APPENDIX:
Baseline Rail Revenue and Cost Projections

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RAIL REVENUE PROJECTIONS

Regional revenue shares were projected for 10 commodity groups, at the two-digit standard industrial classification (SIC) level. Interviews and a literature search established the necessary data base. A series of correlations and regressions were then run using Class I aggregate and individual railroad data in order to find the most effective explanatory variable for use in the forecasts. Data were available in adequate detail for the period 1964-74 to permit testing a number of relationships at the regional commodity level.

The best statistical fits (R^2) and highest T values were provided by time-trending via the logarithmic equation:

$$\ln \frac{N_{ijk}}{1 - N_{ijk}} = a_{ijk} + \frac{b_{ijk}}{t} \qquad (1)$$

where N_{ijk} is the share of national railroad revenues earned by region j through transport of commodity i in year k. The coefficients *a* and b were determined through regression analysis of historical data. Equation 1 was then employed to project regional revenue shares in future years, e.g., 1985 and 2000. Table A-1 presents historical regional shares data, and the projected regional commodity shares for 1985 and 2000 based on the regression analysis.

[1]The data were taken from *Moody's 1976 Transportation Manual;* and *Operating and Traffic Statistics 1964-1975*, Association of American Railroads

Forecasting of revenues was considerably more complicated than that of shares. Revenue calculation requires that actual shipments of specific commodities be forecast, including their production quantities and the allocation of shipments among rail and other transport modes, such as truck, barge, pipeline, or air After carefully examining a number of forecasting methods and models, the TECNET[2] model was employed to predict national commodity outputs and transportation modal shares. In simplest terms, TECNET is a computerized input-output model designed to disaggregate transportation-related data and forecasts into a level of detail considerably greater than that provided by a model of the overall economy—INFORUM. Starting from a base year of 1971, TECNET projects national transportation requirements by

[2]TECNET was developed by International Research and Technology Corporation under sponsorship of the Department of Energy. The acronym stands for Transportation Energy Conservation Network. It projects economic activity within 185 sectors through the year 2025 using the INFORUM input-output model developed under Clopper Almon's direction at the University of Maryland, as modified by William Watson at Resources for the Future. (INFORUM stands for "Interindustry Forecasting Model of the University of Maryland," and is described in his book titled, *1985: Interindustry Forecasts of the American Economy*, Lexington Books, 1974.) The transportation sector is broken into modal shares, i.e., rail, barge, truck, auto, etc., so that the effect of introducing energy-conserving technologies, into these segments can be evaluated. It is used in this study only to estimate the railroad shares of transportation revenues for nine commodities and the "all other" group. As explained in the text, coal forecasts were made separately. For additional description of TECNET, see *Transportation Energy Conservation Network*, Ralph M. Doggett, et al., IR&T Report 485-R, Sept. 15, 1977

Table A-1. Historical and Projected Regional Revenue Share by Commodity

(Percent of national commodity revenues)

SIC code	Title and region	Historical 1966	Historical 1970	Historical 1974	Projected 1985	Projected 2000
01	**Farm Products**					
	East	16.7	14.0	13.4	8.5	4.7
	South	10.2	9.9	9.3	8.2	5.6
	West	73.1	76.1	77.3	83.3	89.7
11	**Coal**					
	East	74.9	70.9	62.5	36.5	25.2
	South	17.0	19.2	19.8	19.8	22.9
	West	8.1	9.9	17.7	43.8	52.0
14	**Stone and Minerals**					
	East	32.4	32.0	28.5	24.5	18.4
	South	25.8	26.6	27.5	31.6	31.4
	West	41.8	41.4	44.0	44.5	50.2
20	**Food**					
	East	32.0	30.3	27.5	21.3	16.5
	South	14.6	15.1	15.5	16.8	17.7
	West	52.9	54.6	56.9	61.9	65.8
24	**Lumber and Wood**					
	East	15.0	14.0	13.6	12.0	10.2
	South	16.0	17.8	19,6	23.2	30.0
	West	69.0	68.2	66.8	64.8	59.8
26	**Pulp and paper**					
	East	36.9	34.1	32.4	26.6	19.8
	South	22.7	24.9	25.4	29.7	34.8
	West	40.4	41.0	42.2	43.7	45.4
28	**Chemicals and plastics**					
	East	31.6	29.0	25.0	18,3	10.8
	South	20.4	22.1	23.1	26.9	31.5
	West	48.0	48.9	51.9	54.8	57.7
32	**Cement and glass**					
	East	35.9	33.9	31.0	25.5	18.9
	South	23.6	25.0	25.5	29.7	34.5
	West	40.4	41.1	43.5	44.8	46.6
33	**Primary metals**					
	East	49.2	50.0	45.8	41.5	34.6
	South	10.3	11.6	11.3	14.7	18.5
	West	40.5	38.4	42.9	43.8	46.9
37	**Transportation equipment**					
	East	48.9	48.6	46.5	44.2	40.0
	South	10.2	11.2	12.3	16.4	23.1
	West	40.9	40.2	41.2	39.4	36.9
— A	**Another**					
	East	36.9	35.1	35.5	30.3	18.8
	South	12.9	15.4	15.1	24.6	29.9
	West	50.2	49.5	49.4	45.1	51.2
•*	**All commodities**[a]					
	East	38.1	36.5	33.9	27.5	20.2
	South	15.4	17.1	17.4	21.1	25.5
	West	46.5	46,5	48.7	51.4	54.4

[a]All commodities total may not add due to rounding.

