VOLUME 2

ANALYSIS OF COMPETITION, CAPACITY, AND SERVICE QUALITY

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Volume 2: Contents

CHAPTER 10 AN OVERVIEW OF COSTS AND REVENUE

CHAPTER 11 RAILROAD PRICING BEHAVIOR

CHAPTER 12 ANALYSIS OF COMPETITION: COAL

CHAPTER 13 ANALYSIS OF COMPETITION: CORN AND WHEAT

CHAPTER 14 ANALYSIS OF COMPETITION: CHEMICALS

CHAPTER 15 ANALYSIS OF COMPETITION: INTERMODAL SHIPMENTS

CHAPTER 16 ANALYSIS OF RAILROAD CAPACITY

CHAPTER 17 SERVICE QUALITY

CHAPTER 18 CONCLUSIONS ON THE STATE OF COMPETITION IN THE U.S. FREIGHT RAILROAD INDUSTRY

REFERENCES

ABBREVIATIONS

3-R Act	Regional Rail Reorganization Act of 1973
4-R Act	Railroad Revitalization and Regulatory Reform Act of 1976
AAR	Association of American Railroads
AFC	Average Fixed Cost
ATC	Average Total Cost
AVC	Average Variable Cost
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
the Board	Surface Transportation Board
BNSF	Burlington Northern Santa Fe
CAPM	Capital Asset Pricing Model
CBO	Congressional Budget Office
CCO	Common Carrier Obligation
CFR or C.F.R.	Code of Federal Regulations
CMP	Constrained Market Pricing
CN	Canadian National
the Commission	Interstate Commerce Commission
CP	Canadian Pacific
CSX	CSX Corporation
CWS	Carload Waybill Sample
DCF	Discounted Cash Flow
DOJ	Department of Justice
DOT	Department of Transportation
FCC	Federal Communications Commission
FDC	Fully Distributed Costing (methodology)
FTC	Federal Trade Commission
GAO	Government Accountability Office
GDP	Gross Domestic Product
ICC	Interstate Commerce Commission (also referred to as “the Commission”)
ICCTA	ICC Termination Act of 1995
KCS	Kansas City Southern
MC	Marginal Cost

MFP	Multi-Factor Productivity
NS	Norfolk Southern
PAF	Productivity Adjustment Factor
PPI	Producer Price Index
R/VC	Revenue to Variable Cost ratio
R-1	Form R-1 data from Class I railroads' Annual Reports filed with the STB
RCAF	Rail Cost Adjustment Factor
RCAF-A	Adjusted RCAF
RCAF-U	Unadjusted RCAF
RPM	Railroad Performance Measures
RPTM	Revenue per Ton-Mile
SAC	Stand-Alone Cost (methodology)
SARR	Stand-Alone Railroad (analysis)
SPLC	Standard Point Location Code
STB	Surface Transportation Board
STCC	Standard Transportation Commodity Code
TFP	Total Factor Productivity
TTX	TTX Company
UP	Union Pacific
URCS	Uniform Rail Costing System
USC or U.S.C.	United States Code
USO	Universal Service Obligation
USDA	U.S. Department of Agriculture

VOLUME 2 LIST OF FIGURES

CHAPTER 8 OVERVIEW OF INDUSTRY PERFORMANCE

CHAPTER 9 RAILROAD COSTS AND TECHNOLOGY

CHAPTER 10 AN OVERVIEW OF COSTS AND REVENUE

CHAPTER 11 RAILROAD PRICING BEHAVIOR

CHAPTER 12 ANALYSIS OF COMPETITION: COAL

CHAPTER 13 ANALYSIS OF COMPETITION: CORN AND WHEAT

CHAPTER 14 ANALYSIS OF COMPETITION: CHEMICALS

CHAPTER 15 ANALYSIS OF COMPETITION: INTERMODAL SHIPMENTS

CHAPTER 16 ANALYSIS OF RAILROAD CAPACITY

CHAPTER 17 SERVICE QUALITY

CHAPTER 18 CONCLUSIONS ON THE STATE OF COMPETITION IN THE U.S. FREIGHT RAILROAD INDUSTRY

VOLUME 2 LIST OF TABLES

CHAPTER 8 OVERVIEW OF INDUSTRY PERFORMANCE

CHAPTER 9 RAILROAD COSTS AND TECHNOLOGY

CHAPTER 10 AN OVERVIEW OF COSTS AND REVENUE

CHAPTER 11 RAILROAD PRICING BEHAVIOR

CHAPTER 12 ANALYSIS OF COMPETITION: COAL

CHAPTER 13 ANALYSIS OF COMPETITION: CORN AND WHEAT

CHAPTER 14 ANALYSIS OF COMPETITION: CHEMICALS

CHAPTER 15 ANALYSIS OF COMPETITION: INTERMODAL SHIPMENTS

CHAPTER 16 ANALYSIS OF RAILROAD CAPACITY

CHAPTER 17 SERVICE QUALITY

CHAPTER 18 CONCLUSIONS ON THE STATE OF COMPETITION IN THE U.S. FREIGHT RAILROAD INDUSTRY

Chapter 6 Contents

CHAPTER 6.
INTRODUCTION AND OVERVIEW OF VOLUME 2

INTRODUCTION

Volume 2 of this report presents our quantitative analyses and results. As a backdrop to our quantitative analyses, we provide an overview of the post-Staggers Act performance of the U.S. freight railroad industry. We examine the railroad industry's productivity, input costs, rates, and earnings. This overview sets the stage for our empirical investigations of competition and captivity, rates, service quality, capacity issues, and investment.

Our econometric analyses of the railroad industry are performed at two levels. We first estimate an industry-wide variable cost function to examine influences on the industry's cost structure. The variable cost function allows us to rely on economic theory to recover information about the production process of freight railroad transportation and how this process has been changing over time. We use the resulting variable cost function estimates to conduct analyses of the changes over time in the marginal cost of rail transport and the factors underlying these changes. These analyses provide a baseline from which to bifurcate rail rate changes into "competitive response" and "market power" components, and also assess the financial viability of the industry.

Next, we examine commodity-specific railroad pricing behavior that forms the basis for assessing the extent to which cost and market structure features of shipments account for variations in unit revenues at the commodity level. In addition, by combining information on "generic" marginal costs per ton-mile from the industry-wide variable cost function with estimates of pricing equation parameters, we characterize costs and markups at finer levels than is practical in aggregated analyses. Using the pricing models, we estimate the effects of two factors which may limit a railroad's ability to exert local market power: the availability of water-transportation alternatives and the presence of railroad competition. Furthermore, we examine whether the effects of these competition factors have changed over time. Since a number of legislative initiatives involve efforts to increase intramodal competition, our estimates of the effects from competition also inform our policy analysis in Volume 3 of this report.

The current volume also examines railroad capacity and service quality issues that may either be a cause of or a result of the industry's market structure and performance. The amount of capacity available from a given quantity of production inputs (i.e., productivity) will be affected by factors such as technological innovations (often embodied in capital), work rules and other regulations, railroad operating practices, and learning by doing. The ability to adjust capacity depends on the ability to adjust these various types of capital and labor inputs and other attributes, with some factors more easily adjusted than others. Another important influence on railroad capacity is the existence of congestion at points in the network. While congestion can occur on mainline segments that are heavily utilized, it often occurs in terminal areas, highly crowded urban areas, ports, and other transloading facilities. From numerous perspectives, there currently do not appear to be network-wide rail capacity constraints, but rather problems appear to be location-specific. We also address service quality issues that were discussed by respondents during the qualitative phase of this project. However, as we describe, the lack of publicly available data prevents us from performing a detailed investigation of service quality issues.

We conclude this volume with an assessment of the structure and performance of the rail industry to determine the extent of any undue exercise of market power. In particular, we examine our results regarding the competitive state of the industry in the context of the 2006 GAO report's findings on railroad rates and shipper captivity.

