RAILROAD DECLINE AND REVITALIZATION

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Introduction

The purpose of this paper is to introduce an integrated framework for lang-range strategic planning in a railroad. The framework is a computer simulation model designed to be useful to most freight-hauling railroads. The model can help to increase the understanding of problems facing the railroad and to aid in developing strategies for addressing these problems. It is designed to forecast railroad performance and to aid in developing more effective policies for railroad management. It can also be used by Federal agencies to evaluate impacts of public policy on railroad performace.

The Model

The model represents dynamic interactions between railroad track and equipment management, freight market share and internal financial variables. It is divided into four sectors: track module, equipment module, market module, and finance module.

The track module traces amounts of standard and substandard track in the system. Standard track is defined as track without deferred maintenance, substandard track is track with deferred maintenance. Track wear - such as deterioration of rails, ties and ballast - causes track to move from standard to substandard condition. Track maintenance - such as rail replacement, tie replacement, ballast conditioning, and track surfacing - causes track to move from substandard to standard condition. Track construction increases the amount of standard track. Track abandonment reduces the amount of both standard and substandard track.

The equipment module traces the number of new and old rail cars and the number of rail cars needing maintenance. The number of new cars increases by car purchases and decreases by aging of new cars. The number of old cars increases by aging of new cars and decreases by aging of old cars (car retirement) and by car sales. The number of cars needing maintenance increases by car wear and decreases by car maintenance.

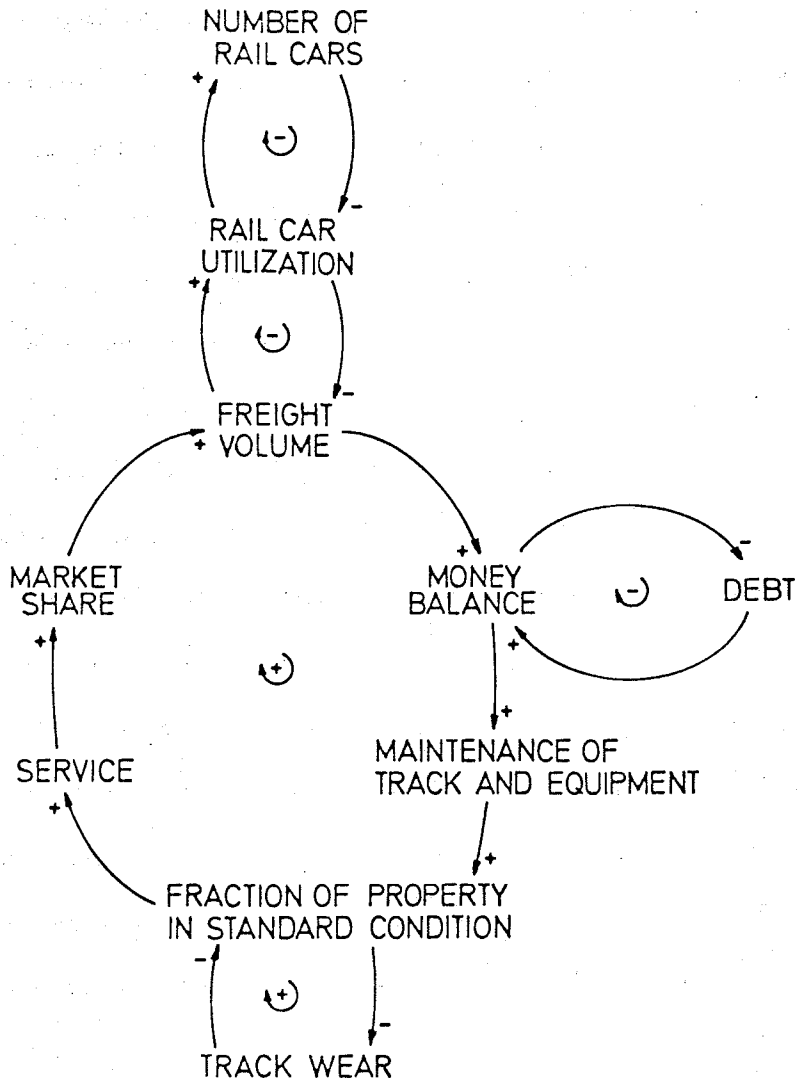
The main activities in the market module are the calculations of revenue ton-miles and market share. Revenue ton-miles is the product of total intercity freight in the

region and the railroad's market share. The amount of regional intercity freight is a function of the region's contribution to GNP. The railroad's market share is determined by the railroad's and the competitor's shipping rate and service levels. The model distinguishes between the following service components: reliability, frequency, and operating speed.