Source: Historical data obtained from Moody's 1976 Transportation Manual. Projections made by IR&T.

mode and economic sector through the year 2025 based on an assumed rate of GNP growth of 2.90 percent before 1985 and 2.95 percent afterward. The national railroad revenues obtained from TECNET were allocated to railroad regions using the share projections presented in table A-1, The resulting regional revenue projections are given in table A-2. The rate of overall traffic growth represents a departure from long-term trends in that it approximately equals the expected rate of increase in gross national product. On the other hand the projected growth is considerably lower than that forecast by the U.S. Department of Transportation and endorsed by the Association of American Railroads.[3]

The coal railroad revenue forecasts presented in table A-2 were developed exogenousy from TECNET. This was done because appraisal of two coal transportation alternatives is the central focus of this study, hence this commodity merits more detailed consideration than achievable through use of the general model. In order to establish the coal-related revenue projections, it was necessary to undertake three steps:

1. Project coal production by railroad region between 1980-2000.
2. Estimate the railroad share of coal shipments in the three regions over the same time period.
3. Convert the originating tonnage estimates in each region into ton-miles and railroad revenues.

Coal supply projections for the years 1985 and 2000 were obtained for the three railroad regions by grouping data provided in the Department of Energy's (DOE) Annual Environmental Assessment Report (AEAR).[4] The AEAR projections identify the energy content of future coal supply from 10 Federal regions. The currently mandated environmental regulatory situation, following passage of the Clean Air Act (CAA) Amendments of 1977, was assumed in forecasting as the coal supply baseline. The DOE coal supply figures were converted into tons of coal, using the average energy content of coal i n each Federal region. The resulting coal supply projections for the years 1985 and 2000 are presented in the following table:

COAL SUPPLY PROJECTIONS By RAILROAD REGION –1985 and 2000
(Milliions of short tons)

Region	1975	1985	2000
East	3445	3983	4942
South	1686	1806	3282
West	1032	4435	8084
Total U S	6163	1,0224	1,6308

There are a number of interesting aspects of the coal production projections. By the year 2000, national coal production is estimated to increase by a factor of 2.6 relative to its 1975 level. Western coal production, however, is projected to increase nearly eightfold, so that by 2000 it will account for approximately half of the national total. Eastern coal output is projected to increase much more slowly, rising by 43.5 percent relative to its 1975 value. As a result, eastern coal's participation in the national total will decline from 55.9 percent in 1975 to 30.3 percent in 2000. The production of southern coal will follow a middle course, nearly doubling between 1975-2000, and it will continue to produce the least of the three regions.

Projections of railroad shares of regional coal shipments were based on analysis of historical trends, adjusted by anticipated shifts in regional coal production. The historical data indicate that railroads' share of eastern and western coal movements (including minemouth usage) steadily declined over the 1964-74 period, while southern railroads gained an increasing share of coal movements in that region. [5] The reasons underlying the

[3]Association of American Railroads, *Yearbook of Railroad Facts, 1977*

[4]*Annual Environmental Analysis Report,* prepared tor the Assistant Administrator of Environment and Safety, DOE, by MITRE Corporation, Consad Research Corporation, Control Data Corporation, and International Research and Technology Corporation, September 1977

[5]Analysis of U S Bureau of Mines data provided in *The Minerals Yearbook* for the years 1969 to 1974

Table A-2. Baseline Regional Railroad Revenue Projections

(Millions of 1971 dollars)

SIC code	Commodity	1980	1985	1990	1995	2000
01	Farm Products					
	East	$ 107.83	$ 89.20	$ 80.37	$ 70.41	$ 64.70
	South	92.13	86.10	86.11	89.27	77.00
	West	846.99	874.30	981.76	1,097.12	1,233.80
	Total	1,046.95	1,049.60	1,148.24	1,257.40	1,375.50
11	Coal					
	East	887.94	1,009.30	1,034.30	1,060.02	1,086.33
	South	392.39	550.99	668.84	811.90	985.57
	West	549.53	1,218.22	1,492.06	1,821.27	2,241.04
	Total	1,829.86	2,778.51	3,195.20	3,696.19	4,312.94
14	Stone and minerals					
	East	109.76	133.70	132.71	150.84	184.90
	South	125.30	169.20	185.80	233.64	315.50
	West	266.13	242.90	362.08	435.30	504.40
	Total	501.19	545.80	680.59	819.78	1,004.80
20	Food					
	East	417.03	380.90	405.45	402.75	465.60
	South	265.23	300.40	334.25	378.67	499.50
	West	985.85	1,107.00	1,238.13	1,407.44	1,856.70
	Total	1,668.11	1,788.30	1,977.83	2,188.86	2,821.80
24	Lumber and wood					
	East	144.81	148.30	153.94	156.45	160.00
	South	239.46	286.80	338.68	399.84	470.50
	West	756.01	801.00	846.05	892.39	937.80
	Total	1,140.28	1,236.10	1,338.67	1,448.68	1,568.30
26	Pulp and paper					
	East	267.18	264.70	280.60	295.78	311.40
	South	257.08	295.60	265.24	448,40	547.20
	West	393.89	435.00	513.66	606.42	714.00
	Total	918.15	995.30	1,059.50	1,350.60	1,572.60
28	Chemicals and plastics					
	East	260.79	282.50	287.82	290.16	290.10
	South	308.32	415.30	529.23	669.61	846.00
	West	649.55	845.80	1,039.89	1,272.26	1,549.70
	Total	1,218.66	1,543.60	1,856.94	2,232.03	2,685.80
32	Cement and glass					
	East	268.13	275.40	306.43	338.61	368.70
	South	269.09	320.80	414.74	530,49	695.90
	West	420.39	483.80	599.66	743.33	906.90
	Total	957.61	1,080.00	1,320.83	1,612.43	1,971.50
33	Primary metals					
	East	482.37	476.00	496.47	556.36	600.50
	South	149.70	168.70	202.40	260.04	321.10
	West	476.82	502.40	574.12	695.46	813.90
	Total	1,108.89	1,147.10	1,272.99	1,511.86	1,735.50
37	Transportation equipment					
	East	434.08	500.30	577.89	668.37	768.70
	South	139.59	185.60	251.14	333.38	443.90
	West	382.45	445.90	521.18	608.78	709.10
	Total	956.12	1,131.80	1,350.21	1,610.53	1,921.70