SYNOPSIS OF VOLUME 2 CHAPTERS

Chapter 7 provides an overview of the data sources and methodology used in the chapters devoted to railroad industry performance, costs and technology, pricing behavior, capacity, and service quality. More detailed discussions of data and methods can be found in the chapters devoted to those topics.

Chapter 8 initiates our quantitative investigation with an analysis of the railroad industry's productivity, costs, rates, and earnings. This analysis sets the stage for the empirical investigation of competition and captivity, rates, service quality, capacity issues, and investment. Section 8A examines railroad rate trends measured by alternative price indexes. Because the various price indexes discussed each have their potential biases, we construct a new set of rate indexes that attempt to capture the relevant cost differences of rail shipments and use chain-weighting techniques. Section 8B examines trends in railroad productivity and input prices. We analyze three primary factors that drive the railroad industry's rates. These factors are the changes in the prices that railroads pay for their inputs, the changes in railroad total factor productivity (TFP), and (the changes in market structure that increase or decrease railroad pricing margins). Section 8C examines trends in railroad financial performance and investment behavior. Longer-term trends in productivity provided by the BLS measure of multi-factor productivity (MFP) for the railroad industry show that railroad MFP growth peaked in the late 1980s, and recent railroad MFP growth rates are similar to those of the late 1970s and early 1980s. Furthermore, the railroad MFP measure confirms that recent productivity growth for the railroad industry has declined both absolutely and relative to economy-wide productivity growth. An overview of the industry's financial performance provides an indication of the degree to which concern is warranted over the exercise of market power in the railroad industry.

In Chapter 9, we obtain information about the rail freight production process by estimating a variable cost function. The estimated function applies to the Class I freight railroad industry as a whole. The variable cost function allows us to rely on economic theory to recover information about the production process of freight railroad transportation and how this process has been changing over time. We use the variable cost function estimates to conduct analyses of the changes over time in the marginal cost of rail transport and the factors underlying these changes. These analyses provide a baseline from which to bifurcate rail rate changes into "competitive response" and "market power" components. Also, the variable cost function allows examination of the incentives for railroads to undertake investment in additional capacity and infrastructure. Finally, the variable cost function provides a foundation for analyzing the impacts of some of the various policy options discussed in Volume 3.

Chapter 10 presents a high-level analysis and comparison of the railroad industry's costs and revenues. We examine how rail revenue per ton-mile, on average, is marked up over the competitive benchmark of marginal cost, and how the markup has changed over time. We identify how much of the change in markups reflects the need to achieve revenue adequacy versus the pursuit of monopoly profits.

Chapter 11 characterizes railroad pricing behavior at the shipment level with an econometric analysis of a panel of Carload Waybill Sample data. We use a profit-maximization model of railroad behavior, subject to constraints from alternative shipping modes, to develop "reduced form" pricing equations that relate reported revenue per ton-mile (RPTM) to cost and market structure features of sampled shipments. The pricing equations allow us to characterize the effects of cost and market structure features on variations in unit revenues at the commodity level. Using our pricing models, we estimate the extent to which the availability of water-transportation alternatives and the presence of railroad competition limit a railroad's ability to exert local market power. The large sample sizes from the Carload Waybill Sample allow us to investigate whether the effects of these competition factors have changed over time.

Chapters 12 to 15 provide in-depth pricing analyses for specific commodity traffic groups. The commodity traffic groups covered in these chapters are coal, grains (corn and wheat), chemicals, and intermodal. We find generally that railroad rates respond to both shipment cost characteristics and market structure factors, consistent with the pricing model developed in Chapter 11. However, we discover and explore several important differences across commodity traffic groups.

Chapter 16 analyzes the issue of capacity using a transportation flow approach, an econometric approach, and a descriptive approach. Based on these different perspectives, we conclude that there currently do not appear to be network-wide rail capacity constraints. Instead, congestion at various points or on specific corridors in the railroad networks appears to be the major culprit in capacity-related performance issues over the last ten years.

Chapter 17 addresses the issue of service quality. In our qualitative research, many respondents expressed concerns related to service quality that included captive shippers receiving poorer service quality as well as service quality declining as capacity became tighter. To investigate the service-quality issue, we use the weekly Railroad Performance Measures (RPM) that the Class I railroads provide to the AAR. Average train speed and average terminal dwell time are the elements compiled in the RPM dataset most closely related to service quality and operating performance. The major limitation of the RPM data is that they are only available at a highly aggregated level, which does not allow us to adequately address service quality issues that may be specific to certain routes, commodities, or shippers.

Volume 2 concludes with a chapter that summarizes our findings about captivity in Class I railroads.

Chapter 7 Contents

CHAPTER 7. DATA AND METHODOLOGY

INTRODUCTION

In this chapter, we provide an overview of the data sources and methodology used in the chapters devoted to industry performance, costs and technology, pricing behavior, capacity, and service quality. More detailed discussions of data and methods can be found in the chapters devoted to those topics. Results from those chapters are also used to evaluate the likely impacts of proposed legislative and regulatory changes to the U.S. railroad industry.

7A. OVERVIEW OF INDUSTRY PERFORMANCE

The analysis of railroad industry rate trends in Chapter 8 relies on published results from three sources. The first source is the October 2006 GAO report on the rail industry, combined with the letter sent by GAO to Congressional requesters on August 15, 2007, concerning updated information on rates and other industry trends. From this source we used the industry-wide rate index and the rate indexes for different commodities. The second source of data is the Surface Transportation Board. We used their Tornqvist index of nominal revenue per ton-mile. The third source is the Bureau of Labor Statistics. We used their Producer Price Indexes for line-haul railroads. We also constructed alternative price indexes using data reported in the Carload Waybill Sample.

Our primary source for analyzing railroad industry productivity trends in Chapter 8 is the Productivity Adjustment Factor, published by the Surface Transportation Board. The Productivity Adjustment Factor is the productivity factor used in the STB’s Adjusted Rail Cost Adjustment Factor. Additionally, we use the multifactor productivity index for the railroad industry produced by the Bureau of Labor Statistics. For purposes of comparison, we also use their multifactor productivity indexes for the private business sector and for the airline industry.

To analyze railroad industry input price trends in Chapter 8, we use the STB’s Unadjusted Rail Cost Adjustment Factor. The Unadjusted Rail Cost Adjustment Factor is based on the American Association of Railroads’ All Inclusive Index, which is an index of input price trends for Class I railroads. We also use the price components of the Unadjusted Rail Cost Adjustment Factor. These components show the price trends associated with labor, fuel, materials and supplies, equipment rents, depreciation, interest, and other expenses.

We rely on data from the Value Line Investment Survey to analyze the railroad industry's financial performance in Chapter 8. We checked for the reasonableness of the Value Line data by comparing them to data reported in the railroad company's annual reports. The measures that we used in this analysis include company revenues; earnings before interest, taxes, depreciation, and amortization (EBITDA); earnings before interest and taxes (EBIT); net profit; earnings per share (EPS); EBIT per share; EBIT per dollar revenue; return on shareholders' equity (RSE); capital spending per share; capital spending per EBIT; capital spending per dollar of depreciation expense; capital spending per dollar revenue; and price-earnings ratios. We also compared the railroad industry with four benchmark industries on a number of these measures. The benchmark industries were electric utilities, transportation, food processing, and chemicals. Data on these benchmark industries were also obtained from the Value Line Investment Survey. Furthermore, we compared the railroad industry's return on shareholders' equity to the equity component of the railroad industry's cost of capital, as measured by the STB. In this comparison, we used both the STB's old methodology (DCF) and its new methodology (CAPM) for measuring cost of capital.

