Cost and volume trends in health care facility construction

by William L. England

In 1987, the Health Care Financing Administration proposed adding capital cost reimbursement to the prospective payment system. A data base was developed from which an index was calculated to adjust for geographic variation in construction cost. Findings from the data base, along with a description of trends in health care facility construction from 1970 through 1986, are presented. Spending (in constant 1986 dollars) and volume of health care facility construction declined from 1970 to 1986. Construction cost per square foot increased until 1983, followed by a decline to pre-1980 levels after the 1983 implementation of the prospective payment system.

Introduction

In May 1987, the Health Care Financing Administration (HCFA) published a proposal to incorporate capital-related costs into the Medicare prospective payment system (*Federal Register,* 1987a). Included in the proposal was an index to adjust the proposed fixed capital (construction cost) reimbursement system for historical geographic variation in the cost of hospital construction. HCFA's proposal was not implemented because, with the Omnibus Budget Reconciliation Act of 1987, Congress pushed back the question of including capital in the prospective payment system (PPS) until 1991. However, the data base used by HCFA to compute the PPS construction cost index is of historical interest for analysis of health care facility construction trends.

Health care facility construction data

After reviewing a number of potential data sources, HCFA selected the Dodge/Data Resources Incorporated (Dodge/DRI) Construction Potentials data base as the best data source for calculating the PPS construction cost index. The Dodge/DRI data base is widely used by the construction industry, and it contains information on all major building projects in the country, both new construction and alterations, that have a projected value of more than $25,000. The data are collected from building permit offices and other sources by a network of 1,500 field correspondents. The data recorded on each project include the project starting date, type of facility to be built, contract cost, square footage to be constructed, and location by city and county. Data are entered into the data base after a contract has been signed and construction is to begin within 60 days (*Federal Register,* 1987a).

To maintain consistency with the PPS wage index and to obtain a reasonable degree of specificity in geographic variation, HCFA chose to calculate the construction cost index at the level of metropolitan statistical areas (MSAs) and New England county metropolitan areas (NECMAs), which are the equivalent of MSAs in the New England area (*Federal Register,* 1986). This produced a separate index value for each of the 317 MSAs and NECMAs, as well as for the 48 State rural areas outside MSA or NECMA boundaries. (Using MSA or NECMA definitions, New Jersey and Rhode Island have no rural areas.)

Originally, HCFA planned to calculate the index using only health care facility construction data from Dodge/DRI. This data set included hospitals, clinics, medical offices, nursing and convalescent facilities, and other health treatment buildings. However, for the 17 years of data available (1970-86), 36 percent of the data cells for MSAs, NECMAs, or rural areas were empty. Of the 365 areas, 110 had no reported health care facility construction in at least 9 of the 17 years, and 12 areas had 3 or fewer years of construction during the 17-year period.

To avoid the controversy of developing a method to accommodate the random variation that would result from calculating the index with such scarce data in some areas, HCFA instead merged the health care facility construction data with non-health care, non-residential, institutional construction data from Dodge/DRI. This second set of data was thought to be a reasonable proxy for geographic variation in the cost of hospital construction. It included schools and colleges, laboratories not owned by manufacturers, libraries and museums, capitols, courthouses, city halls, other government buildings, houses of worship, and other religious buildings. However, merging the two sets of data without adjusting for differences in the types and cost of construction also proved controversial (*Federal Register,* 1987b).

When these two sets of data were combined, all areas had data recorded for each year, the total volume of recorded construction increased from 0.6 to 4.2 billion square feet, and the total cost of construction in the data base increased from $77 billion to $330 billion in constant 1986 dollars. (As used in this article, "volume" means square feet of construction, and "cost" and "spending" for construction are synonymous.)

The PPS construction cost index was computed by calculating an annual index for each of the 365 areas (the ratio of each area's cost per square foot to the national average for the respective year) and then computing a 17-year index for each area by weighting the 17 annual indexes for each area by the volume of construction in each area for each year. Any of the 6,205

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(365 × 17) area values for cost per square foot that exceeded three times or were less than one-third the national average for their respective year were excluded as outliers. The final index was normalized to have a national mean of 1.0. For the published index, only 15 years of data were used, 1972-86, rather than the full 17 years of data available, because it was found that the 2 additional years had almost no impact in further stabilizing the index from random year-to-year variation (*Federal Register*, 1987b).

The data used for this article include both the health care facility construction data set and the institutional construction data set. A population data set was also developed for each area to normalize the cost and volume of construction to a per capita basis (U.S. Bureau of the Census, 1976 and 1986). U.S. Department of Commerce data were used to deflate costs to constant 1986 dollars (U.S. Department of Commerce, 1987). In the Commerce Department data, 1982 was the base year (1982 = 100). For this article, a conversion was made to 1986 = 1.00. The resulting cost deflators were: 1970, 3.063; 1971, 2.874; 1972, 2.700; 1973, 2.484; 1974, 2.158; 1975, 1.982; 1976, 1.898; 1977, 1.758; 1978, 1.564; 1979, 1.382; 1980, 1.246; 1981, 1.151; 1982, 1.118; 1983, 1.090; 1984, 1.051; 1985, 1.020; and 1986, 1.000.

The analysis for this article is at the national and census division level rather than at the level of MSAs, NECMAs, and rural areas. At this level, the health care facility construction data and the institutional construction data can be directly compared, without adjusting for empty data cells, because on the division level, none of the cells in the health care facility construction data set was empty. However, because the analysis is not at the level of MSAs, NECMAs, and rural areas, it is not directly comparable with the PPS construction cost index.

Methods

The 17 years of MSA, NECMA, and rural area data were aggregated into the nine census divisions, and costs were multiplied by the U.S. Commerce Department deflation factors to give constant 1986 dollars. In the graphs in Figures 1-5 and the corresponding Tables 1-5, the national and division averages are shown. The solid and gray shading in the graphs is used to separate adjacent years.

To distinguish the possible influence of PPS on trends in the data, separate graphs were developed for the PPS waiver States (Massachusetts, Maryland, New Jersey, and New York) and for the remaining nonwaiver States. The States comprising each division and their waiver status are given in Table 6. Because costs for construction in Alaska and Hawaii were thought to be substantially different from costs for the 48 contiguous States, their data were excluded from this analysis. Separate graphs were developed for urban and rural areas: The urban graph is the average for all MSAs and NECMAs in the country, the rural graph is the average for all State rural areas, and the national average includes all States and areas.

The graphs in Figure 1 and the values in Table 1 were derived by dividing the total annual spending for health care facility construction in each area by the area population to give the annual per capita health care facility construction spending. For Figure 2 and Table 2, the annual volume of health care facility construction was divided by the population to give the annual per capita square feet of health care facility construction. For Figure 3 and Table 3, the total annual cost was divided by the total annual volume of health care facility construction to give the average health care facility construction cost per square foot. For Figure 4 and Table 4, the cost per square foot of health care facility construction in an area was divided by the area cost per square foot of institutional construction to produce a ratio of health care facility to institutional construction costs. For Figure 5 and Table 5, the volume of health care facility construction was computed as a percentage of the total volume of health care facility and institutional construction in the data base (i.e., both data sets).

Descriptive statistics for the graphs in the figures are given in the tables. The mean is the average of the data over the 17 years. The coefficient of variation was computed by dividing the standard deviation by the mean. The annualized rate is the slope of a simple linear regression line fit to the data, converted to a compound annual percentage rate of change. R^2 is the amount of variation explained by the regression.