Table A-2. Baseline Regional Railroad Revenue Projections—Continued

SIC code	Commodity	1980	1985	1990	1995	2000
	All other					
	East	1,068.70	1,208.00	1,233.50	1,259.50	1,286.10
	South	580.90	978.10	1,250.50	1,599.00	2,044.40
	West	1,421.90	1,795.20	2,242.60	2,801.80	3,500.80
	Total	3,071.50	3,981.30	4,726.60	5,660.30	6,831.30
	Commodities					
	East	4,448.62	4,768.30	4,989.47	5,249.25	5,587.03
	South	2,819.19	3,757.59	4,526.93	5,754.24	7,246.57
	West	7,149.51	8,751.52	10,411.19	12,382.17	14,968.14
	Total	14,417.32	17,277.41	19,927.59	23,385.66	27,801.74

Source: IR&T estimates.

declines in the East and West differ markedly. In the East, the decline–from 71.6 percent to 63.1 percent—was due to modest increases in market penetration by barges, trucks, and mine-mouth generation. There is essentially no barge transport in the West, and truck transport of coal fell from 13.9 percent in 1969 to 4.0 percent in 1974. Furthermore, recent indications are that for both environmental and economic reasons mine-mouth generation will expand only slightly in the future.[6] Therefore, it is anticipated that coal supply growth in the West will be transported primarily by the railroads. On the basis of historical trends, it is estimated that railroads will capture 86.0 percent of western coal shipments (originating tons) in 1985 and 90.4 percent in 2000. The comparable estimates for the East are 59.8 and 53.7 percent, respectively and 80.8 and 84.7 percent for the South.

participation of unit trains in coal shipments is also of interest In the East, unit train participation was nearly constant between 1969-74 at about 36 percent, while in the South and West unit train participation approximately doubled –from 16.1 to 29,3 percent in the South and from 28.2 to 578 percent in the West. It is projected that unit train participation will continue to increase in these two regions — to 40 percent by 1985 and 45 percent by 2000 in the South, and to 75 and 80 percent in those 2 years in the West. It is assumed that economic pressures will motivate some growth in eastern unit train participation. The estimates are that participation will rise to 40 percent in 1985 and 45 percent in 2000.

Coal shipment revenue projections were made by translating the originating tonnage forecasts into ton-miles, then multiplying by estimated revenues per ton-mile for regular and unit trains. The average haul distances in each region were estimated to be 650 miles in the West, 235 miles in the East, and 300 miles in the South.[7] Revenues per ton-mile were estimated from historical data, assuming that regular train rates are double unit train rates, on the average.[8] The railroad coal-transpor-

[6] One potentially offsetting factor would be the construction of a significant number of coal conversion facilities near the mine mouth It is anticipated that coal conversion facilities will encounter some of the same objections as mine mouth generation In this study, the assumption was made that three 250 million standard cubic feet per day synthetic natural gas plants will be brought onstream in the West by 1985 By .2000, six more will be added in the West and two each in the East and South

[7] Review of coal origin and usage regions in the South indicates that present hauls tend to be short averaging 200 miles However, national goals for future coal distribution would extend usage into the more Southern States On this basis, it was estimated that by 1985 the average southern haul will have increased to 300 miles

[8] *National Power Survey Report* as referenced in *Factors Affecting Coal Substitution for Other Fossil Fuels in Electric Power Production and Industrial Uses*, Congressional Research Service report to the Senate Committee on Interior and Insular Affairs, 1975

tation revenue projections given in table A-2 were then obtained for each region by multiplying the coal production in that region by the railroad share of originating tonnages, the average haul distance, and by the revenues per ton-mile, weighted by regular and unit train participation. The results indicate that western railroads, although accounting for 76.5 percent of the ton-miles, will receive only 52.0 percent of the revenues in 2000. This is because unit trains are employed on a larger fraction of the western shipments than in other regions, and because the basic rail rate is lower in the West, averaging only 35 percent of that charged in the East. The regional difference in rates is primarily related to:

1. the short-haul distances in the East and South which means that turnaround times are a larger fraction of the total shipment period,
2. the greater market value of underground mined eastern and southern coal, and
3. logistical advantages for the less heavily traveled western rail system.