7B. Costs and Technology

In Chapter 9, we estimate a variable cost function for U.S. Class I railroads over the period 1987-2006, to obtain information about the rail freight production process. The estimated function applies to the Class I freight railroad industry as a whole, and is used to generate year-specific and railroad-specific estimates of marginal costs and other relevant technological concepts. Most of the data used in the variable cost function estimation come from the Rail Form 1 (R-1 data), which Class I railroads submit to the STB annually. Using the R-1 data, we construct measures of variable cost, variable input cost shares, output, network size, average length of haul, variable input prices, and the quantity of way and structures capital stock. Our variable cost measures include the costs of labor, materials, fuel, and equipment. The quantity of way and structures capital stock is calculated using a perpetual inventory method. The perpetual inventory method constructs a capital stock from current and previous years' plant additions, taking into account the decline in asset efficiency as an asset ages. More detail on the definition and construction of the cost function variables is presented in Chapter 9 of this volume.

7C. Pricing Behavior

Railroad pricing behavior is examined in Chapters 10 through 15. In Chapter 10 we conduct a high-level analysis comparing how rates and costs have moved over time, using the R-1 data and the marginal cost estimates obtained from the variable cost function estimation reported in

Chapter 9. In particular, we use these data to examine the markup of rates over marginal and variable cost, the implied exercise of market power, revenue sufficiency, and how these measures have been changing over the last twenty years.

We then turn to a more microeconomic analysis of pricing behavior using an econometric model that relates the price charged for a shipment to variables that represent the shipment's cost characteristics and variables that represent market structure. This analysis is based on data from the unmasked Carload Waybill Sample (CWS) for the years 2001-2006, using the individual sampled shipments during this period as the units of observation. The shipment's price (rate) is based on the freight revenue per ton-mile of the shipment. Variables representing the shipment's cost characteristics include length of haul, size of load, tons per car, car ownership, and total volume of the commodity shipped. Market structure variables include distance from the origin of the shipment to the nearest port or waterway facility, distance from the destination of the shipment to the nearest port or waterway facility, the number or railroad competitors at the origin of the shipment, and the number of railroad competitors at the destination of the shipment. Finally, control variables are included for the year, quarter, originating railroad, destinating railroad, and the combination of originating state and destinating state for the shipment. Most of the data used to construct these variables come from the CWS. The variables representing the distances to the nearest port or waterway are developed using information on port and waterway facilities from the U.S. Army Corps of Engineers Navigation Data Center and geographical data from the company ESRI.

7D. CAPACITY

Capacity issues are examined in Chapter 16 by an analysis of descriptive measures of capacity, a review of transportation systems' flow models, and an analysis of the results from our econometric estimation of railroad variable cost functions. For the descriptive measures of capacity, we rely on Railroad Performance Measures (RPM) data for terminal dwell time and cars on line, R-1 data on miles of track from Schedule 700, R-1 data on equipment expenditures by category from Schedule 330, and information on freight car and locomotive counts obtained from the AAR. For the review of transportation systems' flow models, we rely on the recent study conducted by Cambridge Systematics. A brief description of our variable cost function estimation can be found above, and the results of this econometric work are presented in Chapter 9.

7E. SERVICE QUALITY

In Chapter 17, service quality issues are primarily examined by an analysis of average train speed by train type. The RPM dataset contain weekly data on train speed for the reporting Class I railroads. The RPM data on train speed allow us to calculate average train speeds across a railroad's network but do not allow for route-specific or corridor-specific analyses, nor do the RPM data allow an evaluation of on-time performance or variability of performance from a shipper's perspective. Train speed is an indicator of how well the network is performing. It is a measure of service quality as well as an indicator of network capacity and operational efficiency. Average train speed is a proxy for service quality, and changes in average speed represent changes in performance and service quality. Therefore, comparisons of changes in average speed across train types—intermodal, manifest, multilevel, coal, grain—provide an indication of changes in service quality across customers of these train types.

Chapter 8 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 8.
OVERVIEW OF INDUSTRY PERFORMANCE

INTRODUCTION

Prior to investigating the behavior and performance of individual railroads and specific markets it is useful to have an overview, or benchmark, of aggregate industry performance. Thus, we initiate our quantitative investigation with an analysis of industry productivity, costs, rates, and earnings. This analysis sets the stage for the empirical investigation of competition and captivity, rates, service quality, capacity issues, and investment.

Section 8A examines railroad rate trends measured by alternative rate indexes. There are two general approaches that have been taken to measure trends in railroad rates. The first approach is to rely on Producer Price Indexes published by the U.S. Bureau of Labor Statistics.[1] The second approach is to construct price indexes from the Carload Waybill Sample. Both the STB and GAO have relied on the Carload Waybill Sample to construct rate indexes. Recently, the Congressional Budget Office (CBO) compared the indexes based on these different approaches. The CBO reported that the Producer Price Indexes have shown moderate increase in rail rates, while the Carload Waybill Sample produced declining rate indexes. We examine these alternative indexes and also construct our own rate indexes from the Carload Waybill Sample.

Section 8B examines trends in railroad productivity and input prices. Trends in railroad output prices, or rates, are driven by changes in the prices that the railroads pay for their inputs as well as changes in railroad total factor productivity. The All Inclusive Index component of the STB's Rail Cost Adjustment Factor (RCAF) methodology is an aggregate measure of railroad input price, although it does not incorporate the opportunity cost of capital used in production. The STB's Productivity Adjustment Factor (PAF)[2] measures the productivity change associated with the inputs included in the All Inclusive Index, and constitutes a good proxy for total factor productivity trends for Class I railroads. The Unadjusted Rail Cost Adjustment Factor (RCAF-U) index incorporates the All Inclusive Index price trends, but not the productivity trends, and hence provides a measure of railroad input price trends. The Adjusted Rail Cost Adjustment Factor (RCAF-A) index incorporates both the All Inclusive

[1] Bureau of Labor Statistics, Producer Price Indexes, at http://www.bls.gov/PPI/.

[2] The PAF is an element of the Surface Transportation Board's RCAF methodology.

Index price trends and the PAF productivity trends, and hence shows their net impact on railroad costs. An analysis of the RCAF-U, RCAF-A, and PAF provides an overview of the trends in input prices and productivity for Class I railroads. We also analyze long-term trends in railroad industry productivity using the Bureau of Labor Statistics' (BLS) measure of Multifactor Productivity (MFP) for the broad railroad industry.[3]

Section 8C examines trends in railroad financial performance and investment behavior. We compare railroad earnings to a number of commonly used benchmarks such as returns for peer industry groups and the broader S&P 500. This comparison allows us to make a qualitative assessment of the existence and potential magnitude of excess profits in the railroad industry. We also analyze the railroad industry's investment behavior relative to its financial performance and selected benchmark industries. Analyzing accounting information on earnings will not provide definitive information on the presences or absence of monopoly profits, but it will provide useful background information on railroad earnings as we investigate more closely the issue of competition in the rail industry.

8A. RAILROAD PRICING

The 2006 GAO report provided evidence on trends in railroad rates since 1985.[4] One piece of evidence presented in this report was an industry-wide index of railroad rates that was developed by GAO staff. Based on this evidence, the report concluded that railroad rates dropped 10 percent between 1985 and 1987, declined at a slower rate between 1987 and 1998, and fluctuated between 1998 and 2004. By 2004, GAO's industry-wide railroad rate index was approximately three percent below its level in 2000, and it was 20 percent below its 1985 level.[5]

This GAO report also showed rate indexes for four commodity groups: coal, grains, motor vehicles, and miscellaneous mixed shipments.[6] These indexes indicated that most rates had decreased between 1985 and 2004, but the rates of decrease were not uniform. The coal rate index had decreased the most, by approximately 35 percent over the period. The

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[3] Bureau of Labor Statistics, Multifactor Productivity Series, at http://www.bls.gov/mfp/.

[4] Government Accountability Office, Freight Railroads: Industry Health has Improved, but Concerns about Competition and Capacity should be Addressed, October 2006.

