with large blocks of data, high reliability, and functions like the blocking of files while updating occurs.
- Distributed processing is required for office functions like routine payroll and management information systems, word processing, and modest analytical efforts.

There is no effective way to guage the relative rates of growth of these functions.

[221] Link Resources Corp., "Electronic Information Industry Forecast," 1983, cited **in P. Huber, op. cit., footnote 216, p. 7.1.**

Table 6-8.—Cost to User of Message Services (cents per message, assuming 1,000 messages per month)

Cost area	Cents per message
In-house PC-based electronic mail	5-7
Service bureau	50-80
Voice storage and retrieval	9-20
Telex 350-760, teletex facsimile	24-143
Overnight courier	850-1,250

SOURCE: Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry,* **prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), Table EM 5.**

Table 6-9.—North American Electronic Information Industry Revenues in 1982 (millions of dollars)

Industry	Revenues
Financial	30.0
Credit	27.7
Legal	9.0
Economics & Econometrics	8.6
Scientific & Technical	6.5
News	3.4
Real Estate	2.7
Other	12.1

SOURCE: Link Resources Corp., "Electronic Information Industry Forecast," No. 4, 1983, cited in Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry,* **prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: US. Government Printing Office, January 1987), Table EM.5.**

New Technologies and System Integration

Given the complexity of the changes just described, it becomes difficult to predict changes in the recipe for delivering communication and business services and information processing. One feature of the production recipe is abundantly clear. While technology will vastly increase the productivity of many information processing functions, the personal costs (and the returns to capital in financial and real estate firms) are always likely to dominate this enterprise. The rising need for specialized services like communications system installation and maintenance, software preparation and maintenance, and other such work will increase inputs from a variety of information-related businesses. The cost of computers and communication equipment, however, is unlikely to dominate overall costs.

Some changes in the approach to the production of communication and information services can be readily identified:

- The telephone industry is examining the role of many "middle management" *functions* in much the same way as the insurance and banking industries. Services requiring human intervention (information, credit card calls, etc.) are being automated rapidly, and production meth-

ods for headsets and other equipment are being scrutinized.

- The distinction between electronic and standard publishing is narrowing rapidly as much text preparation, editorial work, layout, and document transmission is being undertaken electronically. Electronically stored data are transferred directly to printing machines, whose physical location can be chosen to reduce labor costs and delivery times.
- Computers have escaped from sanctuaries presided over by specialists and their power has been distributed widely throughout the businesses they serve, becoming integrated in the routine of ordinary office life. The spectacular decline in cost and increase in power of modern computer equipment is widely recognized.

Interestingly, the process by which computer instructions are created—the production of "software" —though a costly part of the process,[222] continues to bear greater resemblance to medieval craft work than to any 20th century form of employment. Attempts to devise methods for automating the production of software through the use of more transparent programming have proven extraordinarily difficult.

[222] Software costs represent 80 percent or more of the cost of computerized equipment in major enterprises like the insurance industry. The Defense Department spends nearly 80 percent of its data processing budget on software related services; see John W. Verity, "Empowering Programmers," *Datamation*, Aug. 8, 1986. Similarly, 42 percent of a group of experts in insurance indicated that software costs were the largest single barrier to the diffusion of information equipment in insurance while only 5.5 percent cited hardware costs; See B. Baran, op. cit., footnote 212, p. 57.

RECREATION AND LEISURE[223]

Prospects

America's recreation and leisure sector is one of enormous diversity. Its six major segments are defined in Box 6-F. The industry is being reshaped by new home entertainment technologies and changes in the regulations governing communications. The overall mix of home and away-from-home entertainment, though, has not changed significantly. If anything, electronic media are serving to stimulate interest in away-from-home activities rather than to substitute for them. Trade has had a major impact; foreign suppliers have all but eliminated the U.S. production of home electronic equipment and has made major inroads into sports equipment, recreational vehicles, and recreational clothing.

Looking to the future, several kinds of change in the structure of this system are possible:

- Technology can lead to a network of businesses that reduce barriers separating creative minds from interested audiences. This could happen because of both reductions in the cost of preparing high-quality paper, audio and video productions, and multimedia products and expansion in the number of channels through which such products can be delivered. The quality of illusion could be greatly increased. Information technology could give viewers more power to choose products tailored to their specific interest. New systems can provide alternatives to passive communication by offering fascinating opportunities for simulations and games. Improved communication channels can reduce some of the uncertainties of travel, and can increase interest in travel to more destinations in both urban areas and rural parks. Greater investment in education on geography, history, health, and the arts could work in the same direction.
- Foreign producers could increase their hold on the products used for recreation at home and away from home. Centralized control over the most powerful communication media, the convergence of publication and electronic communication, and the substitution of pay-per-view for regulated common carrier broadcasting could reduce diversity. High production costs could reduce real competition. Eroding investment in public recreation and park facilities and an inefficient transportation system could reduce choice in recreation for low-income families.

[223] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Recreation and Lesiure," sector study, Washington, DC, 1987.

Box 6-F.—The Major Segments of the Recreation and Leisure Industries

Media refers to recreation and leisure activities utilizing print, video, and electronic media. The products and services of the media segment can be divided into "hardware" such as television sets, books, home electronics equipment, and the like, and "software" such as TV programming, videogames, and even telephone conversations. The major providers of this segment are the publishing, television, and telecommunications industries, and home electronics manufacturing firms. One other industry is absolutely crucial to this segment—the advertising industry (described in the preceding section of this chapter), which is the central financial mechanism for the creation of television programming.

Arts and entertainment includes all away-from-home entertainment and cultural events. The products are the actual events themselves, as provided by the motion picture, professional sports, music, and other industries. Obviously, this segment is closely linked to the media segment described above, as these arts and entertainment activities are a major source of media programming.

Recreation refers to all outdoor leisure activity that requires the direct participation of individuals or groups, such as camping, sports, and visits to amusement parks. There are two basic categories—the equipment necessary to pursue a particular activity (for example, sporting goods) and the services that make participation possible (campgrounds, amusement parks, parks and recreation facilities, etc.).

Travel *and tourism* includes all activities related to leisure travel. Some typical products and services are lodging, transportation, and travel agent services.

Civic *participation* includes all religious, political, professional, and other civic activity that constitutes an important part of an individual's use of free time, as well as involving expenditures. The major service of this segment is the establishment of organizations whose purpose is to facilitate civic activity. In this respect, the key "providers" are membership organizations, such as churches, trade unions, professional associations, and political parties.

Personal Consumption includes all activities that combine the fulfillment of personal needs—such as shopping or eating—with the pursuit of leisure, which are in some sense also part of the Recreation and Leisure amenity, The major providers are the food services, industry, and retail trade. This is another segment where the advertising industry, to the degree that it stimulates personal consumption, plays an important role.

Note: Although these categories constitute a broad definition, they do not cover all recreation and leisure activities, such as the considerable sums spent on illegal substances and activities. Further, some activities, even though not illegal, simply cannot be traced. Collectors of artifacts undoubtedly spend billions annually pursuing their hobbies, but as many hobbyists trade rather than sell on the open market; their considerable economic impact eludes conventional accounting.

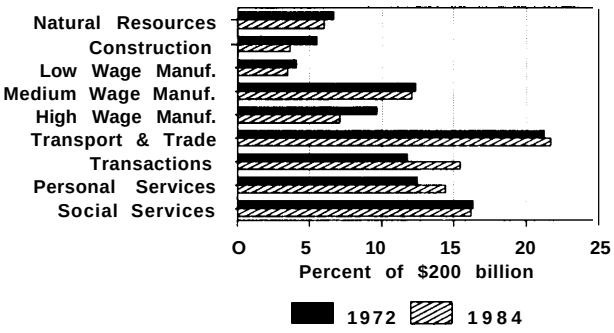
Structure and Performance

The present discussion treats only those parts of the Recreation and Leisure amenity included in the somewhat narrow definition of the sector introduced in chapter 2, which excluded spending on food and domestic travel because it was virtually impossible to distinguish recreational spending from spending for other purposes in these categories. Even using this more restrictive definition of the sector, figure 6-11 suggests that the value-added derived from spending on Recreation and Leisure is spread broadly across the economy. About one-fifth ends up both in manufacturing and in Transportation & Trade. Only *14* percent ends up in the comparatively low-paid Personal Services sector.