To aid in discerning short-term trends in the data, a piecewise linear regression model was used. For such a model, the regression line is a series of connected straight line segments, or pieces, with one or more breakpoints (changes in the slope of the graph) over the 17-year interval. A multiple linear regression was run with 16 dummy variables to determine the best piecewise linear fit of the data. Dummy variable 1 contained the numbers 0 through 16 in ascending order; dummy variable 2 contained two zeros, followed by 1 through 15; and so on to dummy variable 16, which contained 16 zeros followed by a 1. Regression with these variables allowed the slope of a regression for each graph to change in any year. Dummy variables were entered into the regression until R^2 exceeded 0.70 or until five variables were entered. (The choice of using 0.70 or five variables was made to balance simplicity and accuracy in the model.)

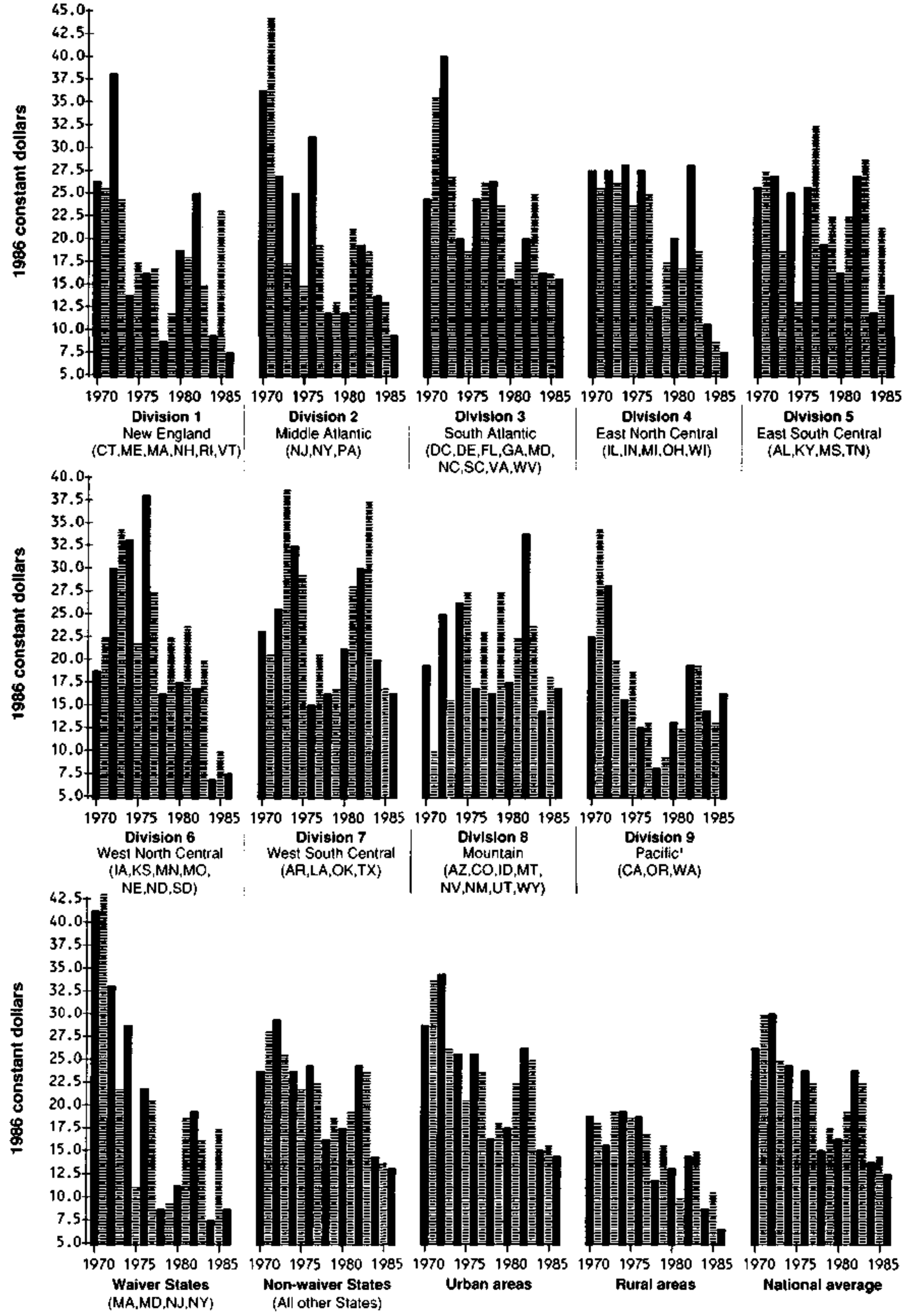
The piecewise linear model for each graph begins at the left-axis intercept value in 1970 and has zero slope until the year of breakpoint 1, which may also be 1970. In that year, the regression line begins sloping at the annualized rate shown for breakpoint 1. In the year shown as breakpoint 2, the slope changes to the annualized rate shown for breakpoint 2, and so on to the last breakpoint year shown. The slope from the last breakpoint continues to 1986. If less than five breakpoints are shown, then R^2, the percent of variation explained by the piecewise linear regression, exceeded 0.70 with fewer than five breakpoints, and additional dummy variables were not entered into the model.

Results

As shown in Figures 1-3 and Tables 1-3, per capita spending and square feet of health care facility construction declined significantly from 1970 to 1986, but the cost per square foot remained relatively constant (in 1986 dollars). An exception to these trends took place in

Figure 1

Health care facility construction spending per person in 1986 constant dollars, by census division, waiver status of States, and urban-rural areas: United States, 1970-86



[1]Alaska and Hawaii are also in this census division but were excluded from the analyses.

SOURCES: Dodge/Data Resources Incorporated Construction Potentials data base; (U.S. Bureau of the Census, 1976 and 1986).

Table 1
Regression models for graphs in Figure 1

Model statistic	Division													
	New England (1)	Middle Atlantic (2)	South Atlantic (3)	East North Central (4)	East South Central (5)	West North Central (6)	West South Central (7)	Mountain (8)	Pacific (9)	Waiver States	Nonwaiver States	Urban areas	Rural areas	National average
Single-variable linear regression														
Mean	$18.37	$20.19	$22.66	$20.41	$21.90	$21.36	$23.74	$20.56	$16.78	$19.65	$20.88	$22.66	$14.41	$20.74
Coefficient of variation	.424	.476	.299	.356	.267	.420	.314	.292	.395	.559	.231	.272	.288	.264
Annualized rate[1]	–3.39	–4.62	–3.15	–3.95	–1.67	–4.06	–1.18	.41	–3.22	–5.31	–2.81	–3.15	–3.58	–3.24
R^2	.284	.521	.474	.607	.130	.468	.043	.005	.289	.561	.597	.574	.710	.655
Piecewise[2] linear regression														
Left-axis intercept	$24.09	$36.37	$24.31	$25.69	$23.61	$18.69	$22.70	$14.34	$22.34	$43.62	$26.62	$32.46	$17.98	$29.05
R^2	.708	.748	.717	.704	.473	.750	.731	.564	.783	.792	.807	.723	.770	.831
Breakpoint 1:														
Annualized rate	20.8	14.8	57.5	–3.8	–4.9	20.6	14.2	56.5	30.8	–17.8	–5.8	–9.9	–7.3	–7.5
Year	1970	1970	1970	1974	1977	1970	1971	1971	1970	1970	1972	1971	1975	1971
Breakpoint 2:														
Annualized rate	–35.9	–29.6	–15.3	–24.1	22.8	–4.5	–21.6	–1.0	–15.8	–2.7	5.7	.0	—	6.3
Year	1972	1971	1971	1982	1981	1973	1974	1972	1971	1975	1979	1975	—	1978
Breakpoint 3:														
Annualized rate	–.3	–3.7	–2.6	—	–59.4	–12.4	31.2	61.7	9.2	—	–20.8	–15.5	—	–14.5
Year	1974	1973	1974	—	1983	1976	1978	1981	1978	—	1983	1983	—	1982
Breakpoint 4:														
Annualized rate	2.6	—	—	—	75.8	—	14.6	–33.4	—	—	—	—	—	—
Year	1976	—	—	—	1984	—	1980	1982	—	—	—	—	—	—
Breakpoint 5:														
Annualized rate	–57.6	—	—	—	–33.6	—	–27.9	9.0	—	—	—	—	—	—
Year	1985	—	—	—	1985	—	1983	1984	—	—	—	—	—	—

