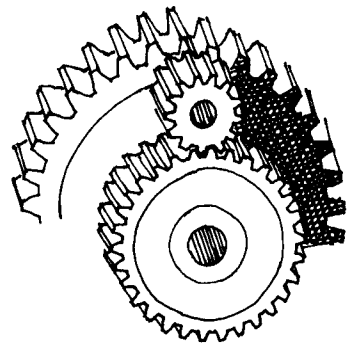

Productivity Reports

Labor and material requirements for hospital construction

DAWN E. DOUGHERTY

In 1980, each $1,000 of contract cost for hospital construction generated an estimated 51.4 hours of work, according to a Bureau of Labor Statistics survey.[1] This means that each $1 billion spent on hospital construction in 1980 would have created 27,129 jobs—12,850 in the construction industry and 14,279 in industries which produce and deliver the materials, equipment, and supplies used in construction. The 1975 survey indicated that each $1 billion of hospital construction would have provided 21,528 jobs in construction and 24,256 in related industries.[2]

The survey covered hospital and nursing home construction. However, this summary presents data for hospitals only; a detailed report covering both hospital and nursing home construction is being prepared. This was the third survey for hospitals and the second for nursing homes. It measured employee hours per $1,000 of contract cost and per 100 square feet of construction. A sample of 34 hospitals and 8 nursing homes completed in 1976 was drawn to represent a universe of 90 hospitals and 16 nursing homes. All projects were funded under the former Department of Health, Education, and Welfare's Hill-Burton program. Data for onsite employee hours, material and labor costs, and project characteristics were obtained through visits to general and special trade contractors.

Employee hours

For each $1,000 of contract cost for hospitals completed in 1976, 87.7 employee hours were required. The following tabulation shows the distribution of employee hours per thousand current dollars for hospitals constructed in 1975, and estimates for 1980.

	1975	*1980*
Construction	39.2	23.4
Onsite	34.7	20.7
Offsite	4.5	2.7
Manufacturing	29.3	16.5
Trade, transportation, and services	15.1	9.1
Mining and all other industries	4.1	2.4

Nearly 89 percent of the hours required in the construction industry in 1975 were spent onsite. The remaining hours represent builders' offsite administrative, office, and warehousing duties.[3] The employee-hour requirements in other industries, which were greater than construction employee hours, composed 55 percent of all hours.[4] Manufacturing accounted for the largest number of these indirect hours with 60 percent.

Onsite hours. Onsite employee-hour requirements per $1,000 of contract cost decreased between each of the three studies. Hospitals surveyed in 1960 and 1966 required 88.8 and 76.1 onsite hours, respectively, compared with 34.7 in 1975.[5] In constant (1972) dollars, 46.7 employee hours were required in 1975, compared with 52.7 in 1960 and 49.9 in 1966. This means that onsite hours declined at an average annual rate of 0.8 percent between 1960 and 1975 and 0.7 percent between 1966 and 1975. Factors contributing to the decline include improvements in construction methods, changes in the types of materials used, differences in individual project characteristics, and increases in productivity. Although onsite hours cannot be used as an exact measure of productivity, changes in onsite hours give an indication of productivity trends in the construction industry.

By occupation. Skilled workers contributed 68.6 percent of all onsite hours in 1975 (table 1). In 1960, skilled workers accounted for 67.8 percent of all hours and in 1966, 70.3 percent. Plumbers (including pipefitters and steamfitters), carpenters, and electricians accounted for the largest proportion of skilled employee hours in all three studies. The proportion of hours contributed by electricians increased with each study, reflecting a growing sophistication and complexity in the electrical equipment and lighting systems used by hospitals.

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Semiskilled and unskilled workers accounted for 22.4 percent of all onsite hours in 1975; in 1960 and 1966, they represented 28.4 percent and 26.4 percent, respectively. The proportion of hours contributed by professional, clerical, and supervisory workers, which was 3.9 percent in 1960 and 3.2 percent in 1966, increased to 8.6 percent in 1975. Supervisory workers' hours accounted for most of this increase.

By type of contractor. General contractors accounted for the greatest proportion in onsite hours with 26.6 percent. In comparison, general contractors contributed 39.1 percent in 1960 and 36.5 percent in 1966. This decline indicates that general contractors are subcontracting more of their onsite duties to special trade contractors. Plumbing and heating, ventilating, and air-conditioning contractors had the second highest proportion of onsite hours, reflecting the extensive amount of plumbing done in hospital construction. Electrical contractors made up the third largest group. This was true for both of the earlier studies, although the proportion contributed by electrical contractors increased between the studies.