The finance module represents mangement accounting in a railroad. The money balance (liquid assets) increases through revenues and issuance of new debt and decreases through operating expenses and costs and repayments of debt. Increase in debt is determined by desired increase in debt and by the debt-equity ratio, where equity is the sum of all assets. Money adequacy, which is a variable in the finance module, indicates the availability of funding and influences the allocation of money to track and equipment maintenance.

Some of the feedback loops in the model are shown on the next page. The main positive feedback loop indicates that a reduction in freight volume leads to a reduction in money balance which causes cutbacks in maintenance of track and equipment.

As a consequence, the fraction of property in standard condititon declines, and the resulting reduction in service



Some of the feedback loops in the railroad model.

reduces the railroad's market share. A reduction in market share causes further decline in freight volume.

Consolidated Rail Corporation

Since the end of World War II, many US railroads have been deteriorating physically and financially. Consolidated Rail Corporation (Conrail), which began operations in 1976, has come into being as a result of this trend. Conrail is a consolidation of the rail properties of six bankrupt railroads.

Despite receipt of 3.3 billion dollars in federal loans, Conrail remains in financial trouble. Additional federal loans, rate deregulation, additional coal freight, track abandonment, and productivity improvements are some of the policies being considered to help Conrail and other railroads out of their difficulties. To evaluate the impacts of such policies on Conrail's performance, the system dynamics model for long-range strategic planning was used by Conrail's Planning and Control Department.

In 1960, Conrail's predecessors carried an estimated 280 million tons an average of 375 miles, which gives a freight volume of 105 billion ton-miles. The total intercity freight in the region covered by the predecessors was estimated

to be 620 billion ton-miles, leaving Conrail with a market share of 17 percent. The average price per ton-mile - the shipping rate - was 4 cents, and the net income was close to zero. We assume that Conrail's predecessors had the same amount of track as Conrail has today: 40,000 miles, of which 10,000 miles were estimated to be in substandard condition in 1960. We also assume that Conrail's predecessors had 150,000 rail cars, of which 105,000 cars needed maintenance in 1960.

These numbers are the initial conditions with which the model simulation starts in 1960. The financial data are in constant 1980-dollars. If the railroad's operating environment had remained at 1960-levels, then it is assumed that the railroad performance would have remained unchanged, which means that the model is initialized in equilibrium in 1960. (This assumption is probably too simplistic. Although most railroads were making profit in 1960, they were overbuilt for the traffic volume at that time.)

However, several changes took place in Conrail's operating environment in the 60's and the 70's, creating the model behavior shown in the base simulation run on page 11.

First, the GNP-contribution of the Eastern District (in which Conrail operates) showed a steady growth in the 60's, which led to growth in Conrail's freight volume despite decreasing market share. In 1970, however, the growth stopped and a slow decline has occured in the Eastern District of the US ever since. The decline can be derived from the fact that not just railroad freight, but also truck freight has been declining in the Eastern District since 1970. This decline in economic activity combined with the decline in market share, led to a steep decline in Conrail's freight volume in the 70's. Also, Conrail has the impression that rail-oriented activities, such as heavy manufacturing and coal mining, have declined even faster than the average economic activity in the Eastern District.

Second, the rate of inflation increased in the 60's and the 70's, causing railroad costs to rise faster than shipping rates. It is assumed in the model that the net effect of inflation on railroad performance is a lag in shipping rate behind operating costs. When costs go up, then the railroad applies for a rate increase. The rate increase is approved by the Interstate Commerce Commision (ICC) only after a considerable delay. This delay implies that the shipping rate will always lag behind cost increases. This lag

will be greater the faster costs grow. In the base simulation run, this effect is seen in the declining real value shipping rate over the period from 1960 to 1980.

Third, the competition from other modes of transportation - trucks in particular - has become more significant. Trucks have been able to reduce their rates relative to those of railroads. Also, substantial improvements in service reliability, service frequency and operating speed have been achieved in the trucking industry. These changes have caused the trucking industry to increase its market share at the expense of the railroad industry.

Finally, federal investments - totaling 3,3 billion dollars - were spent by Conrail to improve property quality. With the federal money, the car maintenance backlog was almost eliminated and the increase in substandard track was halted. These improvements led to reductions in operating losses (i.e.negative net income), but market share (here Conrail's share of the total freight market, not Conrail's share of the rail market) and freight volume continued to decline. (It must be noted that the calculated net income is far from exact because it is very small compared with revenues.)

When used to simulate the period 1960 to 1979, the model projects the following operating data for 1979 (the actual number - when available - is put in paranthesis):

- freight volume of 90 billion ton-miles (93 billion)
- market share of 14 percent
- shipping rate of 3.8 cents per ton-miles (3.8 cents)
- 17,000 miles of substandard track
- 118,000 rail cras (118,000 rail cars)
- 20,000 rail cars needing maintenance
- no net income (loss of 178 million dollars).