[5] Government Accountability Office, Freight Railroads: Industry Health has Improved, but Concerns about Competition and Capacity should be Addressed, October 2006, p. 11.

[6] The GAO also computed similar rate indexes for an additional nine commodity groups, but the results of these indexes are not included in their report. The rate indexes for seven of these commodity groups decreased between 1985 and 2004. For the remaining two commodity groups, the rate index for fireboard or paperboard increased 11 percent between 1985 and 2004, and the rate index for nonmetallic minerals increased four percent during that same time period.

grain rate index differed from the other commodity group indexes in that it showed an overall increase between 1985 and 2004. The grain rate index initially declined between 1985 and 1987, but then increased so that by 2004 the grain rate index was nine percent above its 1985 level.

The GAO updated these different indexes in a subsequent response to Congress in 2007. In the updated results, the industry-wide rail index increased seven percent in 2005, which was the largest one-year increase in the twenty-year study period.[7] This meant that the overall decrease in the industry-wide rail index between 1985 and 2005 was 13 percent, while the increase between 2000 and 2005 was also 13 percent. This subsequent GAO report also updated its commodity-specific rate indexes. The GAO found that the rate indexes for grains and coal each increased eight percent between 2004 and 2005, the rate index for motor vehicles increased three percent, and the rate index for miscellaneous mixed shipments increased 12 percent. Between 1985 and 2005, the grain rate index increased 18 percent, the coal rate index decreased 30 percent, the motor vehicle rate index decreased 27 percent, and the miscellaneous mixed shipment rate index decreased 13 percent.

The STB developed and maintains an industry-wide rate index that can be compared to the GAO index. This index, the STB Tornqvist index of nominal revenue per ton-mile, increased three percent between 1985 and 2005 (compared to the thirteen percent decline shown by the GAO index). Between 2000 and 2005, the STB index shows a 23 percent increase (compared with a 13 percent increase shown by the GAO index).[8]

The Producer Price Indexes (PPI) for line-haul railroads maintained by the BLS provide a third source of information on recent rail rate index trends. The line-haul railroad industry includes all freight and passenger transportation over long distances, and excludes short distance and local freight lines, commuter rail, and switching and terminal facilities. The BLS publishes an aggregate line-haul rail transportation price index, and up until June of 2005, also published rail transportation price indexes for 13 commodity groups: farm products; metallic ores; coal; non-metallic minerals; food products; lumber and wood products; pulp, paper, and allied products; chemicals and allied products; petroleum and coal products; stone, clay, glass, and concrete products; primary metal products; transportation equipment; and all other shipments. In 2005, the BLS reduced its coverage of the railroad industry due to budgetary constraints. Since that time, the BLS rail price index measures have included only the aggregate price index and freight price indexes for carload freight transportation and intermodal transportation.

[7] GAO letter to Congressional Requesters, GAO-07-291R, August 15, 2007.

[8] The results of the STB index cited here are obtained from a handout we received from STB staff at the beginning of this project. Earlier versions of STB rate indexes can be found at http://www.stb.dot.gov/stb/industry/econ_rateindex.html.

The aggregate PPI for line-haul rail transportation has shown more substantial price growth than either the GAO or STB industry-wide indexes. Between 1985 and 2005, the PPI for line-haul rail transportation increased 40 percent; while it increased 22 percent between 2000 and 2005.

Figure 8-1 shows the trends in the GAO, STB, and BLS (PPI) railroad rate indexes, while Table 8-1 compares the percentage changes in these three indexes over different time periods.

FIGURE 8-1
INDUSTRY-WIDE INDEXES OF RAILROAD RATES
1985 = 100

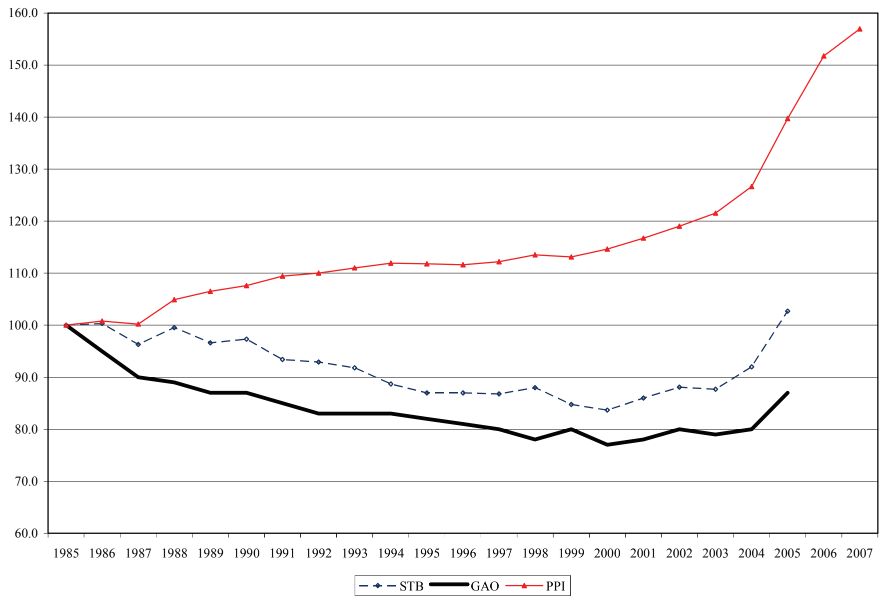

TABLE 8-1
CUMULATIVE CHANGES IN INDUSTRY-WIDE INDEXES OVER DIFFERENT TIME PERIODS

Time Period	STB Index	GAO Index	Producer Price Index
1985 to 2000	-16%	-23%	15%
2000 to 2005	23%	13%	22%
1985 to 2005	3%	-13%	40%

Part of the explanation for the differences across rail rate indexes could be related to the fact that passenger rail transportation is included in the PPI, but given the relative sizes of freight and passenger transportation much of disparity must be due to differences in the methods used to measure prices. The BLS freight price indexes for different commodities also show significant differences from the GAO indexes. Between 1985 and 2004, the PPI for farm product freight transportation increased 48 percent, the PPI for coal freight transportation increased 15 percent, and the PPI for transportation equipment freight transportation increased 42 percent. Figure 8-2 shows the trends in the GAO rate index for grains and the PPI for farm product freight transportation.

FIGURE 8-2
GRAIN AND FARM PRODUCT RATE INDEXES
1985= 100

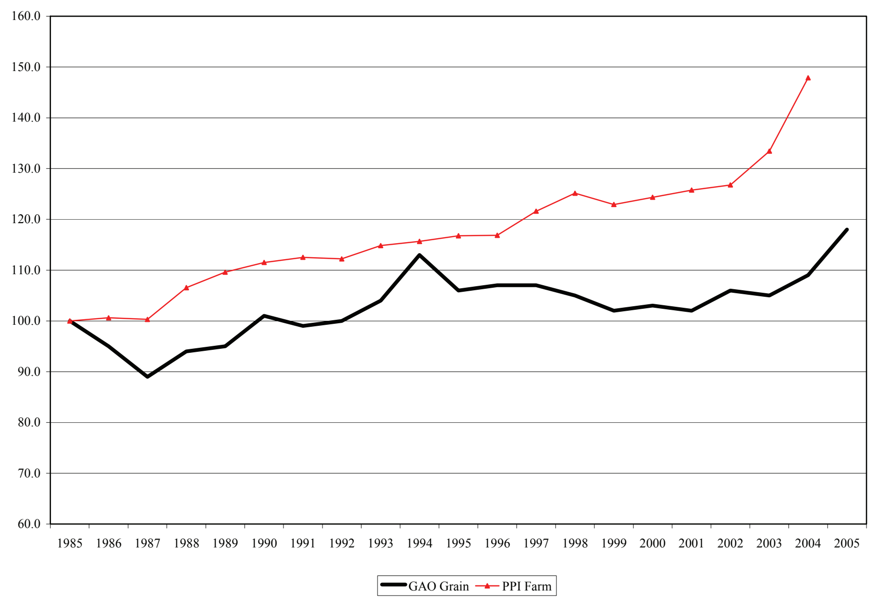

Figure 8-3 shows the trends in the GAO rate index for coal and the PPI for coal freight transportation.