Project characteristics

Hospitals completed in 1976 were larger and cost more to build than those previously studied (table 2).

Table 1. Onsite labor requirements per $1,000 of contract cost, by occupation and type of contractor, 1975

Occupation	Percent	Type of contractor	Percent
All occupations	100.0	Total	100.0
Skilled workers	68.6	General contractors	26.6
Brickmasons	3.5		
Carpenters	12.5	Special trade contractors	73.4
Concrete finishers	2.5	Plumbing, heating and air-conditioning	23.8
Drywall installers	1.0	Electrical	13.0
Electricians	11.9	Plastering and lathing	6.5
Elevator installers	0.7	Masonry	5.5
Glaziers	0.5	Concrete work	4.4
Insulation workers	2.2	Roofing and sheet metal work	2.4
Lathers	2.1	Ornamental and structural metal work	2.2
Operating engineers	2.1	Wallboard	2.1
Painters	1.6	Painting and wallpapering	1.9
Pipefitters and steamfitters	6.0	Terrazzo and tile work	1.7
Plasterers	1.5	Carpentry	1.6
Plumbers	6.6	Excavations, foundations, footings, and grading	1.4
Reinforcing ironworkers	1.6	Elevators	1.2
Roofers	0.6	Insulating	1.1
Sheet metal workers	5.4	All other types	4.6
Structural metal and ornamental ironworkers	2.6		
Tile setters, hard	0.6		
Other skilled workers	3.1		
Semiskilled and unskilled workers	22.4		
Laborers	19.0		
Helpers	1.6		
Truck drivers and other semiskilled or unskilled workers	1.8		
Supervisory, professional, technical, and clerical workers	8.6		

NOTE: Detail may not add to totals due to rounding.

Table 2. Selected project characteristics for hospital construction, 1960, 1966, and 1975

Characteristic	1960	1966	1975
Number of projects	46	61	90
Floor space (1,000 square feet)	56.5	63.5	163.6
Average total cost	$1,463,723	$1,811,459	$8,097,826
Cost per square foot	$25.93	$28.51	$49.48
Number of beds per project	86	82	128
Cost per bed	$16,947	$22,172	$63,448
Proportion of average total cost for—			
Onsite wages and salaries	28.2	29.6	27.7
Materials, built-in equipment, and supplies	53.2	50.4	42.2
Construction equipment	1.2	1.3	2.4
Residual	17.4	18.7	27.7

Additions to existing hospitals continued to outnumber new hospital buildings. The proportion of additions increased from 57.4 percent of all projects in 1966 to 81.9 percent in 1975, which may help to explain the large increase in project cost between the two studies. Cost per square foot is generally higher for additions than for new hospitals, because extensive alterations to the original building are often required before new construction can begin.

Between the earliest and latest studies, the average number of square feet per project increased twice as much as the number of beds. This suggests that the newer hospitals contain more space for equipment and special purpose areas (such as diagnostic and therapy rooms, laboratories, and x-ray rooms) than the hospitals in the earlier studies.

Costs

Components of cost. The proportion of total hospital contract cost for onsite wages and salaries declined between 1966 and 1975, after increasing between the first and second studies (table 2). Materials, built-in equipment, and supplies showed a large decrease, from 53.2 percent of total contract cost in 1960 to 42.2 percent in 1975. The proportion of total cost for contractor's equipment increased slightly between the first and most recent studies. Profit and overhead (which includes interest expenses, salaries of offsite workers, supplementary wage benefits, office and other overhead expenses, and profit) jumped from 17.4 percent in 1960 to 27.7 percent in 1975. Higher interest rates and increases in salaries and supplementary benefits were the major factors contributing to this rise.

Materials costs. Materials, built-in equipment, and supplies accounted for the largest proportion of contract cost. Of the types of materials used, fabricated metal products had the highest cost per $1,000 of construction value (table 3). Stone, clay, glass, and concrete products were next, followed by electrical machinery and equipment. These three product groups accounted for more than half of all the materials used in hospital

construction in 1975. The proportion of total material cost for electrical products increased between 1966 and 1975, replacing built-in equipment and nonelectrical machinery as the third most important product group.