The numbers are used as initial conditions for projections of Conrail performance. For Conrail's operating environment it is assumed in the projections that the economic activity in the Eastern District of the US will continue to decline slowly, that the inflation rate will remain at the 1979-level, that there will be no federal investments after 1980, and that the railroad's competitive environment will not become worse, i.e. that truck rates and service levels remain constant relative to rail.

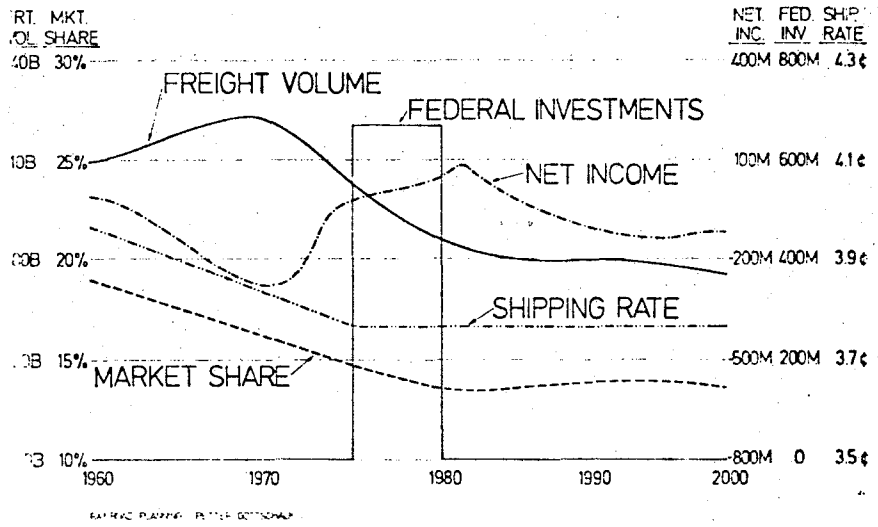
The base simulation run on the next page shows projected Conrail performance from 1979 to 2000. Conrail's market share continues to decline because of continued track deterioration. Conrail's freight volume continues to decline because of declining market share and because of the assumed decrease in regional economic activity. The operating loss remains insignificant. In the year 2000, Conrail's freight volume is 70 billion ton-miles and substandard track amounts to 24,000 miles, more than half of the total track.

Policy Analysis

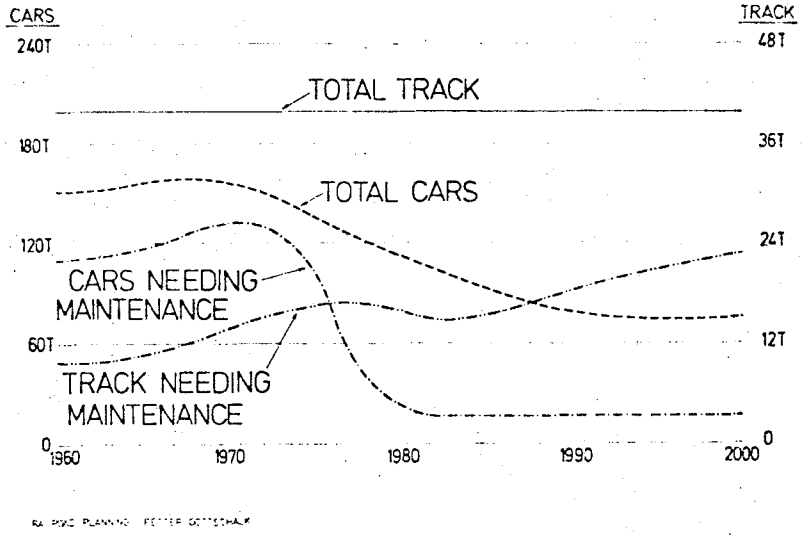
A revitalization of Conrail seems unlikely to occur unless new policies are implemented. No doubt, the federal investements have helped Conrail, but they have only prevented Conrail from a steeper decline, they have not turned Conrail's financial and physical condition around.