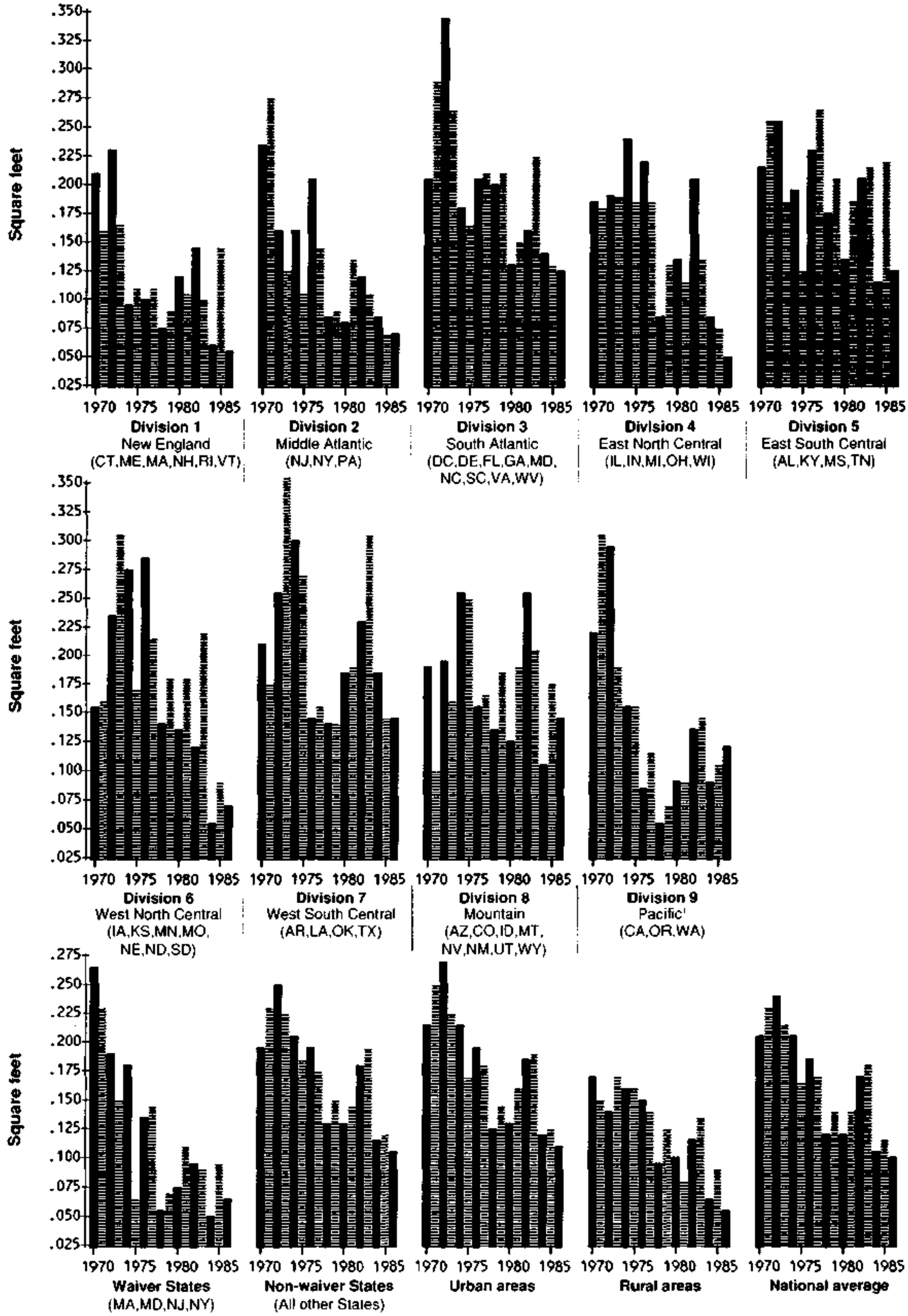
[1]The cumulative slope of the regression is shown converted into a compound annual percentage rate of change.

[2]A piecewise linear regression approximates the graph as a series of connected straight line segments, with 1 or more breakpoints, or changes in the slope of the graph, determined by multiple linear regression. R^2 indicates the amount of variation explained by the regression.

SOURCES: Dodge/Data Resources Incorporated Construction Potentials data base; (U.S. Bureau of the Census, 1976 and 1986).

Figure 2

Health care facility square feet of construction per person, by census division, waiver status of States, and urban-rural areas: United States, 1970-86



[1]Alaska and Hawaii are also in this census division but were excluded from the analyses.

SOURCES: Dodge/Data Resources Incorporated Construction Potentials data base; (U.S. Bureau of the Census, 1976 and 1986).

Table 2
Regression models for graphs in Figure 2

Model statistic	Division													
	New England (1)	Middle Atlantic (2)	South Atlantic (3)	East North Central (4)	East South Central (5)	West North Central (6)	West South Central (7)	Mountain (8)	Pacific (9)	Waiver States	Nonwaiver States	Urban areas	Rural areas	National average
Single-variable linear regression														
Mean	.1192	.1302	.1936	.1499	.1922	.1735	.2054	.1735	.1400	.1186	.1699	.1750	.1211	.1625
Coefficient of variation	.408	.457	.309	.372	.237	.419	.325	.277	.520	.545	.253	.273	.304	.271
Annualized rate[1]	–3.80	–4.69	–3.30	–3.94	–1.83	–3.75	–1.88	–.43	–4.68	–5.40	–3.13	–3.32	–3.73	–3.40
R^2	.417	.586	.499	.550	.203	.380	.115	.007	.452	.622	.654	.651	.709	.708
Piecewise[2] linear regression														
Left-axis intercept	.1903	.2585	.2093	.2017	.2422	.1320	.1864	.1520	.2822	.2598	.2280	.2501	.1605	.2314
R^2	.737	.711	.811	.717	.484	.728	.876	.466	.811	.826	.829	.822	.801	.845
Breakpoint 1:														
Annualized rate	2.2	–17.1	28.0	–10.2	–11.3	31.5	37.6	8.5	–16.4	–16.8	–7.5	–7.9	–9.3	–7.4
Year	1970	1970	1970	1974	1971	1970	1971	1971	1970	1970	1972	1971	1974	1971
Breakpoint 2:														
Annualized rate	–23.3	–5.2	–24.6	1.6	.1	–22.5	–24.1	–6.7	8.3	–3.7	3.2	3.9	–.1	2.7
Year	1972	1973	1972	1978	1973	1973	1973	1975	1978	1975	1978	1978	1978	1978
Breakpoint 3:														
Annualized rate	2.1	—	–2.6	–34.5	–39.2	28.6	13.7	87.8	—	—	–17.8	–16.4	–20.6	–16.8
Year	1975	—	1974	1983	1983	1975	1977	1981	—	—	1983	1983	1983	1983
Breakpoint 4:														
Annualized rate	–52.2	—	—	—	84.1	–11.2	–21.7	–31.2	—	—	—	—	—	—
Year	1985	—	—	—	1984	1976	1983	1982	—	—	—	—	—	—
Breakpoint 5:														
Annualized rate	—	—	—	—	–41.4	—	—	14.0	—	—	—	—	—	—
Year	—	—	—	—	1985	—	—	1984	—	—	—	—	—	—