FIGURE 8-3
COAL RATE INDEXES
1985= 100

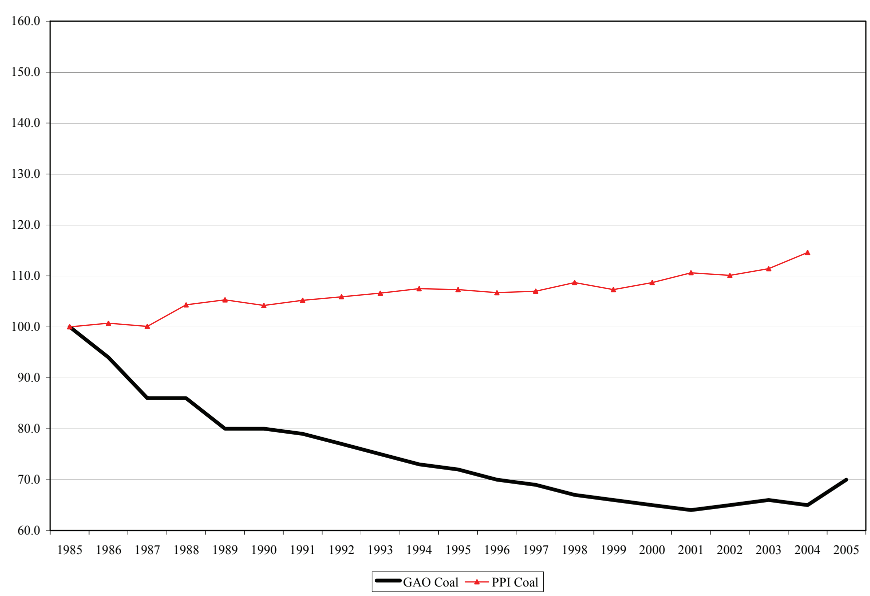

Figure 8-4 shows the trends in the GAO rate index for motor vehicles and the PPI for transportation equipment freight transportation.

FIGURE 8-4
MOTOR VEHICLE AND TRANSPORTATION RATE INDEXES
1985 = 100

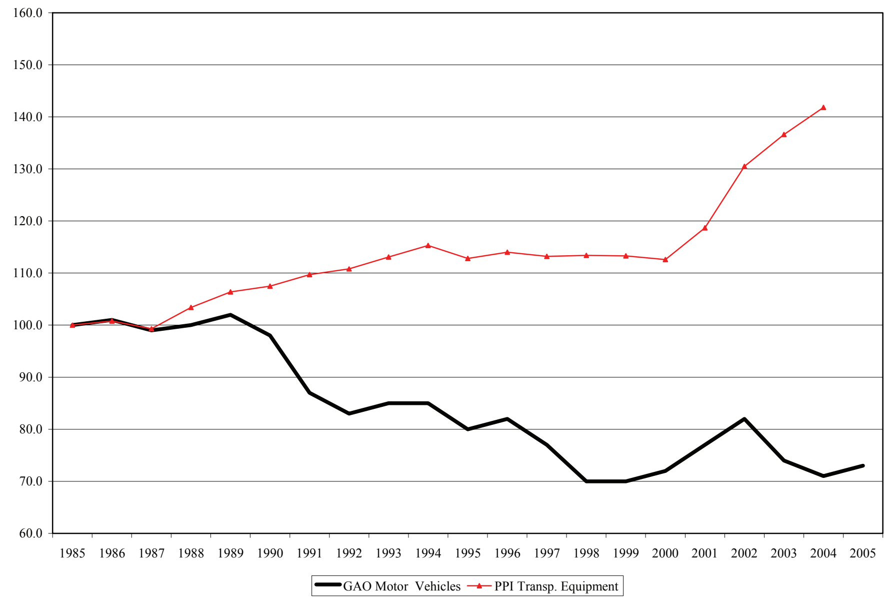

Table 8-2 compares the percentage changes in these six indexes over different time periods.

TABLE 8-2
CUMULATIVE CHANGES IN COMMODITY RATE INDEXES OVER DIFFERENT TIME PERIODS

Time Period	Grain and Farm Products		Coal		Motor Vehicles and Transportation Equipment	
	GAO	PPI	GAO	PPI	GAO	PPI
1985-2000	3%	24%	-35%	9%	-28%	13%
2000-2005	6%	19%	0%	5%	-1%	26%
1985-2005	9%	48%	-35%	15%	-29%	42%

The GAO and STB rate indexes are based on information reported in the Carload Waybill Sample. Both of these indexes are based on revenue per ton-mile for different shipments. Each shipment is classified by a number of characteristics and combined into a cell with other shipments having those same characteristics. The average revenue per ton-mile and changes in revenue per ton-mile over time are computed for each cell, and changes in the revenue per ton-mile changes in the different cells are aggregated together using revenue weights to obtain an overall rate change. However, the GAO and STB indexes rely on different classifications of shipments. The GAO industry-wide index distinguishes shipments by their point of origin (through mapping the shipment to one of eleven geographic zones in the U.S. and Canada) distance (through six distance zones), and by two-digit commodity code.[9] To construct its commodity freight transportation indexes, the GAO uses a slightly different approach, where it maps shipments to one of eleven originating zones and one of eleven destinating zones (with the commodity indexes being constructed at the four-digit commodity code level). The STB index distinguishes shipments by two-digit commodity code and whether the shipment originates east or west of the Mississippi River. The GAO uses a "fixed-weight" method for weighting the rate changes for each cell. The fixed-weight method uses relative shipment sizes for each cell in a base year (in the case of the GAO index the last year of the analysis) to weight the cell percentage changes in rates for all years of the analysis. Academic research on price indexes has long noted that the fixed-weight method can provide misleading indicates on price changes when there are shifts in the services being purchased over time. The STB uses a "chain-weight" method, where the weights changes through time as there are shifts in the types of transportation services being purchased. The particular chain-weight method that the STB uses, the Tornqvist index, does not suffer from the problems identified in the fixed-weight methods, and has been characterizes as a "superlative" index in the academic literature.

One feature of the GAO and STB approaches is that shipments within each cell may still have significantly different characteristics. For example, transportation equipment shipments originating in the Great Lakes region and traveling one thousand miles can be of considerable different shipment sizes. The costs associated with these shipments may be quite different, and for that reason the revenue received per ton-mile may be considerably different. However, the price associated with shipments in that cell is based on the average revenue per ton-mile. If there is a shift from more costly shipments to less costly shipments over time, the average revenue per ton-mile may decrease, even if rates on each shipment do not change.