Additional Federal Investements

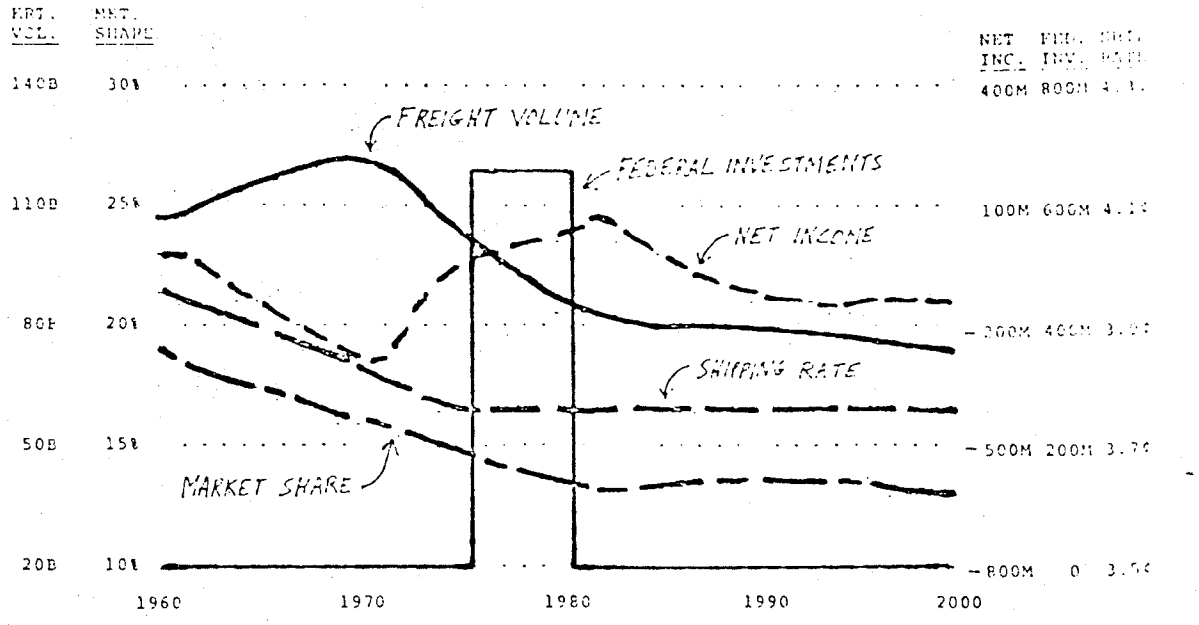
Conrail applied for additional federal investements in 1980. The simulation on the page 12 (bottom), assumes that Conrail receives another 2 billion dollars. The money is mainly spent on track maintenance between 1981 and 1985. The simulation shows a significant reduction in deferred track maintenance: the amount of substandard track is reduced



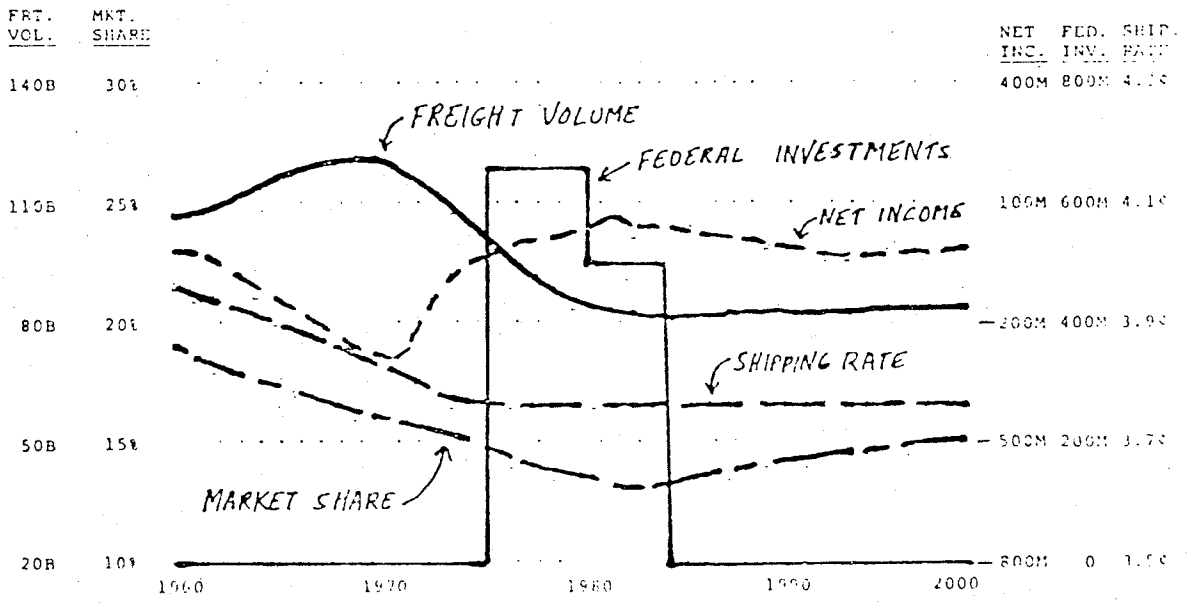
Base simulation run showing freight volume (billion ton-miles per year), federal investments (million dollars per year), net income (million dollars per year), shipping rate (cents per ton-mile), and market share (percent).



Base simulation run showing total track and track needing maintenance (thousand miles), and total cars and cars needing maintenance (thousand cars).