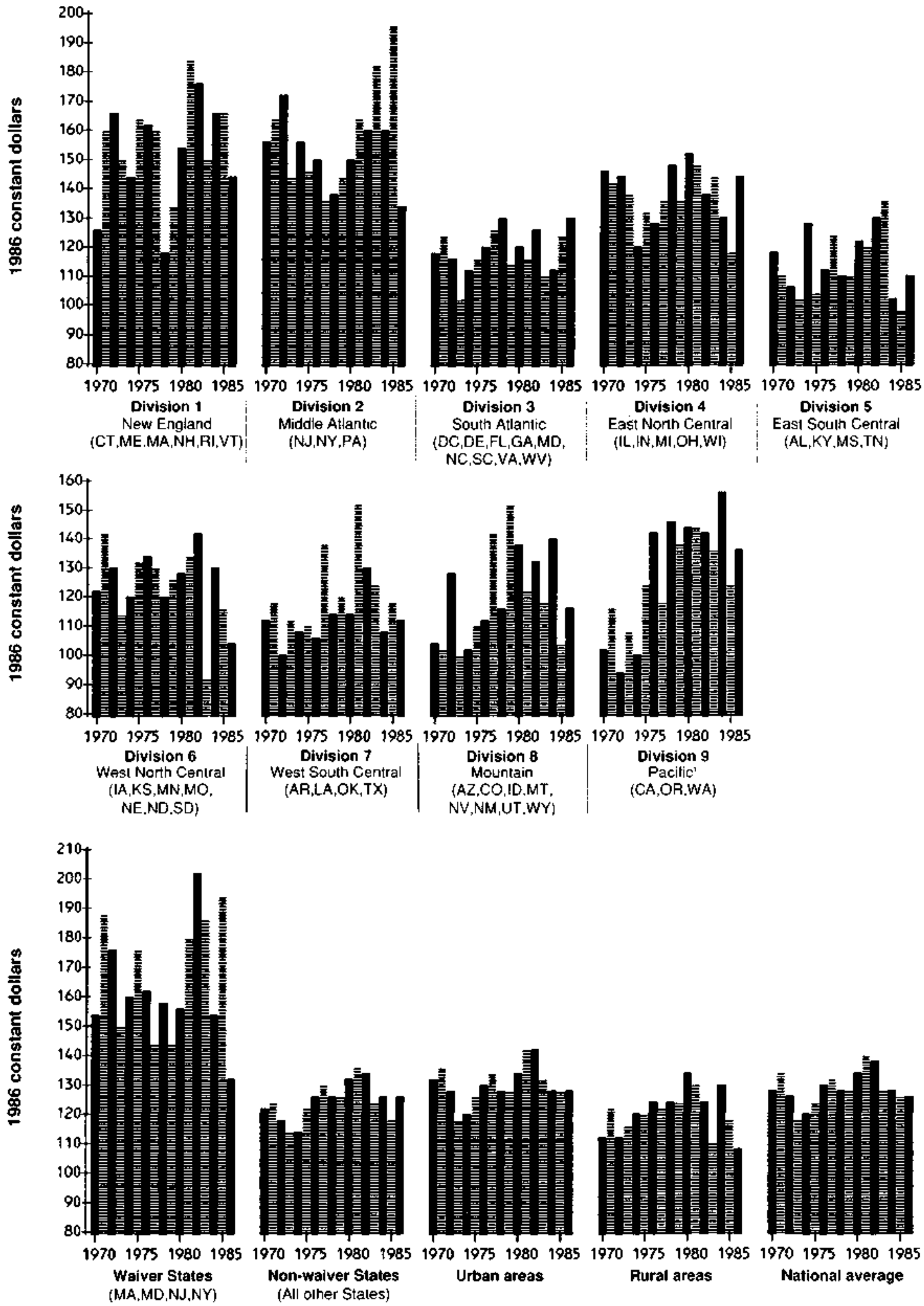
[1]The cumulative slope of the regression is shown converted into a compound annual percentage rate of change.

[2]A piecewise linear regression approximates the graph as a series of connected straight line segments, with 1 or more breakpoints, or changes in the slope of the graph, determined by multiple linear regression. R^2 indicates the amount of variation explained by the regression.

SOURCES: Dodge/Data Resources Incorporated Construction Potentials data base; (U.S. Bureau of the Census, 1976 and 1986).

Figure 3

Health care facility construction cost per square foot in 1986 constant dollars, by census division, waiver status of States, and urban-rural areas: United States, 1970-86



[1]Alaska and Hawaii are also in this census division but were excluded from the analyses.

SOURCE: Dodge/Data Resources Incorporated Construction Potentials data base.

Table 3
Regression models for graphs in Figure 3

Model statistic	New England (1)	Middle Atlantic (2)	South Atlantic (3)	East North Central (4)	East South Central (5)	West North Central (6)	West South Central (7)	Mountain (8)	Pacific (9)	Waiver States	Nonwaiver States	Urban areas	Rural areas	National average
	Division													
Single-variable linear regression														
Mean	$153.5	$154.9	$117.7	$136.8	$113.5	$123.4	$116.3	$119.0	$127.0	$164.8	$123.6	$129.6	$119.6	$128.0
Coefficient of variation	.111	.105	.065	.072	.098	.106	.104	.138	.150	.119	.052	.049	.063	.047
Annualized rate[1]	.51	.38	.32	-.11	.13	-.65	.66	.93	1.87	.13	.43	.24	.18	.24
R^2	.060	.035	.064	.006	.004	.107	.115	.134	.539	.003	.192	.062	.023	.071
Piecewise[2] linear regression														
Left-axis intercept	$126.9	$159.7	$121.1	$148.5	$110.2	$125.9	$113.9	$98.3	$106.3	$166.2	$121.7	$133.7	$111.3	$130.5
R^2	.798	.760	.689	.724	.661	.784	.731	.580	.735	.764	.731	.742	.762	.718
Breakpoint 1:														
Annualized rate	22.8	-2.7	-7.3	-4.0	3.9	6.1	-8.2	10.1	-3.1	-4.0	-3.2	-6.2	1.5	-4.5
Year	1970	1972	1971	1970	1975	1980	1971	1970	1970	1975	1971	1971	1970	1971
Breakpoint 2:														
Annualized rate	.2	4.5	4.5	1.9	-3.9	-36.9	1.7	-9.1	5.0	12.6	2.0	4.2	-4.5	1.6
Year	1971	1978	1973	1974	1977	1982	1972	1972	1972	1979	1973	1973	1980	1973
Breakpoint 3:														
Annualized rate	-27.3	-27.6	-1.0	2.7	5.3	44.0	22.0	7.7	-1.6	-11.4	-2.2	1.5	14.1	-2.7
Year	1977	1985	1977	1976	1979	1983	1980	1974	1980	1982	1981	1974	1983	1982
Breakpoint 4:														
Annualized rate	15.5	—	-3.2	-5.2	-27.4	-10.4	-9.1	-6.3	—	21.6	—	-2.5	-8.9	—
Year	1978	—	1982	1981	1983	1984	1981	1979	—	1984	—	1982	1984	—
Breakpoint 5:														
Annualized rate	-3.3	—	8.6	19.4	4.2	—	1.6	-2.8	—	-31.2	—	—	—	—
Year	1981	—	1984	1985	1984	—	1984	1980	—	1985	—	—	—	—

[1]The cumulative slope of the regression is shown converted into a compound annual percentage rate of change.