RAIL OPERATING EXPENDITURE FORECASTS

Three major operating cost categories were studied in depth: maintenance of way and structures, maintenance of equipment, and nonmaintenance operating expenditures. Twenty-five railroads were selected for cross-sectional statistical evaluation on the basis of operating size (more than 1,000 miles of track) and data availability. One thousand miles of track operation was the minimum size included because larger railroads are expected to account for most of the coal shipments, and these large railraods experience different operating economies than the smaller railroads. The inability of cross-sectional analysis to capture time trends was countered by running the regressions for a series of years, 1970-75. This permitted an evaluation of how the regression coefficients change over time.

Maintenance of Way and Structures

The variables tested to explain historical variation in maintenance of way and structures operating expenditures included: miles operated, ton-miles, average haul, freight car miles, tons per car, and commodity mix, the latter to see if cost patterns could be related to changes in relative importance of commodities hauled. The best explanatory variables, in terms of statistical meaning and reliability, were found to be combinations of ton-miles and miles of track operated. The regression equation selected was the logarithmic form:

$$\ln \mathrm{MWS} = a + b \ln \left(\frac{\text{ton-miles}}{\text{miles of road}} \right) + c \ln (\text{miles of road}) \qquad (2)$$

where MWS is maintenance of way and structures, and miles of road refers to track miles operated. This equation assumes an interaction between intensity of use, as reflected in ton-miles per mile of road, and cost per mile of road. It suggests that economies of scale persist over broad ranges of ton-miles per mile of road operated, with the coefficient *b* acting as the elasticity of supply for ton-mile services. The coefficient c acts as the elasticity of supply for miles of road operated.

Mean values for the coefficients *b* and c over the period 1970-75 were 0.74 and 0.94 respectively. The resulting maintenance of way and structure costs is:

$$MWS_T = k \times MWS_{1971} \times \left[\frac{\left(\frac{\text{ton-miles T}}{\text{miles of road T}}\right)}{\left(\frac{\text{ton-miles 1971}}{\text{miles of road 1971}}\right)}\right]^{0.74} \times \left(\frac{\text{miles of road T}}{\text{miles of road 1971}}\right)^{0.94} \qquad (3)$$

where *k* is a wage and productivity factor, MWS is maintenance of way and structures operating expenditures, and T is the year to be computed. Since *b* is less than 1, economies of scale are present, i.e., for every l-percent increase in traffic or ton-miles, costs will go up by **0,74 percent. The ton-mile forecasts** used to project maintenance of way and structures expenditures for the years *1980-2000* were obtained from the revenue forecasts given in table A-2 by use of regional commodity revenues per ton-mile coefficients.

Miles of road operated was assumed constant over the forecast period, hence the final term drops out of the equation. The results obtained using this form of the equation should be interpreted as reflecting the cost to the railroads of maintaining current levels of road operated. The *k* factor adjusts for changes in the productivity of labor and the real wage **rate.** An empirical expression was developed for k: $k = 0.5 + 0.5(1.0012)^{T-1971}$ The first parameter, 0.5, is the nonlabor share of maintenance of way and structures costs in 1971. The non labor share was assumed to vary directly with ton-miles and miles operated as indicated by the overall regression equation. The labor share, in contrast, is multiplied by $(1.0012)^{T-1971}$ to account for changes in real wages and productivity over time. The factor (1 .0012) was determined by dividing the rate of real wage changes for railroad employees with respect to the GNP deflator by the rate of productivity changes for maintenance of way and structures, as reflected in reductions in MWS labor-hours per unit railroad output, i.e., ton-miles.

Maintenance of Equipment

A number of relationships were tested to explain maintenance of equipment operating costs. The variables employed included: ton-miles, tons per freight car, and freight car miles. The most effective equation was found to be:

$$\ln ME = a + B \ln (\text{freight car miles})$$

where *ME* is maintenance of equipment costs. Regression analysis using this equation resulted in the following expression for projecting maintenance of equipment operating expenditures:

$$ME_T = k \times ME_{1971} \times \left(\frac{\text{freight car miles T}}{\text{freight car miles 1971}}\right)^{0.96} \qquad \textbf{(4)}$$

where k is a wage and productivity factor, and T is the year for which data are to be computed. The scale factor 0.96 is the mean-regression coefficient over the 6-year period, 1970-75. It indicates that an 0.96-percent increase in cost will result from a l-percent increase in freight car miles relative to their 1971 level. The wage and productivity factor, k, is

$$k = 0.45 + 0.55(1.0061)^{T-1961}$$

where 0.45 is the non labor fraction of maintenance of equipment expenditures in *1971,* and the second term defines the variation of the labor share over time. Freight car miles were calculated from tons per car estimates for each region, and the revenue ton-mile projections employed in the maintenance of way and structures analysis. Ton-mile weighted averages for tons per freight car for the Nation and for each railroad region were calculated by aggregating estimates of tons per freight car for individual commodities. Projections for freight-car loadings by commodity in 1985 and 2000 were made on the basis of past trends and extensive interviews with railroads, their customers, and their suppliers as to maximum practicable weight, height, and length (to clear overpasses and negotiate curves) per car. The resulting tons per car projections for the Nation in 1985 and 2000 are presented, with comparative historical data, in table A-3. Loadings are projected to grow 23.1 percent from 1974 to 1985, and 10.7 percent more by 2000. The increase in coal traffic is an important factor in this growth, since this commodity makes the single largest contribution to the commodity-weighted averages.