Home Entertainment

The underlying economics of home entertainment and home information are difficult to reconstruct, since much of the value of the information received through television, radio, newspapers, and magazines is paid for by advertisers and not directly by consumers. Advertising accounts for 50 to 75 percent of the cost of a delivered newspaper or magazine and nearly 100 percent of the cost of most commercial radio and television. Consumers pay indirectly

Figure 6-11.-Value-Added To Meet Demand for Recreation and Leisure ($200 billion* in 1984)



● Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

by the abuse of their patience, and by having advertising costs appear as a part of "transactional" costs throughout the economy. The equation is changing, however, as advertising supported television is replaced by a variety of cable-television options (including pay-per-view technologies), video rentals, and other mechanisms for delivering entertainment software to the home without advertising support. The impact of this change has yet to be felt; advertising revenues of broadcast radio and television remain robust.

Historically, broadcasting has been limited by the availability of usable electromagnetic spectrum. Rather than a local monopoly, the broadcast sector is marked by multiple and roughly equivalent suppliers in a given market. The mode of regulation also differs. Instead of price and rate of return controls, radio and television regulation aims at ownership, program content, and operational controls. Licenses to operate are not granted in perpetuity, but rather are periodically reviewed against a "public interest" standard. Although regulation of telephone common carriage occurs at both the local and Federal level, only Federal regulation occurs for broadcasting. The Communications Act of 1934 specifically defines broadcasting as the "dissemination of radio communications intended to be received by the public, directly or by the intermediatory of relay stations."[224] The Act further distinguishes radio broadcasting as "not . . . a common carrier" activity,[225] and public policy also separates it from "point-to-point" communications.[226]

The Cable Act of 1984 brings cable television under the regulatory auspices of the 1934 Communications Act, while simultaneously relieving the industry of arbitrary franchise, rate, and license renewal requirements imposed by local authorities.[227] One reason for this landmark legislation was that the technology of cable and its market had long ago outstripped the ad *hoc* regulatory framework erected by local, State, and Federal authorities. Among other things, the Cable Act required that basic cable rates be deregulated by 1987, channels be set aside for outright lease to unaffiliated companies, telephone companies not be allowed to operate systems in their regions, cable and broadcast cross-ownership in the same area continue be prohibited, and cable and newspaper cross-ownership be permitted. State regulation of cable companies as common carriers was prohibited.[228] These rules opened the industry to further consolidation and protected it from the advances of stronger telecommunications and broadcast entities seeking to accumulate operating assets across the whole spectrum of the communications and information industries.

There are no legal or regulatory restrictions on the vertical integration of systems operators into programming and distribution under the Cable Act (nor are there restrictions on non-cable entities providing programming services to cable systems, including competitive communications entities). Unlike broadcasters, multiple system operators (MSOs), can control both program content and local cable conduits on a national scale. Many of the top 20 cable origination program suppliers are owned in whole or in part by one or more MSOs. These programming interests are being traded by MSOs in moves to consolidate the now-dispersed program supply within a few entities with financial clout, the cable system outlets, and the system interconnections—all in order to improve the quality of programming and the economic performance of both the programmers and the cable systems.

224 United States Code, No. 47, Sec. 153 (0), 1976.

225 United States Code, No. 47, Sec. 153 (h), 1976.

226 See "Subscription Television Service," Federal Communications Commission, No. 3, Sec. 2d-1 (9), 1966.

227 Cable Communications Policy Act of 1984, PL 98-549 (1984 Amending Communications Act of 1934, 48 Stat. 1064).

228 "Cable Regulation," *Broadcasting,* July 1, 1985, p. 22.

Concentration of ownership of cable systems is not generally subject to any limitation. In 1980, broadcasters owned 33 percent of all cable television systems in spite of the cross-ownership restrictions. Newspapers and book publishers owned 24 percent and operated under no ownership regulation; television program producers and distributors owned 18 percent. The broad ban on telephone company operation of cable systems included in the Cable Act is an attempt to dampen any anticompetitive practices that could result from a local monopoly telephone company owning a cable television facility in the same community.[229] The telephone company cross-ownership ban does not, however, prevent telephone companies from owning or operating cable television service in any area outside local exchange boundaries.

The bans on network/cable cross-ownership and local broadcast station/cable cross-ownership are clearly designed to insure maximum video program diversity in the local community by limiting the power of the networks to acquire cable operations, which by their very nature compete with network programming and supplement the broadcast of both network and local programming by cable carriage of broadcast signals. These bans are continued by the Cable Act.

As an unregulated industry, printing and publishing has not been affected by the major changes in the rules governing the organization of other media industries. New printing technologies, however, such as those involving low-cost "print-on-demand" techniques and the possible substitution of electronic media for certain kinds of publications, may lead to significant shifts in the industry during the next two decades. These are analyzed in the next section.

The development of standards is critical for moving into advanced communication technologies (see also previous discussion of Personal Business and Communication). It has, for example, proven to be extremely difficult to develop a technology for high--definition television that will not render existing receivers obsolete.

[229]Cable operators, it should be recalled, control both the conduit of communication and the content, or programming; telephone companies control only the conduit. Additionally, such cross-ownership would put the telephone company in a conflict of interest position as it negotiated with the cable company for compensation for carriage of the television cable on local utility poles.

Network Components

The Media.–New electronic technologies have led to rapid growth in sales of audio and video equipment for the home, have resulted in many new channels for delivering software, and have even spawned new industries (i.e. audio tapes, compact disks, video tapes, and cable television). Even newspaper and magazine publications have become more differentiated. On the other hand, it is not clear that this diversity of products and a change in the mix between spending on hardware and software has resulted in a significant change in patterns of ownership.

The film industry illustrates a complex pattern of transformation. The industry is no longer built around the vast, vertically-integrated film studio empires of the "Golden Age" of cinema, but is shifting toward more flexible networks of activities that are in effect satellites of major firms. At one time, seven major studios owned their own theater chains, five of which controlled some 70 percent of first-run capacity in the big-city markets. Each was vertically integrated with their own facilities not only for production but for distribution of entertainment spectacles; they were models of standardized industrial mass marketing.[230] Divestiture of the theater chains in an antitrust settlement in 1948, and a series of changes ranging from the decline of center cities to the emergence of television, helped erode the in-house production structure and paved the way for independent producers.[231] Even the belated effort to acquire TV stations and theaters in the 1980s in order to regain control over the exhibition of their increasingly expensive products seems unlikely to reverse the fragmentation of distribution that makes old-style studio operations impossible.[232] Tasks formerly performed by the studios themselves became more and more contract work assigned to specialists. Almost in spite of itself, the motion picture industry has come to be a model of "flexible specialization."[233]

[230]Michael Storper and Susan Christopherson, "Flexible Specialization and Regional Industrial Agglomerations: The Case of the U.S. Motion Picture Industry," research monograph, Graduate School of Architecture and Urban Planning, University of California at Los Angeles, February 1986, p. 7.

[231]Michael Storper and Susan Christopherson, "Labor in a Post-Mass Production Industry: The Case of the U.S. Motion Picture Industry," research monograph, Graduate School of Architecture and Urban Planning, University of California at Los Angeles, 1985.

[232]Aljean Harmetz, "Hollywood Seeks Control of Outlets," The New *York Times,* Mar. 3, 1986, p. D1.

[233]See, for example, U.S. Congressional Clearinghouse on the Future, "High-Flex Workers: Adapting to a Changing Economy," in the "Emerging Issues" series, Washington, DC, November 1985.