[2]A piecewise linear regression approximates the graph as a series of connected straight line segments, with 1 or more breakpoints, or changes in the slope of the graph, determined by multiple linear regression. R^2 indicates the amount of variation explained by the regression.

SOURCE: Dodge/Data Resources Incorporated Construction Potentials data base.

the early 1980s, when the spending, volume, and cost per square foot of health care facility construction all increased rapidly for a few years, then declined abruptly after 1983. These trends are most apparent in the national average graphs. Whether these trends are continuing cannot be predicted, because the large discontinuity in the graphs between 1983 and 1984 makes forecasting beyond 1986 based on pre-1984 data highly speculative.

As seen from the three-breakpoint regression fit for the national average in Table 1, per capita construction spending (in 1986 dollars) declined an average of 7.5 percent annually from 1971 to 1978, then increased 6.3 percent annually from 1978 to 1982, followed by a 14.5-percent annual decline from 1982 to 1986. However, these rates are only averages. In particular, the post-1983 decline took place mostly in 1984, when per capita spending decreased 38 percent, to below the 1978 level. From 1984 to 1986, spending remained nearly constant. Overall, construction spending declined an average of 3.2 percent per year throughout the 17-year period.

The same pattern is seen for urban areas, except that urban spending averaged 9 percent more than the national average throughout the period ($22.66 per capita versus $20.74 per capita). Conversely, per capita spending in rural areas averaged 30 percent less than the national average ($14.41 versus $20.74), or 36 percent less than urban spending. Also, the elevated 1971-72 spending shown in the urban and national graphs is absent in the rural graph, and the 3.6-percent average annual decline in rural spending exceeds the 3.2-percent average annual decline in urban spending.

The pattern for the nonwaiver States is quite similar to the national average (as expected, because this graph is an average of the data for 46 of the 50 States). The pattern for the waiver States is like the national pattern but greatly exaggerated, with per capita spending dropping from $42 in 1971 to $9 in 1978. The reason these States received waivers is that they had implemented alternative hospital cost-containment systems prior to 1983. The presumed impact of these systems in reducing construction spending, compared with the rest of the country, is evident in this graph. Per capita spending in the waiver States declined an average of 5.3 percent annually, almost twice the 2.8-percent rate of decline in the nonwaiver States.

The division graphs in Figure 1 have patterns similar to the national graph, with per capita spending declining throughout the period. The exception is Division 8 (the Mountain States), where spending increased an average of 0.4 percent per year, including a 1982 jump that far exceeded the highs of the early 1970s. Average spending in the last 3 years varied among the divisions by more than 100 percent, ranging from a low of $8 per capita annually in Division 6 (the West North Central States) and in the rural areas to a high of $17 per capita annually in Division 7 (the West South Central States).

The trends in per capita health care facility construction volume in Figure 2 are similar to the spending trends in Figure 1, with the 3.4-percent national average decline being interrupted by a rapid increase from 1981 to 1983. The volume of construction averaged 31 percent less in rural areas than in urban areas, and the rate of decline in the waiver States was almost twice the rate of decline in the nonwaiver States. Division 8 (the Mountain States) had the smallest average annual decline. Again, the 1984-86 values varied by more than 100 percent among the divisions, from a low of 0.07 square feet per capita in Division 6 (the West North Central States) and in the rural areas to a high of 0.16 in Division 7 (the West South Central States).

As seen in Figure 3, the national average cost per square foot displays an "M" pattern, with cost peaking at $133 in 1971, decreasing to $116 in 1973, then slowly climbing to $139 in 1981, declining to $126 in 1983, and remaining at that level through 1986. Overall, the cost per square foot of health care facility construction is seen to be relatively stable in constant dollars, increasing only 0.24 percent per year. However, the R^2 of 0.071 indicates that a linear fit of these data is a poor model of the year-to-year variation. The three-breakpoint regression fit is much better, with an R^2 of 0.718. As seen from this model, the cost per square foot declined 4.5 percent annually from 1971 to 1973, then increased 1.6 percent annually to 1982, followed by a 2.7-percent average annual decline to 1986.

Considerably more year-to-year variation and more rapid rates of change are seen in the other graphs in Figure 3 than in the national graph. On average, the cost per square foot was 8.4 percent higher in urban areas ($129.6) than in rural areas ($119.6). No mid-1970s decline in cost occurred in the rural areas; rather, there was a 1.5-percent average annual increase from 1970 to 1980. After peaking at $135 per square foot in 1980, rural cost declined significantly through 1983, rose 14 percent in 1984, and then dropped sharply in 1985 and 1986. This pattern is different from that seen for the urban areas, where cost peaked at $142 per square foot in 1982 and remained constant from 1984 to 1986.

The waiver States had much greater year-to-year variability in cost per square foot than the nonwaiver States had. This may be because of the smoothing effect of the larger volume of data for the nonwaiver States. However, the increase in cost per square foot that took place nationally in the early 1980s appears to have been more exaggerated for the waiver States than for the nonwaiver States, and the 1985 jump in cost for the waiver States did not take place in the nonwaiver States. Most of this jump is attributable to New Jersey (which accounted for 23 percent of the waiver States' construction volume), where cost rose from $127 to $225 per square foot in 1985, and to New York (44 percent of the volume), where cost rose from $159 to $184 per square foot in 1985. In 1986, New Jersey dropped to $180 per square foot and 4 percent of the waiver States' volume, and New York dropped to $125 per square foot but increased to 63 percent of the volume.

For Divisions 1 and 2 (the New England and Middle Atlantic States, respectively) and for the waiver States, the "M" pattern of the national graph is greatly exaggerated. Overall, the cost per square foot was consistently much higher in these divisions and the waiver States than in the other divisions. However, the large 1986 cost decline in Divisions 1 and 2, not experienced by the other divisions, brought them more in line with the rest of the Nation.

As seen in Figure 4 and Table 4, the ratio of the cost per square foot of health care facility construction to the cost per square foot of institutional construction had a national average of 1.819 and a range over the 17 years from 1.55 in 1973 to 2.05 in 1981. Throughout the 1970s, the cost of health care facility construction increased an average of 2.5 percent faster per year than the cost for institutional construction did. However, after the peak in 1981, the cost of institutional construction increased an average of 3.5 percent faster per year than the cost of health care facility construction did, with most of the increase occurring in 1983.