A major change now underway that affects freight car and train capacities is the growth of intermodal service, i.e., mixing such transportation modes as truck and rail via use of flatcars and piggybacked trailers. This approach offers a number of advantages traditional boxcars cannot. For example, the time usage rate of many old freight boxcars is 10 percent, while that for a piggyback or flatcar is 80 percent. Also, pickup and delivery by the customer with a truck cab at the terminal is usually more cost effective and convenient than the traditional switching of individual rail cars onto customer's tracks. The full implications of this new-style intermodal railroad-truck service are not yet clear, but certainly it will tend to reduce the number of cars needed, and probably reduce the value of the cars to be bought.

Nonmaintenance Operating Expenditures

Nonmaintenance operating expenditures include traffic, transportation, miscellaneous,

Table A-3. Historical and Projected Freight Car Loadings by Commodity

(Tons per car)

SIC code	Commodity	Historical				Projected	
		1968	1970	1972	1974	1985	2000
01	Farm Products	51.2	56.5	62.0	66.9	85.0	93.0
11	Coal	72.4	76.4	80.2	83.3	90.0	95.0
14	Stone and minerals	73.1	74.1	75.1	77.6	90.0	93.0
20	Food	38.0	40.7	42.9	44.9	60.0	80.0
24	Lumber and wood	46.4	49.8	50.9	53.5	57.0	62.0
26	Pulp and paper	33.9	35.5	37.6	39.4	55.0	70.0
28	Chemicals and plastics	53.3	58.2	63.0	66.7	75.0	80.0
32	Cement and glass	56.4	57.7	60.0	60.3	85.0	90.0
33	Primary metals	54.5	55.3	62.7	63.6	77.0	85.0
37	Transportation equipment	22.2	22.8	23.3	23.6	28.0	32.0
•*	All commodities, total	51.8	54.9	56.3	58.4	71.9	79.6

Source: Projections made by IR&T. Historical data obtained from Moody's *Transportation Manual, 1977,* p. a18.

and general categories. The equation used to forecast nonmaintenance expenditures was:

$$NME_T = k \times NME_{1971} \left(\frac{\text{freight car miles T}}{\text{freight car miles 1971}} \right)^{0.87} \quad (5)$$

where *NME* is nonmaintenance expenditures, T is the year to be computed, and the wage and productivity factor, k, is:

$$k = 0.44 + 0{,}56\ (1.0068)^{T-1971}$$

The scale factor 0.87 is the mean-regression coefficient over the 6-year period, 1970-75.

Total Operating Expenditures

Projections for the three operating expenditure categories and their totals are presented for the period 1980-2000, by region, in table A-4. The productivity improvements, achieved primarily through increasing tons-per-car loadings, tend to outweigh the effects of increasing traffic volumes for maintenance of equipment and nonmaintenance expenditures. The effect of these reductions can be directly oberved in the East, but they are obscured in the South and West. The rate of productivity improvements slows after 1985, since most of the gains will have been achieved by that time.

Table A-4. Projections of Class I Railroad Operating Expenditures

(Millions of 1971 dollars)

	1980	1985	1990	1995	2000
EAST					
Maintenance of way and structures . . .	$ 601.45	$ 628.01	$ 651.10	$ 675.68	$ 710.10
Maintenance of equipment	679.18	595.07	609.55	624.37	638.91
Nonmaintenance expenditures.	1,947.93	1,754.90	1,820.93	1,891.09	1,961.52
Total	3,228.56	2,977.98	3,081.58	3,191.14	3,310.53
SOUTH					
Maintenance of way and structures . . .	427.23	511.44	597.98	703.58	837.63
Maintenance of equipment	452.33	486.10	585.15	704.37	847.00
Nonmaintenance expenditures.	1,022.44	1,107.91	1,330.76	1,599.85	1,920.89
Total	1,902.00	2,105.45	2,513.89	3,007.80	3,605.52
WEST					
Maintenance of way and structures . . .	1,054.85	1,347.59	1,553.55	1,780.35	2,065.55
Maintenance of equipment	1,139.43	1,184.93	1,383.09	1,614.36	1,882.37
Nonmaintenance expenditures.	2,745.86	2,888.62	3,373.66	3,943.60	4,604.00
Total	4,940.14	5,421.14	6,310.30	7,338.31	8,551.92
U.S.A.					
Maintenance of way and structures . . .	2,083.53	2,487.04	2,802.62	3,159.62	3,613.28
Maintenance of equipment	2,270.94	2,266.10	2,577.79	2,943.10	3,368.29
Nonmaintenance expenditures.	5,716.22	5,751.44	6,525.35	7,434.54	8,486.42
Total	10,070.69	10,504.58	11,905.76	13,537.26	15,467.99

Source: IR&T.

CAPITAL INVESTMENT REQUIREMENTS

Rolling Stock

Investment requirements over the **1975-2000** period were determined for three classes of rolling stock: coal hopper cars, non-coal freight cars, and locomotives. These investment requirements are the capital expenditures necessary to expand the equipment stock in response to increased business volume and to replace retired equipment. The growth in equipment requirements was determined from the revenue projections of table A-2. As described previously, the revenue projections were converted into freight car mileage projections by use of the estimates for revenues per ton-mile and tons per car, The freight car mileage projections were then converted into freight car requirements in each year by use of an estimate for car utilization rate, that is, miles per car per year. Locomotive requirements were then estimated as a function of total freight car requirements, Freight car and locomotive investment requirements were determined for the new vehicle requirements in each category, taking into account estimated vehicle retirement rates.