Base scenario



Additional federal investments

from 17,000 miles in 1980 to 9,000 miles in 1985. This improvement in railroad condition increases the service and, as a consequence, Conrail's market share starts to rise. The increase in market share compensates for the decline in regional economic activity and the freight volume is stabilized at 85 billion ton-miles. Net income, however, shows no significant improvement since the shipping rate is only sufficient to cover unit operating costs.

Additional Coal Freight

The energy crisis may force utilities and other industries in the US to make significant shifts from oil to coal. As a consequence, the demand for coal transportation will likely rise. Traditionally, railroads have hauled twothirds of the coal (measured in tons). Competing modes, such as slurry pipelines, may pick up the growth because of cost advantages although the high fixed costs probably will prevent the construction of such pipelines in the near future. Also, large-scale pipeline construction could remain impossible, because railroads and environmental interests continue to be successful in blocking eminent domaine legislation. Thus, an increase in Conrail's coal freight is likely. In 1979, Conrail hauled 78 million tons, representing 29 percent of Conrail's

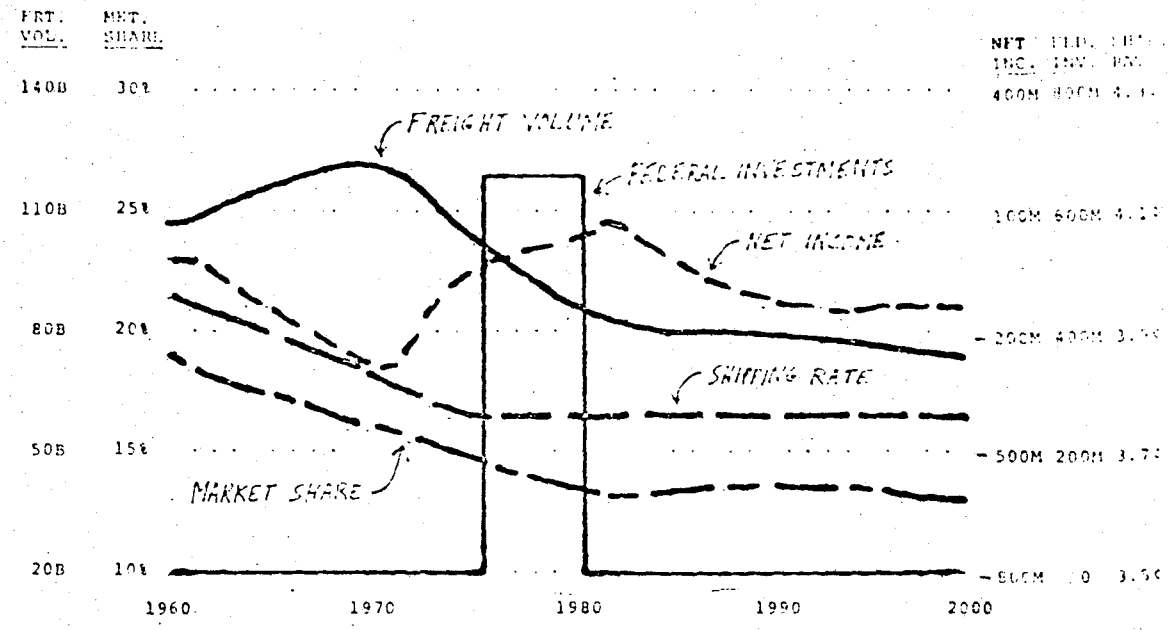
total tonnage. In the simulation run on the next page it is assumed that a doubling of this quantity will occur by 1990 (156 mill. tons) and a trippling by 2000 (234 mill. tons). It is assumed that the freight of other commodities will respond as in the base scenario.

The simulation on the next page shows steep growth in market share and freight volume. Net income, however, shows an initial (though insignificant) decline because operating expenses exceed operating revenues. Around 1990, additional unit coal trains increase productivity and reduce unit operating expenses, causing net income to go up. At the same time funding is generated to reduce deferred track maintenance.