On the division level, the ratios in Figure 4 vary greatly. For Divisions 1 and 2 (the New England and Middle Atlantic States, respectively) and for the waiver States, the ratio was generally at or below the national average, meaning that, although health care facility construction cost was high in those areas (Figure 3), the cost was relatively low when normalized by institutional construction cost. The 33.5-percent drop in the ratio for the waiver States in 1986 is significant, because it is an indication that the 1986 drop in the cost per square foot of health care facility construction for the waiver States (Figure 3) did not result from a general decline in construction cost in those States.

Ideally, for the institutional construction data to be used as a proxy for hospital construction, the ratios in Figure 4 should be relatively constant. Because they are not, merging the two sets of data together biased the index for or against some areas. For example, the ratio in Division 5 (the East South Central States) tended to be above the national average except in 1984 and 1985, but the cost per square foot of health care facility construction in that division (Figure 3) was generally below the national average. This suggests that the cost of institutional construction in Division 5 was even further below the national average than the cost of health care facility construction was. Therefore, merging the two data sets to compute the PPS construction cost index biased the index against Division 5.

In addition, merging the data sets to compute an index implied an assumption that geographic variation in the volume of health care facility and institutional construction in the data was random. However, as seen in Figure 5 and Table 5, the variation was not random. For example, the urban average was 3.75 percent higher than the rural average. In Division 8 (the Mountain States), health care facility construction averaged only 10 percent of the total volume, compared with 19 percent of the volume in Division 2 (the Middle Atlantic States). From 1970 to 1986, the national percentage of health care facility construction ranged from 10 to 21.5 percent, with even larger variation at the division level. Thus, merging the two sets of data without adjusting for differences in the volume and type of construction biased the index. For example, Division 2 (the Middle Atlantic States) was favored, and Division 8 (the Mountain States) was disadvantaged. Smaller biases occurred for other divisions, and urban areas were favored over rural areas.

An additional comparison of the health care facility and institutional construction data sets was accomplished by performing the PPS construction cost index calculations on each data set individually. This produced two indexes that were computationally equivalent to the original index. The correlation coefficient for the two indexes was 0.525 for 17 years of data, or 0.467 if only the 15 years 1972-86 were used. The standard deviation for the 17-year health care facility construction index was 0.197. In comparison, the standard deviation was 0.162 for the institutional construction index. (The standard deviation equals the coefficient of variation because the index was normalized to a mean of 1.0.)

Discussion

Around 1980, a reversal occurred in the trend toward declining health care facility construction volume and spending that began in the early 1970s. A possible explanation of this reversal is that it resulted from concerns about a possible Medicare hospital cost-control system (the prospective payment system) before it was determined that capital (construction) cost would be excluded. Hospitals may have rushed to begin construction projects in the early 1980s, expecting that a capital reimbursement system might be more generous with old construction debt than with new debt. When the actual legislation in April 1983 placed a moratorium on including capital costs in PPS, the rush of capital projects subsided, leading to the large downturn in construction that occurred in 1984.

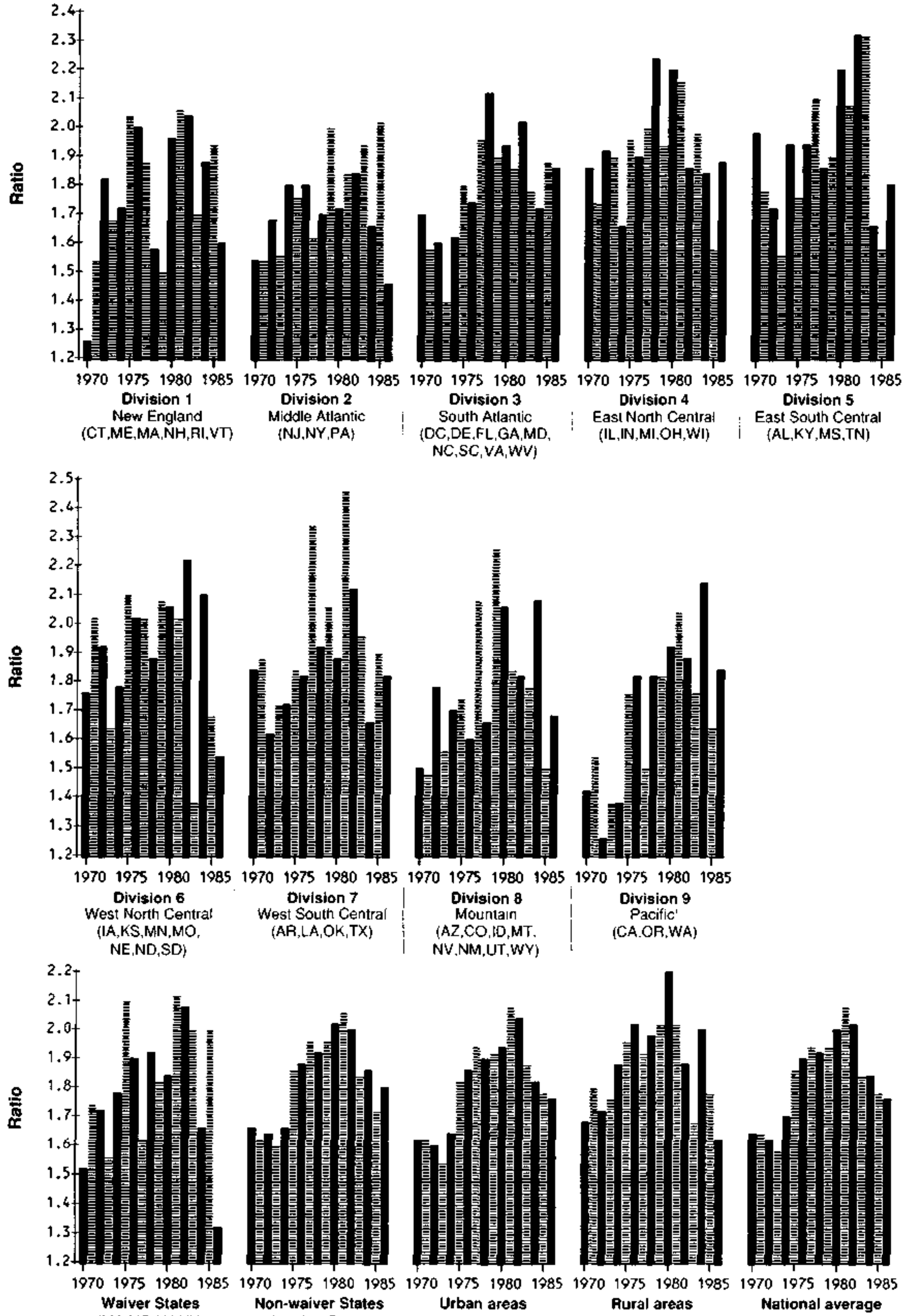
Another theory for the increase in health care facility construction volume and spending of the early 1980s, at least for tax-exempt facilities, is the demand for tax-exempt bonds that was fueled by tax changes making it advantageous to purchase such bonds before 1983 (Merrill, Lynch, Pierce, Fenner, and Smith, Inc., 1983). Although the early 1980s were a period of high interest rates, hospitals that could use tax-exempt financing for construction enjoyed much lower rates.