Regional data

Project characteristics. Data compiled by region[6] reflect differences in project design, size, and cost (table 4). On average, the largest projects were in the South. Hospitals built in the South had the highest average cost, the most floor space, and took longer to build than those in all other regions. Hospitals in the Northeast were the smallest and the most expensive (per square foot). The majority of projects in the Northeast were small additions to existing hospitals; they contained relatively little floor space, and several included extensive rehabilitation work. Fewer hospitals were built in the West than in any of the other regions; thus, the difference between the proportion of additions and new buildings for that region and the United States as a whole.

Hours and wages. The South had both the lowest average hourly wage and the smallest ratio of wages to total contract cost. Onsite employee-hour requirements per $1,000 were highest in the South, which suggests that the relatively low wage rates in the region encouraged the use of labor intensive construction methods. Thus, the low wage rate is thought to be responsible for the South having the smallest ratio of wages to total contract cost, even though employee-hour requirements were highest. The North Central region had the highest average hourly wage, and was tied with the West for the largest ratio of wages to total cost. Employee-hour requirements were lowest in the Northeast, where the majority of projects were located in metropolitan areas. Because hourly wages and the availability of skilled workers are usually greater in metropolitan areas, employee-hour requirements tend to be lower for projects built in metropolitan rather than nonmetropolitan areas. □

Table 3. Cost of materials, equipment, and supplies used in hospital construction, 1975

Type of material	Cost per $1,000 of contract cost	Percent
All materials, equipment, and supplies	$442.24	100.0
Materials, built-in equipment, supplies	417.84	95.5
Agricultural products	.40	.1
Mining of nonmetallic minerals, except fuels	1.44	.3
Textile mill products	1.06	.2
Lumber and wood products, except furniture	13.18	3.0
Furniture and fixtures	10.06	2.3
Paper and allied products	1.73	0.4
Chemicals and allied products	4.48	1.0
Petroleum refining and related products	4.96	1.1
Rubber and miscellaneous plastic products	4.65	1.0
Stone, clay, glass, and concrete products	81.90	18.5
Primary metal products	43.73	9.9
Fabricated metal products	105.26	23.8
Machinery, except electrical	58.77	13.3
Electrical machinery, equipment, and supplies	66.74	15.1
Measuring, analyzing, and controlling instruments	15.11	3.4
Other materials and supplies	4.36	1.0
Construction equipment	24.40	5.5

NOTE: Detail may not add to totals due to rounding.

Table 4. Selected project characteristics for hospital construction, by region, 1975

Project characteristic	United States	Northeast	North Central	South	West
Average number of square feet per project (100 sq. ft.)	1,636.4	859.5	1,798.9	2,091.1	990.0
Average cost per project	$8,097,826	$6,400,883	$7,963,530	$10,009,634	$5,435,938
Average cost per square foot	$49.48	$74.48	$44.27	$47.87	$54.91
Average number of weeks of construction	154	145	149	174	121
Additions as a percent of all projects	81.9	87.7	85.7	84.3	49.5
New buildings as a percent of all projects	18.2	12.3	14.6	15.7	49.5
Percent of projects in metropolitan areas	49.9	62.6	44.5	48.9	49.5
Percent of projects in nonmetropolitan areas	50.1	37.4	55.5	51.1	49.5
Employee hours per $1,000 of contract cost	34.7	32.0	33.8	36.3	35.4
Average hourly wage	$7.99	$8.60	$8.70	$7.18	$8.29
Wages as a percent of total contract cost	27.7	27.5	29.4	26.1	29.4

FOOTNOTES

[1] Employee-hour estimates for 1980 were based on 1975 onsite employee-hour data, adjusted for price and productivity change. The deflator used to adjust the onsite hours for price change was the Bureau of the Census' cost index for nonresidential buildings: 1965–66—65.6; 1974–75—134.65; 1980—217. Productivity change was calculated by adjusting the change in onsite hours for prices between the 1966 study and the latest study. The average annual rate of change was 0.7 percent. Although most of the projects in the latest survey were completed in 1976, most of the construction value was put in place during 1974–75.

[2] Employment estimates were derived using 1,800 hours per year for onsite construction; 2,000 for offsite construction; 2,068 for manufacturing; 1,779 for trade, transportation, and services; and 2,025 for mining and all others.