The motion picture industry has been drawn into the home-media realm, with many productions made exclusively for television use and all made with television ultimately in mind. Some 69 percent of cable subscribers and owners go to movie theaters less than once a month; [234] perhaps half of motion picture revenues now derive from video markets; [235] and VCR rentals may amount to 75 percent of the level of revenues generated by box office admissions.[236] Its new labor arrangements dictate that many of its personnel and facilities work interchangeably in television as well.

The three major television networks continue to dominate national television broadcasting, but changed regulations have fundamentally altered the nature of competition in this industry. In many cases new rules had to be devised to accommodate new forms of broadcast communication, including cable television, multipoint distribution systems, subscription television, direct broadcast satellites, teletext and videotex, and home video services.

Magazine and Book Publishing. -Publishing, once dominated by local papers and broad coverage/national-scope magazines is undergoing two kinds of transformation: newspapers are entering the national market (i.e., *USA Today* and *The Wall Street Journal),* while many cities now lack significant competition in daily papers. On the other hand, "national" magazines have found their markets disappear in favor of more than 11,000 highly differentiated and specialized markets for everything from stamp collecting to yachting.[237] Even magazines serving more generic markets are able to use computer controlled printing systems to specialize their products for local markets. *Business Week,* for example, prepares different editions for different customer classes. Many of the highly specialized publications are, however, owned by large concerns like Time-Life, so that the capacity to mass-market or even reassemble individual general-interest magazines remains more concentrated than a list of titles would lead one to expect.[238] The same network of advertisers and readers, and the same facilities and expertise required to produce any glossy magazine, can be adapted easily to areas of related interest.

The disintegration of the book publishing industry through fragmented market demands has not proceeded nearly as far. Ten American publishers still account for 88 percent of sales. The technological tools now available to publishers—on-line systems, database management systems, and personal computers with "desktop publishing" capability—are available to small firms as well as larger ones, thus checking trends towards consolidation.[239] A rough estimate suggests that the number of book publishers has doubled over the last generation.[240]

Home Electronics. —U.S. firms have all but abandoned the manufacture of home electronic equipment. Virtually all major innovations in video and audio equipment in the past five years (compact discs, video tape recorders, and inexpensive camrecorders) have been marketed by Japanese or other Asian producers. Foreign producers have also made major inroads into the market for professional production equipment (cameras, recorders, editing equipment, and special effects equipment). Foreign command of the industry is likely to continue unabated, because of both an impressive reputation for low cost and high quality and massive investments in research and development. New digital tape systems for sound and video recording, high definition television systems, and a variety of other advanced systems will be produced abroad. Given that capital equipment in the home has come to represent a large share of all spending on home entertainment, this is a serious loss.

New **Technologies and System Integration.—** Emerging technologies with potential to affect the recreation and leisure economy include cellular mobile telephones and radio paging, compact disks, electronic mail, enhanced television, fiber optics, low-power television, multipoint distribution serv-

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[234] LINK Resources, "New Media Consumer Survey: Executive Summary" New York, NY, 1984, p. 18, table 13.

[235] Arlene K. Fleming and Robert November, *The Impact of Technology on Home Information, Transactions, and Entertainment,* contract report prepared for the Office of Technology Assessment by LINK, a subsidiary of International Data Corp., June 1985, pp. 11.20-21.

[236] "Hollywood Worried by Growing Cassette Rentals," *The New York Times,* Nov. 18, 1985, p. C18.

[237] See S. Fatis (note 20, p. 70).

[238] Arlene K. Fleming and Robert November, op. cit., footnote 235, p. 11.47-50.

[239] UNESCO, *The Future of the Book, Part III—New Technologies in Book Distribution: The United States Experience* (Paris: UNESCO, 1984), pp. 27-29.

[240] Dan Lacy, "Publishing Enters the Eighties," pp. 11-25, in U.S. Library of Congress, *The State of the Book World 1980* (Washington, DC: U.S. Government Printing Office, 1981), p. 11.

ices, optical video disks, pay-per-view television, personal computers, satellite master antenna television, signal compression, teletex, the video cassette recorder, and videotex. All of these have the potential to enhance and extend leisure activities in the home. They compete not just with one another but with established media for the consumer's money and time. Some of these technologies are almost mutually exclusive, in that their overlapping capabilities make it improbable that all would exist in any given household. Those that survive will depend not upon their technical feasibility but upon their capacity to deliver the services most in demand. (See figure 3-8, p. 139.)

The spectacular failure of the Keytron videotext venture in Chicago and Viewtron in southern Florida does not seem to have failed to stem interest in the new home information technology. The new investors come primarily from information firms like Reuters, Dow Jones, McGraw Hill, and Dun & Bradstreet, and technology firms like Mead Data Central, Lockheed Corp., CompuServe, and AT&T. These firms have formed interesting corporate alliances to develop home information services:

- Trintex (designed to provide residential videotext, entertainment, and information) = IBM + Sears + CBS;
- Covidea (designed to provide electronic banking and access to public databases) = AT&T + Chemical Bank + Bank of America + Time Inc.;
- IMnet (stock and business data) = IBM + Merrill Lynch; and
- Quotron (stock quotations) = Citicorp.

Away From Home Entertainment

Far from competing with vacation spots, future home travelogues seem more likely to stimulate the desire to visit them. The film Deliverance spawned business for white water raft trips and the television production *Love* Boat boosted business for cruise ships.

The discussions of chapter 3 indicated that the annual two-week domestic family vacation is of declining importance in overall demand for recreation. It has been replaced by more frequent short trips close to home, mixed with occasional jaunts abroad or to distant parts of the country. Variety rather than serenity may be the new keynote of travel.[241]

It is not surprising, then, that the President's Commission on Americans Outdoors discovered demand for better outdoor recreation opportunities close to home when it measured public opinion through polls, position papers, and hearings conducted all over the country. What did surprise the Commission staff was the extent of this demand: in all sections and demographic groups it was overwhelming.[242]

People pressed for time necessarily seek diversions which are close at hand, whether indoor or outdoor, organized or informal, commercial or public. People who live near bowling alleys are most likely to learn how to bowl, while those with convenient access to lakes or pools more probably improve their swimming. To erode dwindling recreation time further in traveling to facilities is vexing to many Americans. Economists estimating the impact of outdoor recreation have realized that omitting travel time from the travel cost method creates a "substantial downward bias" in figuring benefits; a 30 percent allowance for it is taken to be conservative.[243]

Network Components

Getting There.—Patterns of change affecting the entire U.S. travel industry were discussed earlier in this chapter. The factors reshaping the travel agency businesses, however, reflect many forces unique to recreation industries. In the mid-1980s, the 20,000 American travel agencies with their 6,000 branches constitute an industry growing by about 10 percent annually. Countering this expansion is a trend toward consolidation, as smaller agencies merge or are acquired by larger ones enjoying the benefits of mass

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[241] An interesting European perspective is that of Markus Schwaninger, "Forecasting Leisure and Tourism: Scenario Projections for 2000-2010," *Tourism* Management, December 1984, pp. *250-57,*

[242] Conversations with *Barry S.* Tindall, associate director, and Michael P. Rogers, staff associate, of the President's Commission on Americans Outdoors, autumn 1986. The Commission staff generously allowed OTA access to its hearing transcripts, literature review papers, and other data; the conclusions drawn here are, however, those of OTA.

[243] Cindy F. Sorg and John B. Loomis, *Empirical Estimates of Amenity Forest Values: A Comparative Review,* U.S. Department of Agriculture, Forest Service General Technical Report RM-107, Fort Collins, CO, March 1984, pp. 2-3.

discounts and more sophisticated automation.[244] The industry expects to flourish by emphasizing its knowledge resources as opposed to a mere ticket-selling.[245]

The pressures on the travel agents come from several directions. The fear that consolidation will allow just five or six carriers to control 90 percent of air travel implies further domination by those carriers of the travel agents who depend on their business. Reduced services and commissions by the airlines are one prospect. Another is that as services now performed for free become increasingly expensive, their costs will have to passed along to the customer, weakening the economic argument for employing a travel agency. There is also some feeling that ticketing errors and other common mistakes must be reduced if a consumer rebellion against travel agents is to be avoided.