The PPIs are constructed from a random sample of railroad prices. The intent of the sample is to measure price changes for particular services. Each shipment in the sample is identified by a number of characteristics such as origin and destination of the shipment, commodity, type of railcar, whether the car is owned or rented, shipment weight, and number of cars in the shipment. Price changes of this particular type of

[9] The term "commodity code" refers to the Standard Transportation Commodity Code classification.

shipment are tracked over time and combined with price changes in other shipments to obtain the overall PPI change. The random sample is continually refreshed, but there are significant conceptual issues that can create an upward bias in the measured rate of railroad rate increases. The first potential source of bias arises when one service is discontinued and a similar, but not identical, service is initiated. The BLS does not attempt to measure the effective price difference between these two services. Rather, it effectively excludes these two services when computing the overall price change in railroad rates at that time.[10] If that particular type of shipment is discontinued or does not appear, that shipment is dropped from the sample and another one selected. For example, if a particular shipment under tariff is discontinued, but the same type of shipment is offered, but now under contract, the BLS will drop the old shipment from the sample. Due to the methods used by BLS, it will not compare the new contract price with the old tariff price to see if the cost to the shipper has gone up or down. The same is true if the shipper no longer makes shipments of a particular size, but does make shipments of the same commodity over the same route in a different size. The BLS method also suffers from the problem that it introduces new types of services with a lag. For example, if a railroad were to start offering express service to its customers while continuing to offer its old service at its old terms, and its customers took advantage of the new service, this would represent a price decline to the customer, and should be reflected in the price index. The BLS would not pick this price up however until it was randomly sampled, and the net cost savings that the service provides would not be captured in the index. Often the new service being offered is cost reducing to the shipper (although it can also be cost increasing). A related issue is the fact that completely new services (such as express freight transportation) would be introduced into the sample as the sample is refreshed. This would mean that the cost savings to shippers would not be completely captured by the PPI. Finally, the BLS also uses a fixed-weight method for aggregating the different prices that it samples, which as we noted above can provide misleading indications on overall rate trends.

Because the different price indexes discussed above each have their potential biases, we attempted to construct a new set of rate indexes that attempt to capture the relevant cost differences of shipments and use chain-weighting techniques. In order to determine which shipment characteristics lead to significant cost differences, we reviewed the methods being used to construct the output index in the Productivity

[10] In order to determine the effective price change in moving from the one service to the other, the BLS would need to estimate the effective cost increase or decrease to the shipper. For some industries where there are significant changes in the products and services being offered (e.g., the computer industry), the BLS uses what is known as hedonic methods, which effectively puts prices on the underlying quantifiable characteristics that are common to both services, and measures the changes in the differences in the levels of these characteristics.

Adjustment Factor. The objective in constructing the output index is to weight ton-miles of freight in different shipments by the relative costs of transporting those shipments. That output index is based on the Carload Waybill Sample, with shipments assigned to cells based on four sets of characteristics: shipment weight, length-of-haul, car type, and service type. This classification of shipments was arrived at in a study prepared by Reebie Associates in 1988.[11] Reebie Associates initially considered classifying shipments by twenty shipment weight sizes, eleven length of haul groups, seventeen car types, two car ownership types, seven service (i.e., cars per waybill) types, and 50 commodity groups. After a detailed analysis, they concluded that these characteristics could be condensed down into three shipment weight sizes, three length of haul groups, seven car types, and three service types.[12]

Given the shift in recent years away from cars being owned by the railroads, we kept the car ownership classification as well as the two-digit commodity classification. This means that we assign each shipment to one of 835 different cells. Within each cell we compute average revenue per ton-mile, and we construct an aggregate rate index from the revenue per ton-mile indexes using the chain-weighted Tornqvist index formula.

The GAO noted that there has been a substantial increase in miscellaneous charges in recent years. It expressed concerns that the measure of freight revenue on which they constructed their rate indexes does not fully incorporate fuel surcharges, infrastructure upgrade costs, congestion fees, rebates, and incentives. The GAO noted that miscellaneous revenue in the Carload Waybill Sample had increased substantially in recent years, which may reflect fuel surcharge billings. In an attempt to address these concerns, we construct two variants of our industry-wide rate index. The first rate index is restricted to freight revenue per ton-mile, while the second rate index is based on total revenue (freight revenue plus transit and miscellaneous charges) per ton-mile. Figure 8-5 compares the trends in these two rate indexes with the Producer Price Index for line-haul railroads and the GAO industry-wide rate index.

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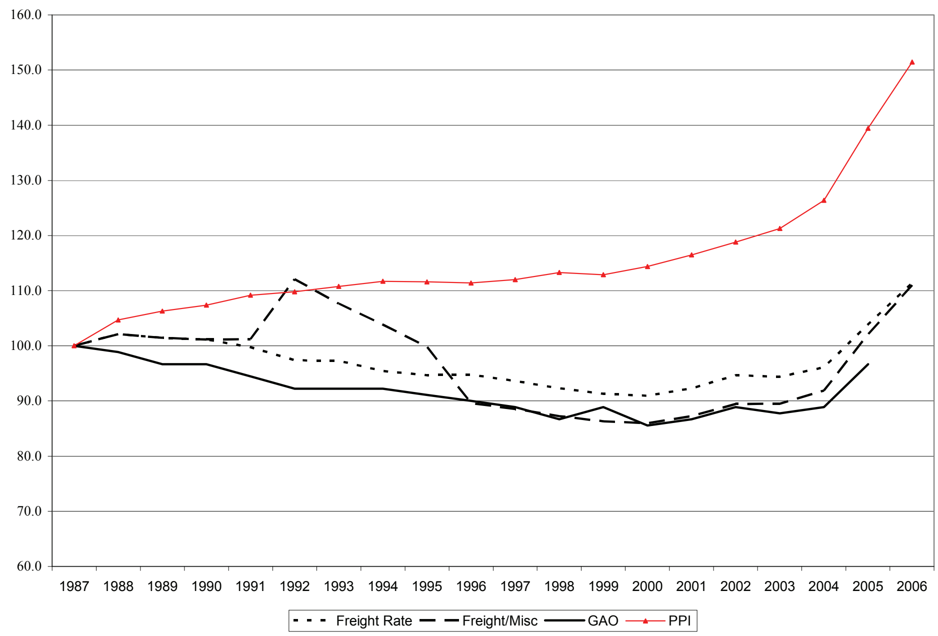
[11] Reebie Associates, with the assistance of Dr. Ralph L. Nelson, Dr. Richard Levin, Dr. Curtis M. Grimm, and Dr. M. Daniel Westbrook, *Railroad Productivity Evaluation, Final Report, Proposed Measures for RCAF and URCS Application*, prepared for the Interstate Commerce Commission, October 11, 1988.

[12] The three shipment weight sizes are 1-25 tons per car, 26-70 tons per car, and over 70 tons per car. The three length of haul groups are 1-499 miles, 500-999 miles, and over 999 miles. The seven car types are boxcar, reefer, and other; gondola; open hopper; covered hopper; flat, excl. TOFC/COFC; tank; and TOFC/COFC. The three service types are 1-5 cars per waybill, 6-49 cars per waybill, and over 49 cars per waybill.

FIGURE 8-5
INDUSTRY-WIDE INDEXES CONSTRUCTED FROM COMMODITY WAYBILL SAMPLE



The index we construct using just freight revenue and the index using both freight and miscellaneous revenue show approximately the same overall increase between 1987 and 2006, but the patterns differ. The index including miscellaneous revenue shows a significant jump in 1992 and stays above the index based solely on freight revenue until 1996. In 1996, the index including miscellaneous revenue fell below the index based solely on freight revenue, while the gap between the two indexes has closed in recent years. Over the analysis period, both indexes show average rate increases that lie between those reported by the GAO and the Producer Price Index.

Table 8-3 shows the percentage rate increases for both of the indexes we constructed. The table shows that between 1988 and 2000, freight rates predominantly decreased, but since 2000 rates increased for the most part. For 2005 and 2006, rates increased over seven percent per year for the index based on freight revenue alone and over eight percent per year for the index based on freight and miscellaneous revenue.