[3] Offsite employee hours were estimated using the ratio of nonconstruction employees to total employees for special trade contractors in the contract construction industry, as reported in *Employment and Earnings,* Bulletin 1312–11 (Bureau of Labor Statistics, 1979). This ratio was applied to the onsite hours obtained in the survey, which had been adjusted for the hours worked by administrative and clerical employees.

[4] Indirect employee hours were calculated using inter-industry growth models. Data on materials and equipment were grouped by type, and the dollar amounts for each group were adjusted by the appropriate producer price index. The data were then processed through the Bureau of Labor Statistics' input-output model to determine the number of employee hours required per $1,000 of construction for each industry group.

[5] The first two surveys are referred to as the 1960 and 1966 studies; however, most of the construction occurred during 1959–60 and 1965–66, respectively. See *Labor Requirements for Hospital Construction,* Bulletin 1340 (Bureau of Labor Statistics, 1962); Herman J. Rothberg, "Labor requirements for hospital construction, 1959–60," *Monthly Labor Review,* October 1962, pp. 1120–24; *Labor and Material Requirements for Hospital and Nursing Home Construction,* Bulletin 1691

(Bureau of Labor Statistics, 1971); and Martha Farnsworth Riche, "Man-hour requirements decline in hospital construction," *Monthly Labor Review,* November 1970, p. 48.

[6] Data were provided for the continental United States and four broad geographic regions. The States included in each region were: *Northeast*—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; *North Central*—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; *South*—Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; and *West*—Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Impact of new electronic technology

RICHARD W. RICHE

The steady stream of technological progress that has characterized our society in America has resulted in higher productivity, elimination of many menial and dangerous jobs, higher wages and shorter hours, and a continuous flow of new products and services which have resulted in a higher standard of living. New industries employing thousands of workers have been formed to manufacture computers, electronic products, and technologies to provide energy and control the environment.

To be sure, innovation in industries such as longshoring, agriculture, and printing, to name a few, has eliminated jobs and required workers to acquire the unfamiliar skills associated with new technology. For some, the adjustment has been painful. But on balance, there is general agreement that the benefits of new technology far outweigh the disadvantages, and that innovation has led to economic progress, new job opportunities, and a more prosperous society.

At this point, early in the decade of the 1980's, there is widespread agreement that the pace of diffusion of technologies which incorporate advanced electronics will be accelerated over the next few years. The experience in the United States suggests that as long as the economy is growing, the introduction of innovations with potential for productivity gains can be compatible with rising employment. When computers were first introduced for office data applications, for example, frequently predictions were made that large numbers of clerical and kindred workers would be displaced and that job opportunities for millions would be curtailed. What actually did happen was quite different. In 1960, clerical workers in the United States numbered about 10 million and accounted for about 15 percent of total employment. By 1980, there were more than 18 million clerical workers and they accounted for about 19 percent of the total. Thus, instead of decreasing as had been predicted, clerical employment increased about 85 percent. And, it is projected to grow significantly to 1990.

Why did clerical employment increase instead of decreasing as predicted? First, normal growth in the volume of clerical work exceeded jobs eliminated by the computer. Second, computers made possible work that was previously impractical because it would have been too costly and too time consuming. Using computers, managers can now prepare reports and analyses that previously were desirable but too costly.

In addition to creating employment by expanding the scope of activities for many industries, the computer required new occupations such as systems analysts, programmers, keypunch operators, console operators, and tape librarians. And new industries were established to manufacture computers and related equipment, creating a variety of occupations and employing thousands.

Technological change can cause job displacement, especially when the industry is concentrated in a particular region or locality. Sometimes the employment impact is direct, as in the case of agriculture. In most cases, however, the effect is less obvious. Output does not advance at the same rate as productivity in all industries or plants, and consequently some industries register employment declines while others register increases. Regardless of the reason, displacements are costly for both the individual and the Nation.

This report examines four major technological changes under way in the United States and discusses prospects for their further diffusion. The four areas are microelectronics, industrial robots, telecommunications, and office automation.

The development of *microprocessors and microcomputers* in the early 1970's, and their widespread diffusion as we enter the 1980's, is a major innovation in electronics. Over the past three decades, the transistor that replaced the bulky vacuum tube was a first step in the development of miniaturized semiconductor integrated circuits which provide more power and reliability in a significantly smaller package. A microprocessor unit contains thousands of electronic components and complex circuits on a silicon chip less than one centimeter square. The unit can be combined with memory and input-output capability to build a microcomputer.

The use of microelectronics has had a significant im-

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