Lodging.—The 1982 Census of the Services Industry by the U.S. Bureau of the Census identified 41,231 establishments in the tourism industry, divided among hotels, motels, and tourist courts; rooming and boarding houses; camps and trailering parks; trailering parks for camp sites for transients; and organization hotels and lodging houses. These employed over 1.1 million persons with an annual payroll of $9.3 billion and receipts of $33.2 billion; 35,030 of these businesses fell in the hotel-motel-tourist category.

The dynamics of change in the "hospitality industry," as it styles itself, are evident. As a leading industry observer, Albert J. Gomes, concludes, it is offering an increasingly diversified product even though the ratio of one hotel room per 100 Americans has been "remarkably constant" for half a century.[246] One hint that greater differentiation is taking place is increasing prominence as a source of revenues of miscellaneous "other" categories, as opposed to room rents and food-anddrink costs. Room rents accounted for 61.5 percent of hotel revenues in the 1972 Census *of Service Industries,* 60.5 percent in 1977, and only 57.8 percent in 1982; food and drink slipped from 21.7 percent in 1972 to 20.4 percent in 1977 to 18.8 percent in 1982; but "other" sources of revenue, including entertainment and amenities of various sorts, swelled from 6.3 percent in 1972 to 8.6 percent in 1977 to 13.8 percent in 1982. Although some of the reduced food costs represent the inroads independent restaurants have made in attracting the hotel guest's business, the growing importance of other amenities seems clear. Likewise, the usually cheaper, less differentiated roadside motels peaked at 62.1 percent of the market in 1972, splitting with hotels after years of steady increase, and declined to 59.9 percent in 1977. Reflecting the generally lower prices of motels, the decline in their receipts was even more pronounced during this period, going from 52.5 percent to 44.2 percent.[247]

Since the 1982 survey, a difficult-to-measure, literally "cottage industry," the bed-and-breakfast (B&B) house, has grown phenomenally. It maybe viewed in the context of consumer desire for differentiated accommodations. In picturesque tourist destinations, attractive or historic homes furnished with period antiques often exceed the rates of nearby hotels; in large cities, on the other hand, such accommodations may cost a fraction of the price of a convention hotel. Because these informal, owner-operated establishments rarely belong to trade organizations and often advertise solely by word-of-mouth, it is difficult to calculate their numbers or economic impact in the leisure economy; a 1986 directory lists some 200 reservation services representing 15,000 B&Bs nationwide.[248] Many others doing business largely or entirely by word-of-mouth probably swell the total. Clearly the 1982 industry census does not reflect the recent B&B phenomenon, which could have a significant impact throughout the sector.

Specialized packaging of American accommodations, whether for senior citizens, art lovers, or people traveling with pets or children, could flourish in the United States; in fact, a proposal to open a resort perceived as catering to homosexuals has generated controversy in Las Vegas and Ft. Lauderdale. Realizing that they yield a higher profit margin than group

[244] For *industry trends, see Travel Week/y,* Louis Harris Study Issue, 1984; and Mary J. Pitzer with Richard W. Anderson, "Mega-Agencies Are Gobbling Up the Travel Business," *Business* Week, No. 2910, Sept. 2, 1985, pp. 56-57.

[245] Interview conducted for OTA by the Institute for Career and Leisure Development with D. Minic, Director of Public Relations, and Julianne Johnson, Director of Membership Services, American Society of Travel Agents, May 2, 1985.

[246] Albert J. @roes, *Hospitality in Transition: A Retrospective and Prospective Look at the U.S. Lodging Industry* (Washington, DC: American Hotel and Motel Association, 1985), p. 53.

[247] See Gomes, op. cit., footnote 246, pp. 24, 57-58.

[248] Bernice Chesler, *Bed & Breakfast Coast to Coast* (Lexington, MA: Stephen Greene Press, 1986).

guests, the Tokyo-based Hotel New Otani chain courts individual visitors through a card-holding membership system that involves amenities like room discounts and checkout time extensions;[249] American lodgings could eventually reverse their traditional disincentives to lone travelers on the same basis. There is already some effort by the larger lodging chains to address market diversification at least on the economic level; Holiday Inns have inaugurated a line of inexpensive Hampton Inns, evocative of the small, family-run motels of the 1950s and 1960s.[250] This response to market segmentation, called "tiering," by levels of price and facilities, has made the new budget motel operations the fastest-growing segment of the industry; a form of do-it-yourself tiering has also occurred, in which two couples will split the costs of the new residential-suite lodges, with which consumer satisfaction is high.[251] The success of a non-smokers' motel near Texas Stadium, evocative of the old "temperance hotels" that once catered to teetotalers, could herald a health-oriented trend among many specialized markets.

Destinations. —Recent predictions of national homogenization by means of the mass media seem to be giving way to a tide of celebration of what is unique in many areas of our land. State and regional fairs thrive, while the development of local opera and theater companies produces a measurable increase in attendance at live performances.[252] Even the newfound vitality of museums in America's cultural life has been attributed to revitalized local institutions.[253] Regionally oriented publishing has come into its own, while local or regional food events like Mississippi catfish carnivals or the "Memphis in May" National Barbecue Festival draw national and even international participants. For the tourist economy, the more an area's particular assets are developed and publicized, the greater its potential as a destination. This new American regionalism may flourish, with benefits to the American tourism economy.

Older resorts cannot depend upon steady business when new or revitalized competitors lure their business away. Decline can be sudden. In 1982, 67 percent of visitors to Virginia Beach, VA were repeat vacationers; by 1984 the resort area enjoyed 64 percent repeat business, and by 1986 just 43 percent. Although the decline is in some degree related to a dip in tourism in the immediate region, the lack of a strong, coordinated effort to enhance Virginia Beach as a vacation spot and the nostalgic reliance on the old-fashioned, two-week family vacation seems to mandate quick action if the old resort is to avoid economic decline.[254] This and other older tourist magnets will have to feature their unique amenities if they are to draw affluent vacationers.

Intrinsic tensions have always separated groups interested in the preservation of nature and those interested in making a profit from outdoor activities. There are, however, many places where the interests of these groups converge. Preserving America's heritage as a travel destination can yield many common benefits.[255] For forest-related activities, studies from several States have been gathered in their discussion of methodology to determine economic benefits. The adjusted values for camping, converted to 1982 dollars, ranged from a low per activity day of $5.80 to highs of $26.18 and $26.35.[256] Cold water fishing ranged from $8,58 to $67.55, and hiking from $8.25 to $45.76[257] Obviously, the variance of these diverse estimates owes much to the varying methodology.

Unfortunately for park authorities, the economic benefits of natural areas are generated indirectly. In time, pressure on natural resources such as wildlife refuges to justify themselves in thoroughly inappropriate cost-benefit terms can produce incompatible uses and destructive pressures that damage their intrinsic value.[258]

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[249] *Mitsubishi Bank Review, vol. 17, No. 1,* **October 1986,** p. **989.**

[250] Phil Patton, "America's **Home Away From Home Is Still a Good Motel,"** *Smithsonian, vol. 16, No. 12,* **March 1986, p. 127 ff.**

[251] *Consumer Reports, No.* 477.