Other factors that may have contributed to the increased construction volume and spending in the early 1980s include the loss of regulatory influence of health systems agencies, which may have temporarily depressed construction in the late 1970s, and the growth of alternative delivery systems. It is notable that the surge in construction volume and spending in the early 1980s did not generally bring volume and spending back up to the levels of the early 1970s, except in Division 8 (the Mountain States), as shown in Figure 1.

The 1981-82 upturn in the graphs of Figure 3 indicates that not only were health care facilities doing more construction than in previous years but they were also paying more per square foot (in constant dollars). Perhaps the increased construction volume created a builder's market, and contractors became less competitive in pricing. Alternatively, in a rush to beat PPS and tax law changes, health care facilities may not have sought or obtained as competitive rates as they might otherwise have. The health care facility construction data set does not contain information to permit adjusting for the specific types of construction that took place. Therefore, it is also possible that health care facilities rushed to get capital-intensive projects, such as surgery unit renovations, underway before PPS began, and that may have caused a temporary increase in the construction cost per square foot.

Figure 4

Ratio of health care facility to non-health care institutional construction cost per square foot, by census division, waiver status of States, and urban-rural areas: United States, 1970-86



[1]Alaska and Hawaii are also in this census division but were excluded from the analyses.

SOURCE: Dodge/Data Resources Incorporated Construction Potentials data base.

Table 4
Regression models for graphs in Figure 4

Model statistic	Division: New England (1)	Middle Atlantic (2)	South Atlantic (3)	East North Central (4)	East South Central (5)	West North Central (6)	West South Central (7)	Mountain (8)	Pacific (9)	Waiver States	Nonwaiver States	Urban areas	Rural areas	National average
Single-variable linear regression														
Mean	1.766	1.727	1.785	1.910	1.903	1.886	1.906	1.763	1.692	1.794	1.819	1.798	1.868	1.819
Coefficient of variation	.130	.093	.101	.091	.125	.123	.115	.131	.149	.124	.083	.089	.086	.084
Annualized rate[1]	.91	.69	1.01	.15	.44	–.32	.59	.82	1.82	.46	.82	.98	.17	.86
R^2	.144	.155	.301	.007	.034	.018	.074	.114	.509	.037	.285	.369	.011	.308
Piecewise[2] linear regression														
Left-axis intercept	1.236	1.566	1.650	1.801	1.750	1.837	1.853	1.542	1.472	1.630	1.577	1.530	1.673	1.567
R^2	.648	.716	.781	.717	.722	.789	.706	.671	.701	.704	.817	.847	.884	.863
Breakpoint 1:														
Annualized rate	22.5	1.5	–5.4	4.6	2.6	1.7	–9.8	1.5	–10.2	1.6	2.4	2.6	2.4	2.5
Year	1970	1970	1971	1974	1973	1973	1971	1970	1971	1970	1970	1970	1970	1970
Breakpoint 2:														
Annualized rate	–1.5	–12.2	6.4	–7.8	–29.2	–36.4	2.7	21.9	4.6	6.3	–3.4	–3.2	–7.3	–3.5
Year	1972	1983	1973	1978	1983	1982	1972	1976	1972	1980	1981	1981	1980	1981
Breakpoint 3:														
Annualized rate	19.5	20.7	–1.5	4.0	4.2	50.3	16.3	–19.5	–2.3	–11.3	—	—	17.0	—
Year	1979	1984	1978	1979	1984	1983	1980	1977	1981	1982	—	—	1983	—
Breakpoint 4:														
Annualized rate	–1.6	–27.2	—	–6.7	—	–14.8	–10.9	27.7	—	16.9	—	—	–9.9	—
Year	1980	1985	—	1981	—	1984	1981	1978	—	1984	—	—	1984	—
Breakpoint 5:														
Annualized rate	–13.3	—	—	15.9	—	—	4.9	–3.8	—	–33.5	—	—	—	—
Year	1985	—	—	1985	—	—	1984	1979	—	1985	—	—	—	—

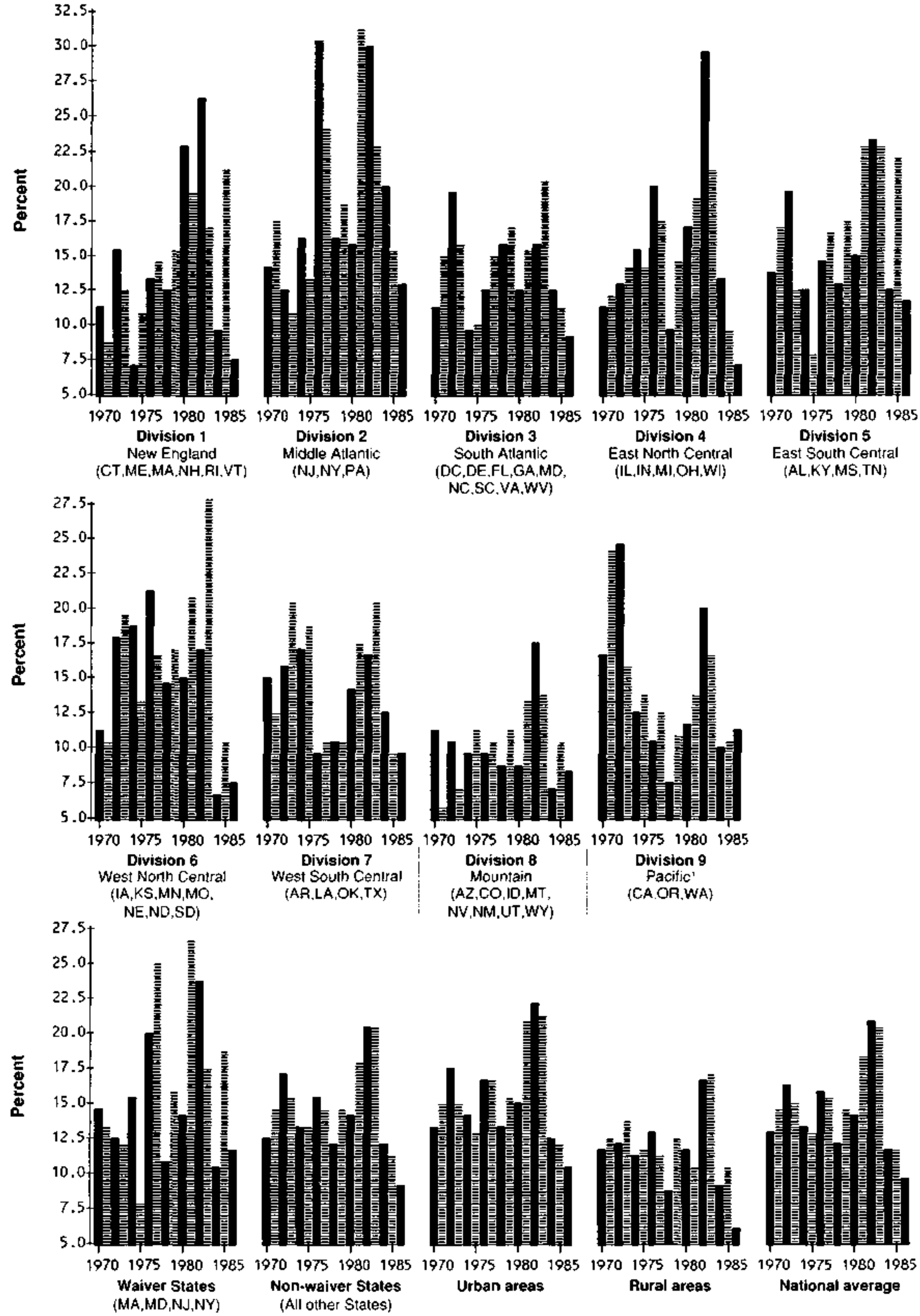
[1]The cumulative slope of the regression is shown converted into a compound annual percentage rate of change.