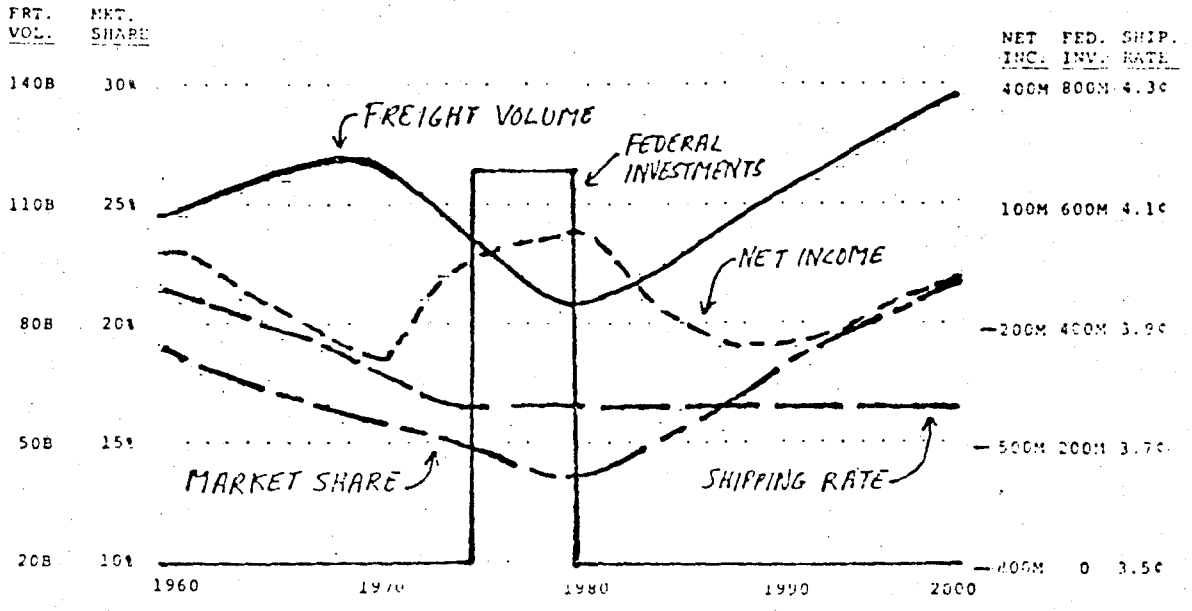
It is difficult to predict how fast unit operating expenses can be reduced by additional coal freight, but the projection presented here may seem too pessimistic. If a faster reduction is assumed, then the initial decline in net income will not occur.

Track Abandonment

Conrail operates approximately 40,000 miles of track and 20,000 miles of road (there are two track-miles per road-mile on average). Many of the areas served by Conrail have lost