[252] Linda Deekard, *"Good* **Year for Fair Industry Despite Economy, Insurance,"** *Amusement Business, vol. 27,* **December 1986, p. 1, reports that the top fifty North American fairs drew 47,204,576 during that year; information on increased patronage of museums and cultural events derived from the** *Statistic/ Abstract* **of** *the United States 1987,* **op. cit., footnote 128.**

[253] Interesting **perceptions that the "arts have reached mainstream status in communities around the country" appear in** Anne E. Abramson, "Dear Readers," *Museum and Arts Washington,* **Jan. -Feb. 1987, p. 4.**

[254] Gerri Willis, **"Resort at Risk,"** *Virginian-Pilot,* **Aug.** *9,* **1987,** p. E1, **offers a model analysis of an aging resort's problems.**

255 The "Focus on Tourism" issue of the National Recreation and Park Association's *Parks & Recreation vol. 21, No.* **10, October 1986, reflects the trend.**

[256] Sorg and Loomis, op. **cit., footnote 243,** p. **8.**

[257] **1 bid., pp. 11-15.**

[258] Jim Doherty, **"Refuges on the Rocks,"** *Audubon,* vol. **85,** July 1983, **pp. 74-116.**

In such an environment, the consumer wins a better product—a better physical environment, a more comprehensive recreation program, and more effective fitness instruction—at higher cost. In the public sector, there is evidence that Americans are willing to pay a price. The (arguably leading) questions in the 1982-1983 National Recreation *Survey* arrived at conclusions much in keeping with other opinion surveys in recent years: "a preference for cost sharing of visitor service expenses [between taxes and user fees] is very widespread among the public. ''259 Indeed, Americans seem willing to contribute toward such purposes; for instance, in 1985 recipients of Michigan State tax refunds checked off $500,000 alone to aid in restoration of nongame wildlife.[260] It is likely that this kind of funding will increase.[261]

In the private sector, a mass economy/individualized economy dichotomy is likely to emerge. YMCAs, YWCAs and community centers appear to be in great demand to meet popular desire for physical fitness instruction and facilities, while posh exercise salons or specialized martial arts studios will cater to those who can afford more personalized attention. Exotic thrill sports, ranging from hang gliding to adult wargaming, constitute a continuing element of the upscale consumption.

Transportation as a Destination. -Those who flock on board Amtrak's excursions across the continent would hardly endure the same journies on board the slow, jolting, sooty railcars that carried previous generations of travelers. The Norfolk and Southern railroad offers air-conditioned luxury cars as well as old-fashioned ones on its steam train excursions, a concession to those who temper their nostalgia with a concern for comfort.

The American cruise industry, ranging from the steamboat trips down the Mississippi to the island-hopping Caribbean liners popularized by the television series "Love Boat," appeals to the revived notion of transportation as destination. Few customers have the resources of money and leisure to take the leisurely world cruises of the past; to appeal to the many who would sample the tranquility of shipboard life, shorter packages have emerged. The logical extreme, "cruises to nowhere, " where the sensations and amenities are themselves the attraction, dispense with destination entirely.

New **Technology and System Integration.—** Technology poses new challenges for integrating the diverse set of activities involved in away from home recreation. The travel industry has taken major steps to integrate transport and lodging reservations. Airline reservation systems, developed with the help of regulated air rates, provide a powerful tool for facilitating air travel. It has proven difficult for any new system to compete with those already in place given the economics of an unregulated industry. Travel agencies have improved their ability to arrange accommodations around the world. New systems would permit a greater variety of small facilities to be a part of such systems. The automated teller machine systems described in the section on Personal Business and Communication are being expanded to provide consumer entry points into reservation systems, and to sell tickets for transportation, theater, and sporting events. American Airlines has 5,000 terminals for dispensing tickets in travel agencies. Avis handles some rental returns through terminals.[262] In the future, such systems could let prospective clients do more "shopping" for destinations of interest through interactive video systems.

The venerable Thomas Cook agency now uses an "expert system, " capable of answering "quite complicated questions about how best to achieve certain [travel] objectives, and all large agencies stand to benefit from the improved reservation systems present and potential."[263] However, technologies that can reduce costs and errors for the travel agent may also be employed directly by the consumer. The French Minitel system, discussed in the preceding section of this chapter, allows inhabitants of the most remote villages not just abundant information about transportation and lodging throughout the country, but also the capacity to make and pay for reservations. Likewise, passengers may walk into the railroad station in Lyons and ticket themselves directly onto the TGV to Paris through an easy-to-use and polite computer; Amtrak has introduced such vend-

[259] *1982-1983 National Recreation Survey,* pp. 43-44, 63-65.
[260] *Michigan's Environmental Quality: 1985* (Lansing, MI: Michigan United Conservation Clubs, 1985), p. 5.
[261] See Derrick A. Crandall, "Recreation on Public Lands: Should the User Pay?" *American Forests vol.* 90, March 1984, p. 10, for important caveats.
[262] B. Rosenberg, "Money Machines Outgrow Banking," *High Technology Business, vol. 7, No.* 10, October 1987, pp. 34-37.
[263] *Tourism* Management, vol 7, No. 1, March 1986, p. 143.

ing machines in the United states as well, Thus some of the routine business of the travel agent is bypassed.

Business already has access to travel information in a number of ways, including SiteSelex On-Line, a videotex service offering subscribers information on 6,000 hotels, resorts, and conference centers.[264] More comprehensive services are also emerging with some access for the general public. The National Tourism Data Base program, initiated in 1985 by the U. S. Conference of Mayors, could grow into the basis for improved services by travel agents to their clients; yet it could grow beyond that level to direct integration with consumers themselves.[265] Already some 21,000 travel agencies-85 percent of the automated agencies in the country-are able to supply Data Base information free to their customers. Offices of the U.S. Travel and Tourism Administration make the Data Base available to foreign inquirers.

The National Tourism Data Base is not now interactive, and it is too early to tell how successful the effort will be. At present, its strength is specificity; it offers the hours, admission charges, descriptions, and telephone numbers of perennial attractions such as the Washington Monument, and more importantly the relevant data on ephemeral events, such as concerts, so that travelers may plan ahead and arrange for tickets difficult to obtain at the last minute. Thus a traveler planning to visit a participating city such as Anchorage, Alaska, is better able to take advantage of current goings-on as well as the city's regular attractions.

Automated on-site terminals already provide one alternative means of informing visitors. For instance, Baltimore has installed INFOTOUCH, "the new, touch-screen City Directory System . . . housed in attractive, easily-recognizable kiosks" at seven visitor sites around the city—"offering a series of menu-driven screens, Infotouch highlights all of Baltimore City's attractions, events, dining, shops, services, and more with colorful, exciting, high-resolution graphics."[266] Listings are available in various categories to advertisers for origination fees plus varying monthly rates.

[264] *American Printer*, November 1986, p. 18.

[265] Brochure, U.S. Conference of Mayors, June 1986; American Airlines news release, Apr. 23, 1985; Robert Loomis, "Check Citilog for 'After Business' Activities," *Online Today*, April 1986, p. 19; conversation and system demonstration with Monica Harvey, National Tourism Data Base, Nov. 13, 1986.

[266] Brochure, Info Corporation, Baltimore, MD

MANUFACTURING

Many studies of innovation in manufacturing have been published during the past few years.[267] Many of the issues have already been discussed in connection with specific amenity networks examined earlier in this chapter. While it is not useful to repeat these discussions, the following section will review some common themes: movement toward smaller, more flexible manufacturing establishments, reduced use of energy and materials, and increased use of automated production equipment and intermediate inputs of "services."

Factors Forcing Change

Manufacturing enterprises in the United States are comparatively free of government control. Their behavior, therefore, is presumably described relatively well by macroeconomic analysis. A number of informal institutional constraints, however, often block effective competition. Some of these involve rigidly hierarchical and often insular bureaucratic structures within large organizations. Some involve longstanding ties between vendors and relatively small purchasers of capital goods. Some are purely matters of personality and "old-boy" networks perpetuated by regular contacts.