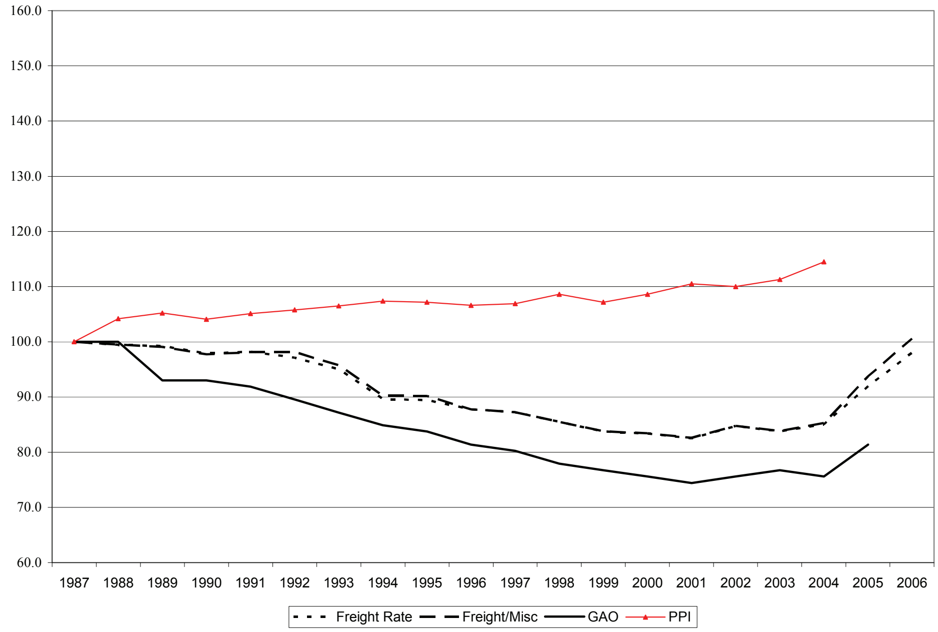
In interpreting the results from this table, one must recognize that there are factors, both positive and negative, which might affect the cost to shippers but are not picked up in the Carload Waybill Sample. On the one hand, the GAO noted that not all shipper discounts and incentives are picked up by the sample. On the other hand, it also noted that there have been claims of cost shifting, where shippers must bear costs that formerly have been borne by railroads. In addition, there may have been changes in the terms of service for shippers that are not quantified in the sample.

TABLE 8-3
ANNUAL PERCENTAGE INCREASES IN INDUSTRY-WIDE RATE INDEXES

Year	Index Based on Freight Revenue	Index Based on Freight and Miscellaneous Revenue
1988	2.1%	2.1%
1989	-0.6%	-0.7%
1990	-0.3%	-0.3%
1991	-1.4%	0.0%
1992	-2.4%	10.2%
1993	-0.1%	-4.0%
1994	-1.9%	-3.6%
1995	-0.8%	-4.0%
1996	0.1%	-10.8%
1997	-1.2%	-1.2%
1998	-1.5%	-1.5%
1999	-1.1%	-1.0%
2000	-0.4%	-0.5%
2001	1.4%	1.5%
2002	2.6%	2.5%
2003	-0.3%	0.0%
2004	1.8%	2.6%
2005	7.8%	10.5%
2006	7.0%	8.4%
1987-2000	-0.7%	-1.2%
2000-2006	3.4%	4.3%

Because the GAO and Producer Price Indexes also showed significantly different results for coal transportation, we developed coal rate indexes from the Carload Waybill Sample. Figure 8-6 compares the rate indexes we developed with the GAO index and Producer Price Index.

FIGURE 8-6
COAL RATE INDEXES
1987 = 100



The figure shows that the two indexes we constructed from the Carload Waybill Sample lie between the Producer Price Index and the GAO index. Here the index based on freight revenues and the index based on freight and miscellaneous revenues show very similar trends throughout the analysis period. Our indexes also show that the rates for coal have increased significantly since 2004. Table 8-4 shows the percentage changes in the two indexes we constructed.

Both indexes show that rates predominantly decreased between 1988 and 2000. Between 2001 and 2004, there were a series of small increases and decreases. For 2005 and 2006,, the rate increases were substantial, with average rate increases for both constructed indexes above seven percent in those years.

To summarize, the rate indexes we developed using the Carload Waybill Sample show rates of increase that lie between the indexes reported by the GAO and the Producer Price Indexes. We conclude that they provide useful evidence of recent rate trends. The indexes show that rate increases have by and large been moderate until very recently, but between 2004 and 2006, the rate increases were substantial, as the indexes we constructed show rate increases on the order of seven to eight percent per year during this period.

TABLE 8-4
ANNUAL PERCENTAGE INCREASES IN COAL RATE INDEXES

Year	Index Based on Freight Revenue	Index Based on Freight and Miscellaneous Revenue
1988	-0.5%	-0.5%
1989	-0.2%	-0.4%
1990	-1.4%	-1.4%
1991	0.3%	0.4%
1992	-1.1%	0.0%
1993	-2.2%	-2.5%
1994	-5.8%	-5.9%
1995	-0.1%	-0.1%
1996	-1.9%	-2.8%
1997	-0.6%	-0.6%
1998	-2.0%	-2.0%
1999	-2.1%	-2.0%
2000	-0.4%	-0.5%
2001	-1.0%	-1.0%
2002	2.6%	2.6%
2003	-1.1%	-1.1%
2004	1.5%	1.7%
2005	7.8%	9.4%
2006	6.4%	7.0%
1978-2000	-1.4%	-1.4%
2000-2006	2.7%	3.1%

8B. RAILROAD INDUSTRY INPUT PRICE AND PRODUCTIVITY TRENDS

Trends in the railroad industry's output prices, or rates, are driven by three primary factors: changes in the prices that the railroads pay for their inputs, changes in railroad total factor productivity, and changes in market structure that increase or decrease railroad pricing margins. Changes in input prices and changes in productivity determine the rate at which railroad unit costs increase over time. Any differences between the rate at which railroad output prices change and the rate at which railroad unit costs change flow through to the profit margins that the railroad industry generates.

Our primary analysis of the railroad industry's input price and productivity trends relies on the STB's RCAF and the associated PAF. These measures provide several advantages: they are based on a well-established methodology, regularly audited and published by the STB, and widely known. The Bureau of Labor Statistics' (BLS) multifactor productivity (MFP) index for line-haul railroads is a second potential source for evaluating the railroad industry's productivity trends. The MFP index for the railroad industry is one of many that the BLS produces for different sectors of the U.S. economy.

The next section provides an overview of the STB's RCAF and the BLS's MFP methods. Following this overview, we discuss trends in the RCAF metric since the first quarter of 1989, when the methodology was established. We then discuss MFP productivity trends since the late 1950s.

Overview of STB RCAF and BLS MFP Methods

In 1989, the STB instituted a methodology for measuring the RCAF that explicitly incorporates input price and productivity trends of Class I railroads. Input price trends are measured using the All-Inclusive Index, maintained by the Association of American Railroads. The All-Inclusive Index measures price changes for the major components of the railroad industry's operating expenses: labor, fuel, materials and supplies, equipment rents, depreciation, interest, and other expenses. The All-Inclusive Index is used to establish the RCAF-U, or in other words, the RCAF-U represents trends in railroad input prices. The second element of the RCAF methodology is the PAF, which represents trends in output per unit of input. The output measure used in the PAF is based on a revenue-weighted index of railroad ton-miles, distinguished by shipment weight, length of haul, car type, and service type. Distinguishing ton-miles by these different shipment characteristics means that the more expensive types of shipments are given more weight in the index than the cheaper types of shipments. The input measure used to compute the PAF is constant dollar operating expenses, which is obtained by dividing total operating expenses by the RCAF-U. The final element of this methodology is the construction of the RCAF-A, which is obtained by dividing RCAF-U by the PAF. By construction, the RCAF-A metric measures trends in the railroad industry's unit costs.