Base scenario

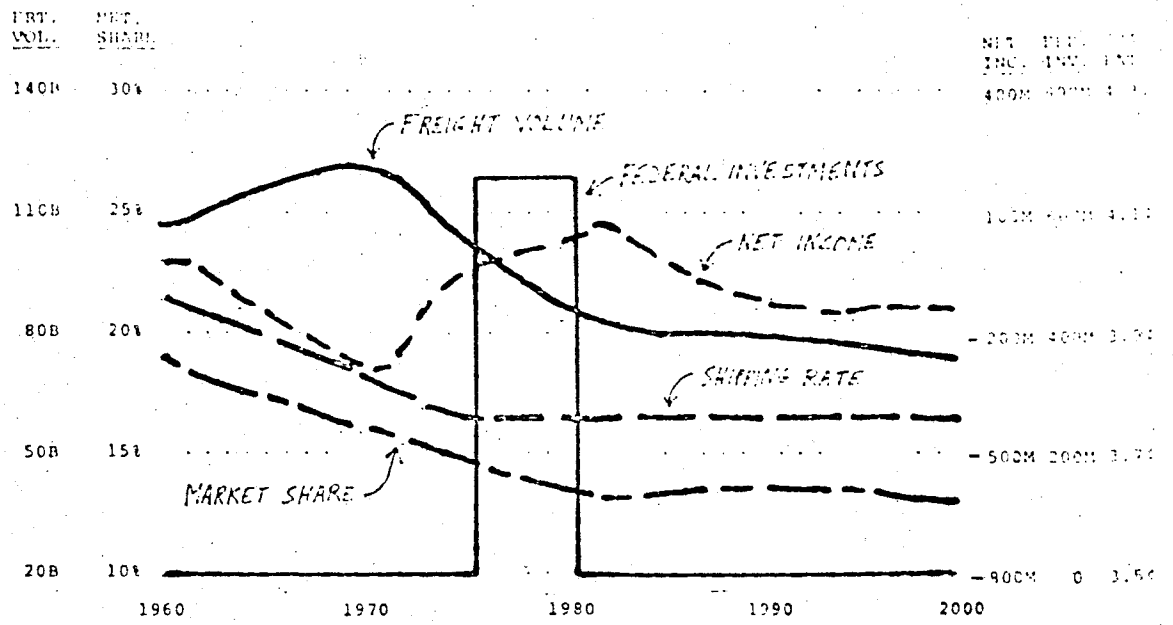


Coal transportation

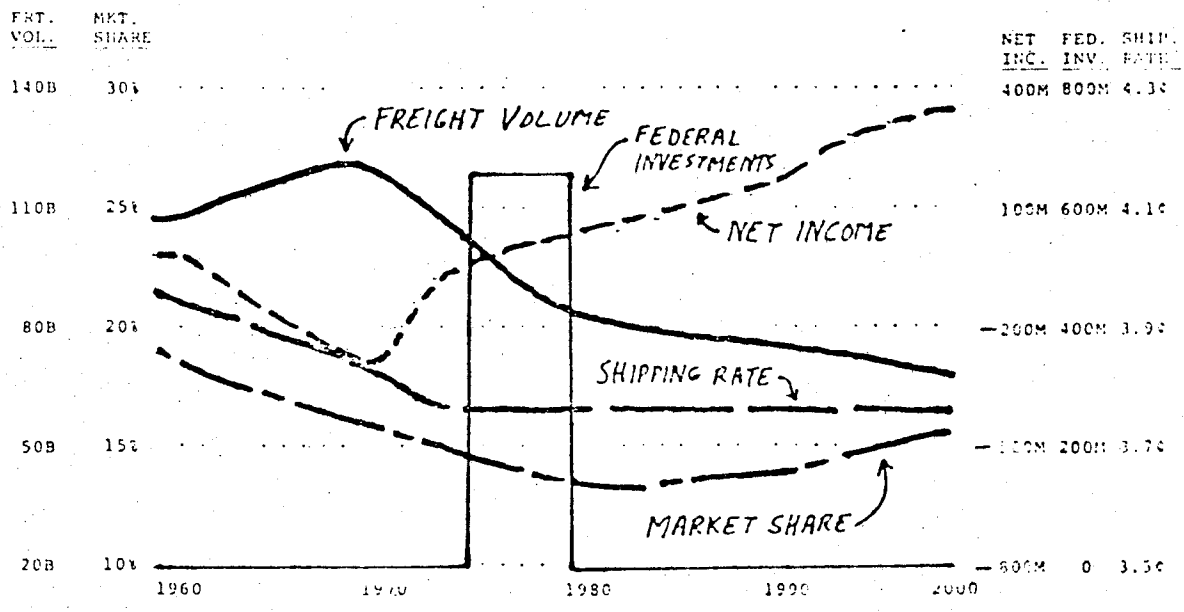
their industrial base. So far, however, the Interstate Commerce Commision has prevented Conrail from abandoning the track in these - or any other - areas. Deregulation of the railroad industry and/or federal intervention may change this situation. Since Conrail has stopped maintaining track where it would like to abandon the line, the simulation model assumes that track is abandoned in respons to the amount of substandard track.

On the next page, the model's simulation of this abandonment policy is shown. The total number of track miles is reduced to 27,000 miles by the year 2000. The main effects of track abandonment are that only a slight reduction in freight volume will occur, while operating expenses show significant improvements, leading to growth in net income.

In the simulation, market share goes up while freight volume goes down. The reason for this result is that market share is calculated based on the region covered by the railroad. When track is abandoned, the region covered by the railroad decreases in the model proportionally, while only marginal freight is lost leading to an increase in market share.



Base scenario



Track abandonment

Other Policies

The US Congress was debating a deregulation bill which - among other things - can give the railroads the freedom to determine their own shipping rates. Given this deregulation, the model shows that Conrail increases its average shipping rate in response to negative return on investment.

Another policy is related to Conrail's productivity. Compared with other major railroads, Conrail's productivity is low. For example, the number of ton-miles per employee per year is far below average. Conrail had a workforce of 87,000 in 1979. Through negotiations with the United Transportation Union, Conrail has attempted to achieve furthre reduction in train crew size. Labor expenses account for 50 percent of total expenses. In a model simulation, it was assumed that labor productivity is improved by 10 percent by 1990 and by 20 percent by 2000 relative to the productivity level in 1980. The reduction in operating expenses makes funding for property improvements available and stops the decline in market share.

Comparison of Policies

The policies discussed in this paper are not actions which depend on a single decision-maker. Most of them involve federal authorities as well as Conrail. Additional federal

loans are granted by the US Congress, but the spending of such loans on competing railroad needs is decided by Conrail management. Additional coal freight is mainly dependent upon such factors as OPEC, the federal authorities' support to industries which convert from oil to coal and pollution standards, but Conrail's equipment and service will also influence its coal freight. Track abandonment can either be accepted by the Administration or decided upon by Conrail itself in the case of deregulation, but political factors will still influence its decision. The bill which will deregulate the railroad industry must pass the US Congress, but the use of rate freedom as granted in the bill is derermined by Conrail. Productivity improvements in Conrail's operations will be achieved more quickly with cooperation of the unions.

Below, a summary of simulation results are presented. All policies will improve both Contrail's financial and physical condition compared with the base simulation in the year 2000. Additional federal investments and coal freight will improve Conrail's psysical condition, but reduce its financial performance compared with the situation in 1980. Only track abandonment and productivity improvements seem to revitalize Conrail, i.e. permanent improvement in the railroad's physical and financial condition is achieved by 2000.