The flow of information and real decision-making authority through manufacturing systems is poorly documented and poorly understood. Most decisions about technology are made in response to advice from capital goods suppliers, specialty products man-

[267] The theoretical literature is reviewed in L. Tornatsky et al., The *Process of Technological Innovation: Reviewing the Literature* (Washington, DC: National Science Foundation, 1983), Two OTA studies have also surveyed the literature in technology and manufacturing in some detail: *Computerized Manufacturing Automation, OTA-CIT-235* (Washington, DC: U.S. Government Printing Office, April 1984), and *Technology and Structural Unemployment: Reemploying Displaced Adults*, op. cit., footnote 163.

ufacturers, or "turn key" engineering firms. Occasionally, research problems are contracted out to independent research laboratories such as the Battelle Memorial Research Institute, SRI International, the Midwest Research Institute, or the Southwest Research Institute.[268]

Many traditional forms of regulation have come under intense assault from both foreign competition and the opportunities created by new technology. While the quality of management in U.S. manufacturing may not have grown noticeably worse in the past two decades, U.S. management is being tested in unprecedented ways. Management structures that worked well in an era where domestic markets were highly predictable, or could be manipulated in ways that would make them predictable, may not be well suited to an era of uncertainty and a lack of control over international markets.[269]

Rigid hierarchical firms, and those governed by rigid cost-benefit formulae, tend not to make innovations in production techniques. Greater uncertainty may accentuate the rigidity of these organizations rather than force them into more creative management practices. For example, a survey of producers of automobile parts, agricultural machinery, and pumps and compressors found that the 26 firms using advanced production equipment tended to have less centralized management, a general manager with broader authority and more technical background, and a recognized long-term planning program.[270] Financial managers located in distant "front offices" were viewed as a major barrier to innovation.

The precise costs and benefits of a new technology are virtually impossible to quantify to the satisfaction of most financial analysts, few of whom have any direct experience in the engineering details of manufacturing. By the time such numbers can be developed with precision, the concept has had many years of reliable field experience and is no longer an "innovation." This difficulty is compounded by the fact that many of the advantages of new production technology cannot be captured in a simple analysis of internal rates of return, typically designed only to highlight the advantages of systems for reducing direct labor costs.

As with all the business networks explored in this chapter, the full advantages of production technology can seldom be captured without a far-reaching review of the way production is managed and the way employees are integrated into the process. A major automobile manufacturing firm recently discovered that a change in management and incentive systems in an older plant led to rapid growth in productivity, while a massive investment in new technology not accompanied by changes in the relationships between workers and line management fell far short of productivity goals.[271]

The problem is further exacerbated by the fact that the production workers and personnel in manufacturing typically do not have much "clout" in the hierarchies of large companies in comparison with marketing or financial staffs. In extreme cases, a manager may believe that expensive innovations in manufacturing technology are simply forbidden by a rigid and fixed budget to cover replacements of capital equipment. The survey described above identified several cases where outside consultants were hired to push a new idea within a firm because outsiders could make a better case to the financial experts in the firm.

Scale and Scope

The impact of tightly integrated production networks, described repeatedly in earlier sections of this chapter, are having dramatic—although sometimes contradictory-effects on the structure of U.S. manufacturing enterprises. Demand for timely delivery, reliable quality, and exacting tolerances are forcing many production firms to purchase more sophisticated equipment and adopt new techniques of organization. This may make it easier for relatively small firms to participate in a dynamic production network.[272]

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[268] Mary M. Watkins (cd.), *Research Centers Directory* (Detroit, MI: Gale, 8th Edition).

[269] W.J. Abernathy et al., *Industrial Renaissance: Producing a Competitive Future for America* (New York, NY: Basic Books, 1983).

[270] Carol Parsons et al., "The Development of Programmable Automation Systems in Discreet Parts Manufacturing Industries," contract report prepared for the Office of Technology Assessment, Washington, DC, 1984.

[271] W. Hampton and J.R. Norman, "General Motors: What Went Wrong," *Business Week, No. 2990,* Mar. 16, 1987, p. 102.

[272] Michael Piore and Charles Sable, *The Second Industrial Divide* (New York, NY: Basic Books, 1984).

The widespread application of microchip-based technology has fundamentally altered previous notions of scale and scope for American businesses. The availability of inexpensive Computer Assisted Design (CAD) and Computer Assisted Manufacturing (CAM) technologies that run on personal computers has allowed even small machine shops to adopt this technology, reducing waste, errors, and down time. The time required from receiving a customer's drawing to cutting a die has been reduced by a factor of seven.[273] Metal fabrication facilities that formerly required large staffs, fixed automation, and long production runs can now make use of technologies such as flexible manufacturing systems (FMS) that used to be the sole preserve of large businesses. Minimum efficiency can now be achieved with six machines and six people.[274]

Smaller firms, however, often cannot afford the more complex automated equipment and the associated personnel needed to meet the demanding tolerances and schedules, and are turning instead to the highly competitive "aftermarkets." In the case of agricultural parts production, computer controlled equipment allowed at least one major supplier to survive the recession by competing successfully with highly specialized local producers. The firm relied on low-cost production using conventional manufacturing technology, in addition to a knowledge of niche markets and traditional relationships.[275]

At a broader level, chapter 5 presented data that indicated that manufacturing firms were increasing their scope through ownership of a more heterogeneous collection of manufacturing establishments, but that the establishments themselves were becoming more specialized.

Recipe Changes

While significant progress has been made through a workman-like accumulation of incremental improvements, the past few years have also witnessed a series of breakthroughs that change the product and the production process in fundamental ways. The manufacture of float-glass is one such example —it reduced capital, labor, and materials costs simultaneously while improving the quality of the product. In the production of metal parts, advances that reduce the total number of components needing assembly can be as important as techniques for improving the productivity of making each part. In addition, converting to alternative materials (powdered metals, plastics, or composites) can radically change the manufacturing process and render traditional metal forming processes irrelevant.[276] There are also synergistic effects, New components once requiring the assembly of several parts can be produced in a single step. Helicopters made from advanced composites, for example, can be assembled from 1,500 parts instead of the 11,000 needed for conventional manufacture; the number of fasteners is reduced by 90 percent.[277]

While new manufacturing technologies represent a diverse collection of innovations, taken together they appear to offer the following advantages:

- sharply increased labor productivity,
- declining economies of scale in production,
- increased precision and reliability,
- reduced costs in design and setup,
- increased ability to substitute materials based on cost and performance,
- more efficient utilization of energy and materials,
- more efficient use of manufacturing space, and
- reduced inventory.

An ability to adapt quickly to changing domestic and international market conditions, and to unanticipated changes in the costs of materials, has become critical for many manufacturing firms. Rapid response and controlled inventory networks emerging throughout the country are demanding such flexibility. Even firms not closely tied to such networks find that long-term survival depends on adaptability.

New manufacturing equipment, such as numerically controlled machine tools (NCMTs), robotics, CAD, and automated delivery and transport systems, play a key role in increasing flexibility and productivity.[278] For example, by coupling several of these

[273] *Mechanical Engineering*, **January 1987, p. 6.**

[274] Ramchandran Jaikumar, "Postindustrial **Manufacturing,** " *Harvard Business Review, vol. 86. No. 6,* **November/December 1986,** p. **76.**

275 C.Parsons et al., op. cit., footnote 270.

[276] Robert H. Williams, **Eric D. Larson, and Marc H. Ross, "Materials, Affluence, and Industrial Energy Use,"** *Annual Review of Energy*, NO. **12, 1987, pp. 99-144.**

[277] R.C. **Forney, "Advanced Composites, the Structural Revolution,"** *Journal of Metals vol. 38, No. 3,* **pp. 18-20, cited in** R.H. Williams et al., op. cit., footnote 276.

[278] John Ettlie, "Facing the Factory **of the** Future," **Industrial Technology** Institute Working Paper, unpublished, August 1984, p. 2.

technologies together into an FMS, GE has been able to cut the cycle time of production of locomotives down from 16 days to 16 hours.[279]

The potential of these advanced manufacturing technologies is further enhanced when used in combination with new materials requiring significantly simpler production strategies. There are indications that plastic-forming tools can be operated economically with far shorter production runs than typical steel stamping equipment in the production of products like automobile fenders.[280] Through use of advanced manufacturing technologies and new materials, the recipe of production can be radically changed.