It was estimated from carloadings of coal relative to loading of mineral ores and of stone and gravel that in 1973, coal cars represented 62.2 percent of the total U.S. open-top hopper car fleet. On this basis, there were 207,682 coal hopper cars in 1973, Since there were 1,460 mill ion coal-related freight car miles in that year, the average utilization rate was 7,030 miles. Regression analysis of historical utilization-rate data over the period 1962-769 revealed that a 1.13 percent compound annual growth in utilization rate had been achieved. **It was** assumed that the historical trend in car utilization rates will continue over the period of this study, except in the case of long-haul unit train shipments. For the latter shipments, the analysis described in chapter IV indicated that 50,000 loaded miles per year per car can be reasonably expected. Since long-haul unit trains are anticipated to account for 50.6 percent of coal shipments in 2000, improved utilization of such cars has a significant effect upon coal-related car requirements. For example, in 2000 the nonlong-haul coal car utilization rate was projected to be 9,521 miles per year per car, and coal shipments to amount to 620.9 billion ton-miles. At an estimated 95 tons per car, these shipments correspond to 6,535 million freight car miles, 50.6 percent of which are via long-haul unit trains. Using the car utilization rates established for each type of shipment, a total coal hopper car requirement of 405,000 in 2000 was determined. This result is 41 percent less than the number of cars that would have been required to ship the same amount of coal without the utilization rate gains achieved in the long-haul shipments.

Annual retirements of coal hopper cars were calculated assuming a 15-year average lifetime. This is a shorter lifetime than for noncoal cars because of the higher utilization rate in unit train service. Coal car investment requirements were determined as that necessary to accommodate growth in total requirements and replacement of retired cars, at an average cost of $13,000 per car (1971 dollars). The estimated coal car requirements for the period 1975-2000 are presented in table A-5.

Noncoal car requirements were calculated in a similar manner to that employed for coal cars. Mean noncoal car utilization over the 1973-75 time period was 10,877 miles, and the historical 1.13 percent annual growth rate was assumed to hold over future years for all cars. Retirement of noncoal cars was estimated with the help of the following age distribution and retirement rate data, based on a 22-year average car life:[10]

NONCOAL FREIGHT CAR AGE CHARACTERISTICS

Age (years)	Car age distribution (in 1975)	Retirement rate (per year)
0-10	40%	2.5%
11-20	30%	15 %
21 +	.30%	70 0%

[9]Association of American Railroads, Yearbook 01 *Railroad Facts*, 1977

[10]"Long Term Freight Car Forecasts, American Freight Car Institute, 1975

The new car requirements were then determined, with the corresponding investment costed at $16,000 per car. The results for non-coal freight car requirements are presented in table A-5 The requirements decline between 1975 and 1985 as a result of the fairly rapid increase assumed for tons per freight car loadings Beyond 1985, the effect of increasing traffic volume predominates. The number of locomotives required in each year was estimated to be 1.8 percent of the total freight car requirements This is a higher ratio of locomotives to freight cars than prevailed in the past because of the increasing car loadings. On the basis of historical trends, an annual increase in locomotive hauling capacity, approximately 1,65 percent, was taken into account in estimating the overall dependence of locomotives upon freight car requirements. Locomotive retirements were assumed to follow the noncoal car schedule. The resulting locomotive capital investment requirements, based upon $246,000 per car [1971 dollars), is given in table A-5.

Table A-5. Rolling Stock Investment Requirements, 1975-2000

Category	Year	Required stock (# cars)	Annual retirements (# cars)	Annual new car requirements (# cars)	5-year investments requirements (thousands of 1971 dollars)
Coal hopper cars.	1975	226,000	15,000	19,400	$ 252,200
	1980	248,000	15,000	20,000	260,000
	1985	273,000	15,000	22,800	296,400
	1990	312,000	19,400	28,000	364,000
	1995	355,000	20,000	30,000	390,000
	2000	405,000			
Non coal freight cars.	1975	1,301,000	68,800	40,600	649,600
	1980	1,160,000	54,400	29,400	470,400
	1985	1,035,000	45,200	60,400	966,400
	1990	1,111,000	48,800	61,400	982,400
	1995	1,194,000	45,600	63,200	1,011,200
	2000	1,282,000			
Locomotives	1975	27,523	1,459	1,023	215,658
	1980	25,344	1,157	797	196,062
	1985	23,544	1,091	1,556	382,776
	1990	25,866	1,070	1,595	392,370
	1995	28,494	1,070	1,686	414,756
	2000	31,572			

Source: IR&T.

Way and Structures

Way and structures investment projections were made by evaluating the requirements associated with three shipment categories: long-haul coal movements considered within four case studies, other long-haul coal movements, and all other commodity movements.

Four in-depth case studies were conducted for unit train movement of western and southern coal to five States: California, Texas, Minnesota, Wisconsin, and Florida. These case studies are described in chapter IV. The cumulative investment requirements for the case study coal movements for intervals between 1975 and 2000 are presented in table A-6. The set of "other specific long-haul" coal shipments are those described in chapter IV amounting to more than 5 million tons per year over distances greater than 500 miles. The investment requirements for these other specific long-haul shipments were estimated by applying a ton-mile adjustment to the investment requirement identified in the case studies. The other specific long haul and the total specific long-haul coal investment requirements are shown in table A-6.