[2]A piecewise linear regression approximates the graph as a series of connected straight line segments, with 1 or more breakpoints, or changes in the slope of the graph, determined by multiple linear regression. R^2 indicates the amount of variation explained by the regression.

SOURCE: Dodge/Data Resources Incorporated Construction Potentials data base.

Figure 5

Health care facility square feet of construction as a percentage of total institutional square feet of construction, by census division, waiver status of States, and urban-rural areas: United States, 1970-86



[1]Alaska and Hawaii are also in this census division but were excluded from the analyses.

SOURCE: Dodge/Data Resources Incorporated Construction Potentials data base.

Table 5
Regression models for graphs in Figure 5

Model statistic	Division: New England (1)	Middle Atlantic (2)	South Atlantic (3)	East North Central (4)	East South Central (5)	West North Central (6)	West South Central (7)	Mountain (8)	Pacific (9)	Waiver States	Nonwaiver States	Urban areas	Rural areas	National average
Single-variable linear regression														
Mean	14.24	18.80	13.86	14.97	16.01	15.51	13.98	10.08	14.09	15.75	14.41	15.30	11.55	14.48
Coefficient of variation	.387	.347	.234	.360	.285	.346	.277	.279	.343	.337	.209	.213	.222	.206
Annualized rate[1]	2.37	1.75	–.27	.71	1.61	–.81	–1.34	1.25	–2.62	1.38	–.23	.14	–.92	–.06
R^2	.141	.086	.003	.011	.106	.016	.073	.062	.229	.054	.003	.001	.051	.000
Piecewise[2] linear regression														
Left-axis intercept	9.85	11.61	13.20	13.47	16.21	14.26	16.49	11.34	16.50	11.93	13.99	14.58	11.59	14.01
R^2	.684	.678	.537	.713	.787	.740	.729	.759	.777	.489	.822	.782	.768	.823
Breakpoint 1:														
Annualized rate	57.1	9.8	8.4	16.9	–14.9	2.1	–16.0	–29.1	48.0	6.9	10.4	8.3	23.1	10.5
Year	1971	1970	1976	1978	1972	1970	1974	1970	1970	1971	1979	1978	1981	1979
Breakpoint 2:														
Annualized rate	–30.3	–12.0	–26.3	–22.5	11.3	50.1	6.0	2.6	–19.6	–10.5	–42.0	–41.9	–43.6	–42.1
Year	1972	1977	1979	1982	1975	1982	1977	1971	1971	1977	1983	1983	1983	1983
Breakpoint 3:														
Annualized rate	15.5	102.5	16.2	–34.3	–46.1	–72.1	16.4	31.0	11.9	104.4	–11.7	–9.0	–17.0	–10.3
Year	1974	1980	1980	1983	1983	1983	1979	1980	1976	1980	1984	1984	1984	1984
Breakpoint 4:														
Annualized rate	–32.9	–7.9	–35.0	—	71.6	4.6	–42.1	–32.2	–12.4	–19.7	—	—	—	—
Year	1982	1981	1983	—	1984	1984	1983	1982	1982	1981	—	—	—	—
Breakpoint 5:														
Annualized rate	–11.5	–19.6	–14.4	—	–46.7	—	–12.5	7.4	—	–13.5	—	—	—	—
Year	1983	1982	1984	—	1985	—	1984	1984	—	1982	—	—	—	—

[1]The cumulative slope of the regression is shown converted into a compound annual percentage rate of change.

[2]A piecewise linear regression approximates the graph as a series of connected straight line segments, with 1 or more breakpoints, or changes in the slope of the graph, determined by multiple linear regression. R^2 indicates the amount of variation explained by the regression.

SOURCE: Dodge/Data Resources Incorporated Construction Potentials data base.

Table 6

States, by census division and waiver status: United States, 1970-86

Division and waiver status	States included
Division	
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic	New Jersey, New York, Pennsylvania
South Atlantic	District of Columbia, Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia
East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
East South Central	Alabama, Kentucky, Mississippi, Tennessee
West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
West South Central	Arkansas, Louisiana, Oklahoma, Texas
Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific[1]	California, Oregon, Washington
Waiver status	
Waiver	Massachusetts, Maryland, New Jersey, New York
Nonwaiver	Remainder

[1]Alaska and Hawaii are also in this census division but were excluded from the analyses.

NOTE: Waiver States were exempt from the Medicare prospective payment system, implemented in 1983; nonwaiver States were not.

SOURCES: U.S. Bureau of the Census: Divisional groupings; Health Care Financing Administration: Waiver status.

Perhaps the most interesting aspect of these graphs concerns the changes that took place after 1983. The fact that almost every graph reflects an abrupt decline in 1984 strongly suggests that the implementation of PPS had a pronounced effect on health care facility construction. Even though PPS did not directly affect construction reimbursement, health care facilities may have cautiously slowed construction out of concern that, if or when capital reimbursement was incorporated into PPS, post-PPS construction debt might be handled less generously than pre-PPS debt.

This theory is somewhat supported by the graphs for the waiver States, where it is seen that health care facility construction spending and volume underwent a major boom in 1985, prior to the end of the PPS demonstration waivers in New York and Massachusetts in 1986. For New York and Massachusetts, the volume of construction increased 133 percent from 1984 to 1985, compared with a 10-percent increase in the other two waiver States (Maryland and New Jersey) and only a small increase in the nonwaiver States. Although some health planners were concerned that hospitals would respond to PPS by increasing construction spending in an effort to reduce operating cost by renovation, this does not appear to have taken place during the first 3 years of PPS.

The significant variation by division in cost per square foot (Figure 3) suggests that a construction cost index was appropriate for the PPS capital reimbursement proposal. Although the correlation between the health care facility and institutional construction data sets was only 0.525, the institutional construction data were not necessarily inappropriate as a proxy for hospital construction. Instead, the mediocre correlation could result from the scarcity of data in the health care facility construction data set, which caused it to vary widely, as evidenced by the 21 percent larger standard deviation for the health care facility construction cost index than for the institutional construction cost index. The results shown in Figures 4 and 5 suggest that some sort of weighting to adjust for geographic variation in the percentage volume of health care facility construction would have been preferable to simply merging the two data sets.

Conclusions

Although the per capita annual spending and volume of health care facility construction decreased more than 45 percent during the 17 years 1970-86, the cost per square foot of construction (in 1986 dollars) remained relatively constant. In the early 1980s, many health care facilities initiated construction projects, interrupting the general decline in construction that had lasted throughout the 1970s. However, the interruption ended abruptly in 1984, after the implementation of PPS. Spending, volume, and cost per square foot of health care facility construction leveled off and remained quite stable from 1984 to 1986. In spite of the fact that capital cost was excluded from PPS, spending for health care facility construction was significantly reduced in 1984. Among the possible explanations for this decline are tax law changes and a concern that capital costs might soon be included in PPS. To accommodate what appears to be sizable geographic variation in the cost of health care facility construction, this analysis supports the need to include a construction cost index in any future plan to add capital reimbursement to the prospective payment system.

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