The advantages of new, flexible production equipment depend critically on the number of identical units being produced. If parts must be made in extremely small numbers it is typically cheaper to make them by hand using conventional machine tools. If there is a predictable demand for many hundreds of parts each year (as in automobile production, small appliances, or telephone handsets), it is usually desirable to build a plant dedicated to "mass production." On the other hand, when demand is between 10 and 300 large, complex units (i.e., marine engines, large electric motors, and tractors), or between 300 and 15,000 simple parts, it is becoming attractive to use tools that can be flexibly programmed for limited runs. In 1980, between 60 and 80 percent of the value of all machining operations was produced in this intermediate range of production runs.[281] While statistics are poor, anecdotal evidence suggests that the share of production value in these intermediate or "batch" production regimes is increasing.

Inventory control and quick response networks place increasing burdens on producers. The textile and apparel network (described in the discussion of the Clothing and Personal Care network earlier in this chapter) provides a good example.[282] The shortening of the cycle time makes the contracting firm more dependent on suppliers, while simultaneously making the firm more flexible because it no longer has to undertake the function performed by the supplier. Chrysler attributes this increased use of suppliers as the primary factor behind both quality improvements in production and a 50 percent reduction in engineering costs.[283]

Probably the most significant "recipe" change that must accompany the implementation of these new procedures and technologies involves changes in the size, composition, and use of the U.S. work force (a topic covered in more detail in chs. 10 and 11). Workers are less likely to be physically manipulating machine operations, and more likely to be monitoring several machines.[284] The resultant skills demanded become more cognitive and conceptual, rather than perceptual-motor—placing demands on firms to upgrade employees' skills and knowledge. In the few instances where a true FMS has been set up, the manpower savings have resulted in a realignment of skills: in one instance, production workers outnumbered engineers by 22 percent under a conventional production process whereas engineers outnumbered production workers by a factor of three under an FMS configuration.[285] This increased dependence on human capital was also reflected in a survey of the member companies of the National Electrical Manufacturers Association that identified "lack of staff knowledge" as the major obstacle to implementing advanced manufacturing technologies.[286]

Unlike conventional machine tools, programmable manufacturing equipment cannot simply be purchased and turned on. The sophistication of many of these advanced manufacturing technologies requires that machines be tailored to a specific process, creating an idiosyncratic and unpredictable implementation procedure that necessitates a high level of technical expertise. Manufacturers, especially small- and medium- size ones, frequently lack the necessary technical resources to adopt and adapt technology to their needs.[287] Thus, even if a company has access to pertinent information, the infor-

[279] Ibid., p. 4.
[280] J. P. Clark and M.C. Flemings, "Advanced Materials and the Economy," *Scientific American, vol.* 255, No. 4, pp. 51-57.
[281] Machine Tool Task Force, Technology *of Machine Tools*, October 1980.
[282] Robert M, Frazier, op. cit., footnote 148.
[283] Elizabeth A. Haas, "Breakthrough Manufacturing, " *Harvard Business Review, vol. 87, No. 2,* March/April 1987, p. 79.
[284] L. Hirschorn, *Beyond Mechanization* (Cambridge, MA: The MIT Press, 1984).
[285] R. Jaikumar, op. cit., footnote 274, P. 73.
[286] National Electrical Manufacturers Association, "summary Report for the Automated Systems User Survey of NEMA Membership," Washington, DC, 1984.
[287] David H. Swanson, "Research Needs of Industry," *Journal of Technology Transfer, vol. 9, No.* 1, 1984.

mation is largely useless without the capability to adapt that information to its situation.[288]

Network Components and Productivity Change

Energy

New technologies have had the effect of greatly reducing demand for materials per unit of output in manufacturing. Higher energy prices led industry to discover a remarkable series of technologies capable of reducing energy inputs.[289] Between 1974 (the first oil embargo) and 1981, fossil fuel energy used per unit of output in manufacturing declined 20.5 percent. The rate of improvement in fossil fuel energy efficiency was twice the rate experienced between 1967 and 1974. Some of the improvement resulted from structural shifts within manufacturing, which moved the industry away from energy-intensive industries (like steel) and toward products requiring fewer energy inputs per unit of output (like semiconductors). About 66 percent of the post-embargo change in the energy/output ratio, however, resulted from real improvements in production efficiency within each industry. About 27 percent of the shift was attributable to a decline in the materials-intensive manufacturing industries.

Trends in the use of electricity are much different. The electricity used per unit of output in manufacturing has actually increased slightly since the 1974 embargo. Sectoral shifts that led to a decline in industries using a comparatively large amount of electricity per unit of output were offset by increases in electricity use in individual industry sectors, This indicates an overall shift from fuel to electricity as a manufacturing energy source.[290] As electricity represents only about one-third of the primary energy consumed by U.S. industry, net energy use has fallen since the embargo.

[288] Thomas J. Allen, *Managing the Flow of Technology* (Cambridge, MA: The MIT Press, 1977).

[289] Robert H. Williams, Eric D. Larson, and Marc H. Ross, op. cit, footnote 276.

[290] G. Boyd, J.F. McDonald, M. Ross, and D.A. Hanson, "separating the Changing Composition of U.S. Manufacturing Production from Energy Efficiency Improvements: A Divisa Index Approach," *The Energy Journal, vol. 8, No. 2, 1987,* pp. 77-96.

Materials

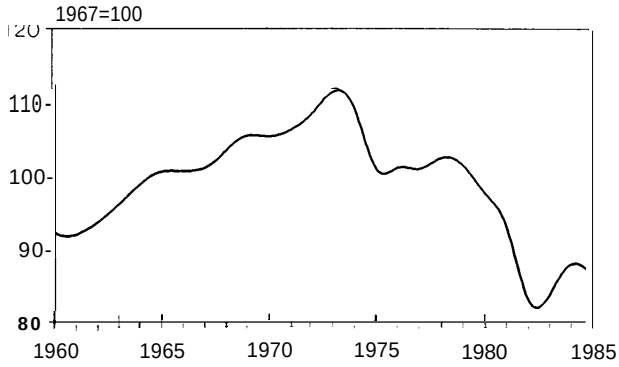
Material usage per unit of output has also fallen rather steadily. Figure 6-12 indicates that the weight of material needed per unit of U.S. economic output has fallen substantially since the mid 1970s while demand per person has remained roughly the same. Several factors have been suggested to explain this change:[291]

- **A Substitution Effect.** Development of higher strength-to-weight plastics, composites, and other materials allows substitution for steel in applications ranging from packaging materials to aircraft parts, and can reduce the weight of material needed for a variety of functions. The comparatively high cost per pound of new materials can often be justified by their unique strength and other properties. For example, a turbocharger rotor made of ceramics may weigh only one-third as much as a metal rotor.[292] One estimate suggests that by the year 2000, U.S.

[291] E. D. Larson, R.H. Williams, and A. Bienkowski, "Material Consumption Patterns and Industrial Energy Demand in Industrialized Countries," Princeton University, Center for Energy and Environmental Studies, PU-CEES Report No. 174, Princeton, NJ, 1984.

[292] R. Williams, et al., op. cit., footnote 276.

Figure 6-12.-Materials Use in the U.S. Economy (indexed pounds per dollar of GNP, 1967= 100)*



*Aggregate indexes of materials consumed in the United States. Tonnages of paper, steel, aluminum, petroleum refinery products, cement, and a combination of 20 large-volume industrial chemicals, weighted by the energy-of-manufacture intensities from the late 1970s.