	Net Income (Mill.$)	Substandard Track (Miles)
SITUATION IN 1980	0	17,000
BASE SCENARIO 2000	- 150	23,000
RATE DEREGULATION 2000	- 100	22,000
ADDITIONAL COAL FREIGHT 2000	- 80	13,000
ADDITIONAL FEDERAL LOAN S 2000	- 20	10,000
PRODUCTIVITY IMPROVEMENTS 2000	+ 120	13,000
TRACK ABANDONMENT 2000	+ 340	2,000

Reference

Gottschalk, Petter: The Dynamics of Railroad Decline and Revitalization. GRS-311. Resource Policy Group 1980. 159 pages.

CLASS II DOCUMENTATION STANDARDS
FOR SIMULATION MODELS

1. ACCESS TO MODEL:

Name of Model: Railroad Simulation Model

Name and current address of the senior technical person responsible for the model's construction: Petter Gottschalk, Resource Policy Group, Sagveien 21, Oslo 4, Norway

Who funded the model development? Stipend from Norwegian Government

In what language is the program written? DYNAMO

On what computer system is the model currently implemented? IBM

What is the maximum memory required to store and execute the program? 5000 words

What is the length of time required for one typical run of the model? .4 seconds

Is there a detailed user's manual for the model? Yes

2. PURPOSE OF THE MODEL:

For what individual or institution was the model designed? Consolidated Rail Corporation

What were the basic variables included in the model?

Track, equipment, freight, income and expenses

Over what time period is the model supposed to provide useful information on real world behavior?

From 1960 to 2000

Was the model intended to serve as the basis of:

an academic exercise designed to test the implications of a set of assumptions or to see if a specific theory would explain historical behavior — No

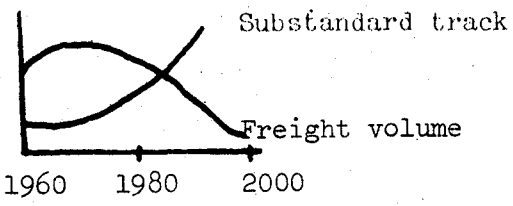
communication with others about the nature and implications of an important set of interactions — No

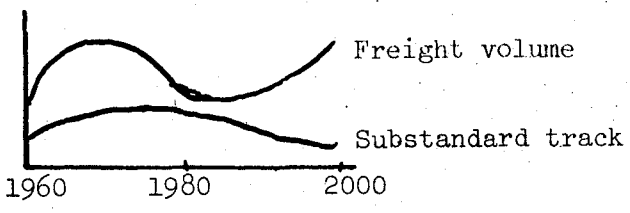
projecting the general behavioral tendencies of the real system — Yes

predicting the value of some system element(s) at some future point in time — Yes

3. MODEL SPECIFICATION AND THEORETICAL JUSTIFICATION:

Provide two diagrams illustrating the extreme behavior modes exhibited by the major model elements:





If they are not included in the body of the paper indicate where the reader may find:

a model boundary diagram that indicates the important endogenous, exogenous and excluded variables: None

a causal influence diagram, a flow diagram, the computer program and definitions of the program elements: GRS-311

Is the model composed of:

simultaneous equations: No

difference or differential equations: Yes

procedural instructions: Yes

Is the model deterministic: Yes or stochastic: ____

continuous: Yes or discrete: ____

4. DATA ACQUISITION

What were the primary sources for the data and theories incorporated in the model?

Data: Technical and financial data from Conrail

Theory: Discussions with Conrail managers

What percent of the coefficients of the model were obtained from:

measurements of physical systems: 30

inference from social survey data: ____

econometric analyses: ____

expert judgment: 60

the analyst's intuition: 10

What was the general quality of the data? Good

5. PARAMETER ESTIMATION

If they are not given in the publication, where may the reader obtain detailed information on the data transformations, statistical techniques, data acquisition procedures, and results of the tests of fit and significance used in building and analyzing the model? None. The computations are not documented.

6. MODEL PERFORMANCE AND TESTING

Over what period was the model's behavior compared with historical data?

From 1960 to 1980

What other tests were employed to gauge the confidence deserved by the model?

Discussions with Conrail about model structure and robustnesstests.

Where may the reader obtain a detailed discussion of the prediction errors and the dynamic properties of the model? Partly in GRS-311. Petter Gottschalk:

The Dynamics of Railroad Decline and Revitalization. Resource Policy Group 1980.

7. APPLICATIONS

What other reports are based upon the model? None

Name any analysts outside the parent group that have implemented the model on another computer system. None

List any reports or publications that may have resulted from an evaluation of the model by an outside source. None

Has any decision maker responded to the recommendations derived from the model?

Conrail's Planning and Control Department

Will there be any further modifications or documentation of the model? No

Where may information on these be obtained?