A review of historical trends in "all other" way and structures investment indicated that these have remained relatively constant at approximately $431 million per year (1971 dollars). Other studies such as Clopper **Almon's 1985** *Interindustry Forecasts of the American Economy* have produced regression equations that suggest way and structures investments are more strongly influenced by real interest rates than traffic volumes.[11] Since real interest rates are not varied within this study, the "all other" way and structures investment was held constant at its recent historical value.

On the foregoing basis, the following results are obtained for total Class I railroad way and structures investment over the 1975-2000 period:

ANNUAL WAY AND STRUCTURES INVESTMENT REQUIREMENTS

(Millions of 1971 dollars)

Shipment categories	1975-1985	1985-1990	1990-1995	1995-2000
Specific long-haul coal*	70	39	22	25
Other commodities	431	431	431	431
Total	501	470	453	456

* See table V-6

[11]Almon's equation, p. 92, for railroad investment is

$$I = 331.7 + 0.00068Q - 23.18R$$
$$T = (2.4)\ (0.06)\ (5.1)$$
$$R^2 = 0.51, \quad A\ W = 0.85$$

where *I* is Investment, Q is rail traffic, *R* is the real rate of interest, and the numbers in parentheses are the *T* scores This equation Indicates that Q has very little impact on *I*, while *R*? impact is significant

Table A-6. Cumulative Way and Structures/Investment Requirements for Specific Long-Haul Coal Shipments

(Millions of 1971 dollars)

	1975-1985	1975-1990	1975-1995	1975-2000
California	$ 44	$ 64	$117	$144
Florida	95	116	116	166
Minnesota	5	5	5	5
Texas	108	260	316	361
Wisconsin	7	7	7	7
Subtotal[a]	259	452	561	683
Other specific long-haul coal shipments[b]	435	435	435	435
Total	$694	$887	$996	$1,118

[a]These shipments pertain to the case studies described in chapter IV.
[b]Other specific long-haul coal shipments are those identified in chapter IV amounting to more than 5 million tons per Year over distances greater than 500 miles. They represent a portion of all utility steam coal, and they tend to come onstream by 1985 and not increase much beyond that time.
Source: IR&T.

Leasing

For tax and accounting purposes, there are obvious differences between direct investment, e.g., purchases of cars and locomotives, compared with I ease/rental arrangements. Direct investment purchases are financed through either debt or equity. Debt service charges, i.e., interest and amortization, come out of net railway operating income. Equity-based purchases, on the other hand, are financed out of retained earnings or stock issues on which dividends are paid, with both retained earnings and dividends coming out of after-tax net income. If equipment and track are leased or rented, the expenditures come from net railway operating revenue. The actual choice between direct purchase versus rental/leasing is complicated by tax, risk, return on investment, and capital market considerations. Since the investment and capital issues addressed in this study mainly concern the need and ability to generate sufficient funds to maintain and expand rolling stock and way and structures, it was assumed that the annual cost to the railroads of providing appropriate capital stock via leasing is roughly equivalent to the cost of direct purchase.

The capital requirements determinations have not included investments in loading and unloading facilities. These are usually shipper- and receiver-owned. Shipper-leased equipment is also excluded. These both represent a transportation-related cost to society in that they absorb real resources, even if not directly paid for by the railroads Financing ownership of unloading facilities may be easier for public utilities than **for railroads.** The former often have more favorable access to capital markets, and are guaranteed a specific rate of return on investments by public utility commissions. Likewise, major shippers that provide their own loading facilities may be able to obtain capital at a more attractive rate than the railroads. The growth in ownership or leasing of rolling stock by the shippers, and in the case of utilities by the receivers, has reduced capital requirements for the railroads. This has also lowered the rate railroads can charge per ton-mile. The advantages to the lessees of such arrangements are greater certainty in availability of equipment. Full-service leases relieve the lessees of the logistics of maintenance.

EMPLOYMENT AND COMPENSATION

Labor compensation was estimated during specification of the operating expenditure projections, as discussed previously. The k factor for each expenditure category allocated the costs between labor and nonlabor shares. The resulting labor compensation projections for 1980-2000 (in 1971 dollars) are given by region in table A-7. Compensation in the East declines between 1980 and 1985 because of the equipment productivity gains projected, but after that, traffic-volume increases lead to higher levels of compensation. Compensation in the South and West increases throughout the period.

The compensation projections were employed to estimate employment requirements. Compensation was divided by the average wage rate in each year to determine total employee hours, the total hours were divided by the average annual hours per employee to determine the number of employees. The average wage rate in future years was estimated by the expression: $4.52(1\ .0304)^{T-1971}$, where ***4.52*** was the 1971 average railroad employee compensation in dollars per hour, and real wages were assumed to increase annually by 3.04 percent. The average annual hours per employee in recent years has been 2,440 hours, which includes the effect of overtime. Using these two factors and the compensation estimates of table A-7, regional estimates for Class I railroad employment were obtained for the period 1980-2000. These employment estimates are presented in table A-8.