SOURCE: Robert H. Williams, Eric D. Larson, and Marc H. Ross, "Materials, Affluence, and Industrial Energy Use," *Annual Review of Energy, No.* 12, 1987, pp. 99-144.

demand for polymer composites will reach $12 billion.[293]

- **Changes in Product Mix.** Manufacturing growth has tended to emphasize sophisticated products with relatively high value-added to weight ratios, such as electronic equipment, instead of products with relatively low value--added to weight ratios, such as heavy lifting equipment. For example, $1 of electronic computing equipment uses one-quarter as much steel and two-thirds as much aluminum as the production of $1 worth of machine tools,[294]
- **Redesign of Products.** The average U. S.-made car weighed about 3,800 pounds-in 1975 but only 3,230 pounds in 1985; iron and steel weight dropped from 2,500 to 1,760 pounds during the same period. Industry experts expect the weight of an average car to fall to 2,350 pounds by 1992 with total iron and steel weight falling to less than 1,400 pounds.[295]

  About one-fifth of all the aluminum consumed in the United States is used in cans. Thinner sidewalls reduced weight by 22 percent and better top designs reduced the weight of lids by 13 percent during the past two decades.[296] Total per capita consumption of metals like copper, lead, zinc, manganese, chromium, nickel, tin, molybdenum, titanium, and tungsten has declined in spite of new demands. The decline results both from reduced demands for steel (where the metals were used for alloys) and from better designs in products ranging from batteries to die castings.

  In spite of the information and packaging explosion, paper demand per unit of output in the economy has continued to decrease.

Services

The growing links connecting service and manufacturing firms was described at some length in chapters 4 and 5. This, coupled with the complex pattern of mergers and acquisitions that have taken place in the industry, makes it difficult even to define a "manufacturing firm." By 1984, twelve percent of the employment of firms categorized as "manufacturing" was in establishments which were not classified as manufacturing. Non-manufacturing establishments, owned by manufacturing firms, had an employment growth rate of six percent between 1982 and 1984, compared to a loss of one percent in the manufacturing establishments.[297]

As described in chapter 4, the role of services in the production recipe of manufacturing has expanded significantly since 1972. Embedded within many manufactured products are intermediary service inputs. For example, the Office of the U.S. Trade Representative estimates that 80 percent of the value embedded in a computer is in fact a service product: software.[298] Many of the inputs to the new advanced manufacturing technologies being used to modernize industry are also service products, such as CAD software, machine cell design and integration, and data processing services. Many "service" businesses in the United States depend heavily on the fate of the U.S. manufacturing sector.[299]

Net Changes in the Production Recipe[300]

The changes just described are summarized in Table 6-10 which shows how productivity growth in manufacturing can be credited to different factors. Labor productivity led all advances, but its contribution declined considerably during the past 15 years. The productivity with which materials are used in manufacturing continues to increase, although the rate of improvement has also declined in recent years. Energy productivity, which had been

[293] U.S. Congress, Office of Technology Assessment, *New* Structural *Material Technologies: Opportunities for the Use of Advanced Ceramics—A Technical Memorandum* (Washington, DC: U.S. Government Printing Office, September 1986).

[294] U.S. Input/Output tables for 1977, cited in R. Williams et al., op. cit., footnote 254.

[295] E. Larson et al., op. cit., footnote 291.

[296] Ibid.

[297] Marjorie Odle and Catherine Armington, "Is American Manufacturing Creating Jobs Again?" unpublished working paper, Applied Systems Institute, Washington, DC, p. 3.

[298] U.S. National Study on Trade in Services, Office of the U.S. Trade Representative, December 1983.

[299] Steven S. Cohen and John Zysman, "The Myth of a Post-Industrial Economy," *Technology Review,* February/March 1987, p. 33.

[300] This analysis is based on the Multifactor Productivity Series, 1949 to 1983, developed by the Bureau of Labor Statistics, U.S. Department of Labor, unpublished, 1986. See William Gullickson and Michael J. Harper, "Multifactor Productivity Measurements for Two-Digit Manufacturing Industries," presented at the Western Economic Association meetings in San Francisco, CA, July 1986, p. 48; and Michael J. Harper and William Gullickson, "Cost Function Models and Accounting for Growth in U.S. Manufacturing, 1949-83," paper presented for the American Economic Association, New Orleans, LA, Dec. 28-30, 1986.

Table 6-10.–Contributions to Productivity Change in Manufacturing, 1949-83

Factor	Average percent change in single-factor productivity 1949-65	1965-73	1973-83	
Capital	0.80	–0.70	–2.90	
Labor	2.70	2.70	1.60	
Energy	–1.20	–0.10	1.40	
Materials	1.30	0.70	0.40	
Services	–1.10	–1.30	–1.90	
Multi-factor	2.90	1.90	0.50	
Factor shares of gross output[b]	**1949**	**1965**	**1973**	**1983**
Capital	0.220	0.232	0.187	0.162
Labor	0.418	0.453	0.468	0.428
Energy	0.019	0.020	0.022	0.044
Materials	0.289	0.218	0.233	0.262
Services	0.054	0.076	0.090	0.104

[a]"Single.Factor productivity'' measures the change in dollars of output in an industry resulting from a $1 increase in the factor purchased (capital, labor, energy, materials, services). The statistic shown in the annual percent change is this productivity averaged over the time-periods shown.
[b]The "Factor Share of Gross Output" is a measure of the extent to which a change in an input to the production process (Capital, energy, materials, labor) contributes to a change in the value of an industry's output. For example, in 1983 a 1% increase in services purchased by manufacturing would have resulted in a 0.5% change in manufacturing output, These factor shares must all add to 1 if, as is usually assumed, the total output of manufacturing businesses would increase by 1% if all purchased inputs increased by 1%.

SOURCES: William Gullickson and Michael J. Harper, "Cost Function Models and Accounting for Growth in U.S. Manufacturing: 1949-1983," paper prepared for the American Economic Association, New Orleans, LA, Dec. 28-30, 1988; U.S. Department of Labor, Bureau of Labor Statistics, unpublished.

falling prior to the oil embargo, has since risen significantly. Capital productivity has fallen sharply, as has the measured productivity of purchased services. The "multi-factor" productivity measure represents the combined effect of productivity changes in all the inputs (the "single factor" productivities weighted by the "factor shares" outlined below and in the second part of the table).

The changes in rates of productivity improvement were clearly tied to differences in the relative costs of the different inputs. The price of labor grew much faster than any other factor between 1949 and 1973, while labor prices grew more slowly than energy or material prices from 1973 to 1983. During the earlier period, labor price increases were responsible for two-thirds of the increase in manufacturing input prices, while they were responsible for only 45 percent during the later period.

The relative importance of inputs combined in the manufacturing industries is shown in the second part of table 6-10. It indicates, for example, that purchased services made twice the contribution to manufacturing in 1983 than they did in 1949. In 1949, a 10 percent increase in the amount of services purchased by manufacturers would have resulted in a 0.5 percent increase in manufacturing output. In 1983, it would have increased manufacturing output by 1 percent. The role of energy also increased, while capital inputs become comparatively less important.

The productivity changes of each source are combined to show how they have contributed to labor productivity. The result, displayed in table 6-11, indicates that the output per hour worked in manufacturing in the 1973-83 period was considerably below that of the 1949-73 period. What is striking is the sharp decline in the growth rate clearly attributable to technical change (the "multi-factor" productivity) in the recent period, which has occurred despite a significant increase in capital invested per worker. During the 1973-83 period, increased purchases of services per manufacturing worker and increased purchases of materials per worker were, taken together, four times as important as increases in measured multi-factor productivity.

Table 6-11.—Contributions to Changes in Output per Hour Worked

Contributing factor	1949-73	1973-83
Output/Hour (O/H)	2.57	1.51
O/H attributable to growth in Multi-Factor Productivity	1.34	0.15
O/H attributable to growth in inputs per hour worked	1.22	1.36
Capital/Labor	0.47	0.70
Energy/Labor	0.07	0.01
Materials/Labor	0.41	0.32
Services/Labor	0.27	0.33

SOURCE: M.J. Harper and W Gullickson, "Cost Function Models and Accounting for Growth in U.S. Manufacturing: 1949-1983, " paper prepared for the American Economic Association, New Orleans, LA, Dec. 28-30, 1988.