A decline in employment is observed

Table A-7. Class I Railroad Labor Compensation Projections, 1980-2000

(Millions of 1971 dollars)

	1980	1985	1990	1995	2000
EAST					
Maintenance of way and structures	$ 303.99	$ 319.32	$ 333.05	$ 347.71	$ 367.62
Maintenance of equipment	378.96	334.70	345.59	356.84	368.08
Nonmaintenance expenditures	1,159.45	1,080.55	1,159.85	1,246.05	1,337.01
Total	1,842.40	1,734.57	1,838.49	1,950.60	2,072.71
SOUTH					
Maintenance of way and structures	215.93	260.05	305.88	362.06	433.64
Maintenance of equipment	252.93	273.41	331.76	402.56	487.96
Nonmaintenance expenditures	608.58	682.18	847.63	1,054.15	1,309.31
Total	1,076.90	1,215.64	1,485.27	1,818.77	2,230.91
WEST					
Maintenance of way and structures	533.15	685.20	794.68	916,17	1,069.33
Maintenance of equipment	635.77	666.46	784.11	922.63	1,084.43
Nonmaintenance expenditures	1,634.39	1,778.62	2,148.87	2,598.47	3,138.17
Total	2,803.31	3,130.28	3,727.66	4,437.27	5,291.93
NATION					
Maintenance of way and structures	1,053.07	1,264.57	1,433.61	1,625.94	1,870.58
Maintenance of equipment	1,267.12	1,274.57	1,461.51	1,682.02	1,940.47
Nonmaintenance expenditures	3,402.40	3,541.36	4,156.36	4,898.68	5,784.50
Total	$5,722.59	$6,080.50	$7,051.48	$8,206.64	$9,595.55

Source: IR&T.

Table A-8. Class I Railroad Employment Projections, 1980-2000

(Thousands of people)

	1980	1985	1990	1995	2000
EAST					
Maintenance of way and structures	21.05	19.04	17.09	15.36	13.99
Maintenance of equipment	26.24	19.95	17.74	15.77	14.00
Nonmaintenance expenditures	80.29	64.42	59.53	55.07	50.87
Total	127.58	103.41	94.36	86.20	78.86
SOUTH					
Maintenance of way and structures	14.95	15.50	15.70	16.00	16.50
Maintenance of equipment	17.48	16.30	17.03	17.79	18.57
Nonmaintenance expenditures	42.14	40.67	43.51	46.58	49.81
Total	74.57	72.47	76.24	80.37	84.88
WEST					
Maintenance of way and structures	36.92	40.85	40.79	40.48	40.68
Maintenance of equipment	44.03	39.73	40.25	40.77	41.26
Nonmaintenance expenditures	113.18	106.04	110.30	114.83	119.39
Total	194.13	186.62	191.34	196.08	201.33
NATION					
Maintenance of wayand structures	72.93	75.39	73.59	71.85	71.17
Maintenance of equipment	87.75	75.99	75.02	74.33	73.83
Nonmaintenance expenditures	235.61	211.14	213.34	216.48	220.07
Total	396.29	362.52	361.95	362.66	365.07

Source: IR&T.

throughout the forecast years in the East, and between 1980-90 in the South and West. This phenomenon is directly traceable to the carloading assumptions used to derive the freight car miles. Car productivity was projected to grow quite rapidly through *1985,* then to slacken off between 1985 and 2000 as physical limits to car and track capacities are encountered. Thereafter, even though labor productivity assumptions are positive, i.e., assumed to grow at 2.91 percent compounded annually for maintenance of way and structures, at 2.88 percent for maintenance of equipment, and at 2.34 percent for nonmaintenance expenditures, an overall increase in railroad employment is projected in each region.

TAX FORECASTS

Projections were made for payroll, State, local, and Federal taxes. The payroll tax projections *were* obtained from the labor compensation projections, assuming an increase in effective tax rate from 15 percent in 1976 to 17 perc ent in 1980 and 0.30 percent in 2000. The resu lts are given in the following table:

PAYROLL TAX PROJECTIONS
(Millions of 1971 dollars]

	1980	*1985*	*1990*	1995	2000
East	31321-	381. 61	44124	52666	62181
South	183.07	267.44	356.46	491.07	66927
West	476. 56	68866	89464	1,19806	1,58758
USA	97284	1,33771	1,692.36	2,'215	791,87866

The Railroad Revitalization and Regulatory Reform Act of 1976 specifically prohibits the continuation of discriminatory tax practices against the railroads, which have often been taxed more heavily than other taxpayers in equivalent legal circumstances. Balanced against this presumed downward pressure on State and local taxes, especially property, franchise, and public utility taxes, is the weight of history during which taxes have been growing as a percent of assets, income, and revenues. State and local taxes are, on balance, not expected to change very much from their present relationships with operating income. Regressions testing several potential explanatory variables for State and local taxes on Class I railroads resulted in the hypothesis that only about 40 percent of these taxes were operating revenue-dependent For lack of better information, State and local income taxes were projected to be about 1 percent of net operating revenue (the difference between operating revenue and operating cost) while other State and local taxes were projected to remain constant in real terms over time. The composite result is shown in the following table for State and local taxes, by region, over the 1980-2000 time period,

RECIONAI STATE AND LOCAL
RAILROAD TAX PROJECTIONS
(Millions of 1971 **dollars)**

	1980	*1985*	1990	1995	2000
East	12318	126.50	12880	131.51	135.02
South	5740	67.16	75.17	87.93	10345
West	191 52	20818	225.44	145.94	272.83
USA	372.10	401.84	429.41	405.38	511.30

The marginal effective Federal tax rate actually applied to railroads seems to be approximately 25 percent, and the 1969-72 average effective rate was considerably lower, ranging between 13 and 20 percent. Federal taxes were calculated on the basis of a tax rate of approximately 20 percent for the scenarios employed in the present study.

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