Aside from the PAF, another potential source for evaluating the railroad industry's productivity trends is the MFP index for line-haul railroads from the BLS. The MFP index for the railroad industry is one of many that the BLS produces for different sectors of the U.S. economy. The BLS uses the same methods for constructing all of its MFP indexes, and these methods are based on an extensive economic literature concerning productivity measurement. One difference between the MFP and the PAF metrics is that the MFP measure looks at productivity trends for the entire line-haul railroad industry (NAICS 482111), not just Class I railroads. Like the PAF, the railroad industry's MFP measure uses an output index that is based on ton-miles distinguished by different shipment characteristics. In the case of the MFP measure, these characteristics include length of haul, commodity type, and shipping mode. To measure inputs, the MFP methodology distinguishes capital (equipment, structures, land, and inventories), labor, and intermediate inputs (purchased materials and services). Quantity measures for these different input categories are constructed and then combined into an overall index of input. The methods used to construct these input quantity measures are different in nature from the methods used to construct constant dollar operating expenses, which leads to another difference between the PAF and MFP metrics. Since the PAF and MFP are based on different quantity measures of both output and input, they will not yield exactly the same results. Nevertheless, it is quite useful to see whether the productivity trends shown by the PAF are supported by the evidence from the MFP measure.

Trends in RCAF and PAF, 1989-2008

As mentioned above, the RCAF-U is based on the All-Inclusive Index, which is a fairly comprehensive measure of railroad inputs as it measures price changes for the major components of the railroad industry's operating expenses: labor, fuel, materials and supplies, equipment rents, depreciation, interest, and other expenses. Although the All-Inclusive Index does not include an element that captures changes in the opportunity cost of equity, its near comprehensiveness does provide a good indication of input price trends for Class I railroads. The PAF measures the productivity change associated with the inputs whose price changes are captured by the All Inclusive Index, while the RCAF-A index incorporates both the All Inclusive Index price trends and the productivity trends, and hence shows their net impact on railroad costs. An analysis of the RCAF-U, RCAF-A, and PAF provides an overview of the trends in input prices and productivity for Class I railroads.

Figure 8-7 shows the quarterly RCAF-U from 1989 through the second quarter of 2008. Figure 8-8 shows the PAF over this same time period. Figure 8-9 combines the graphs of RCAF-U (input prices) and PAF (productivity).

FIGURE 8-7
RCAF-U, 1989-2008

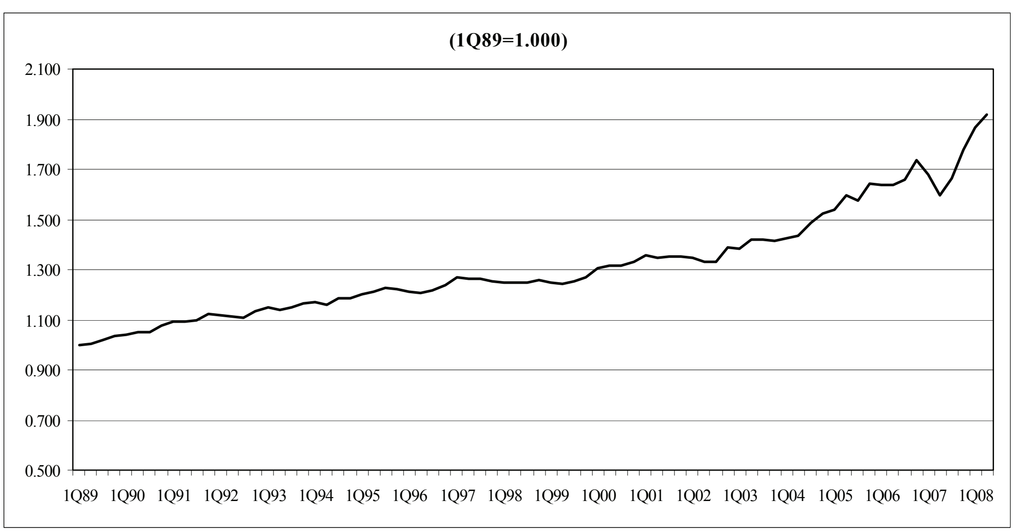


FIGURE 8-8
PRODUCTIVITY ADJUSTMENT FACTOR (PAF), 1989-2008

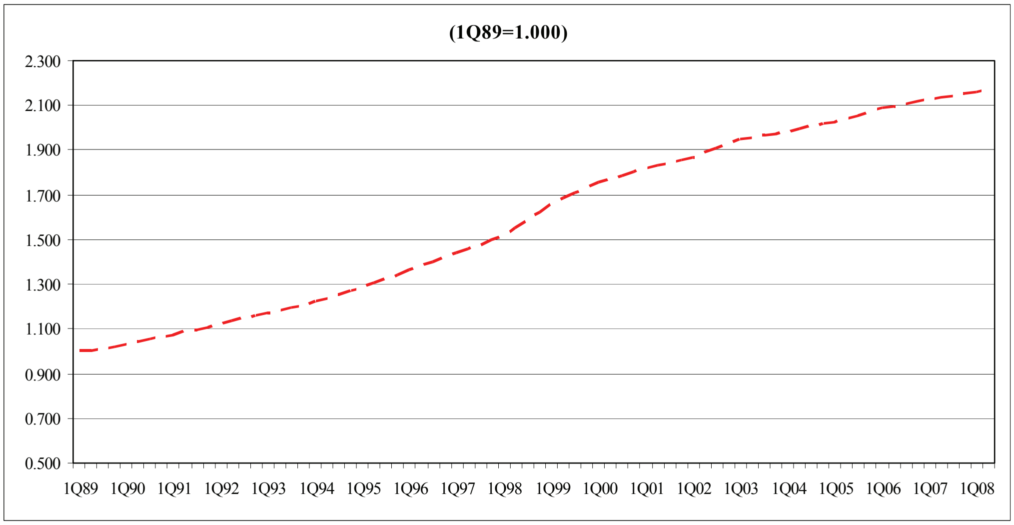
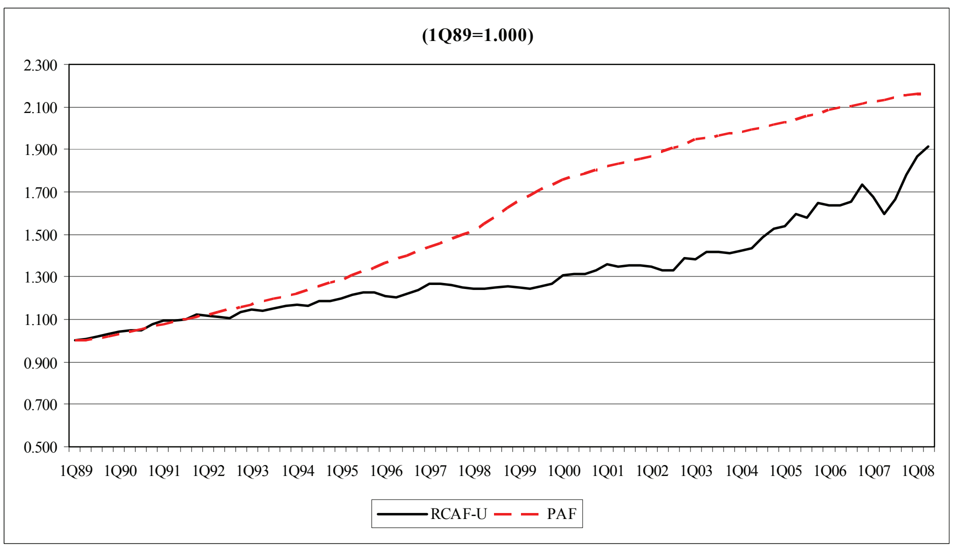


FIGURE 8-9
RCAF-U AND PAF, 1989-2008



The offsetting effect of railroad productivity gains on railroad input price growth is illustrated by the RCAF-A (the difference between RCAF-U and PAF) in Figure 8-10. The downward trend in the RCAF-A from the early 1990s until 2002 was the result of railroad productivity gains outpacing input price inflation. However, since the third quarter of 2002, the relationship has reversed, with railroad input price growth outpacing productivity growth, reflected in the generally upward-sloping RCAF-A plot since that quarter.

FIGURE 8-10
RCAF-A, 1989-2008

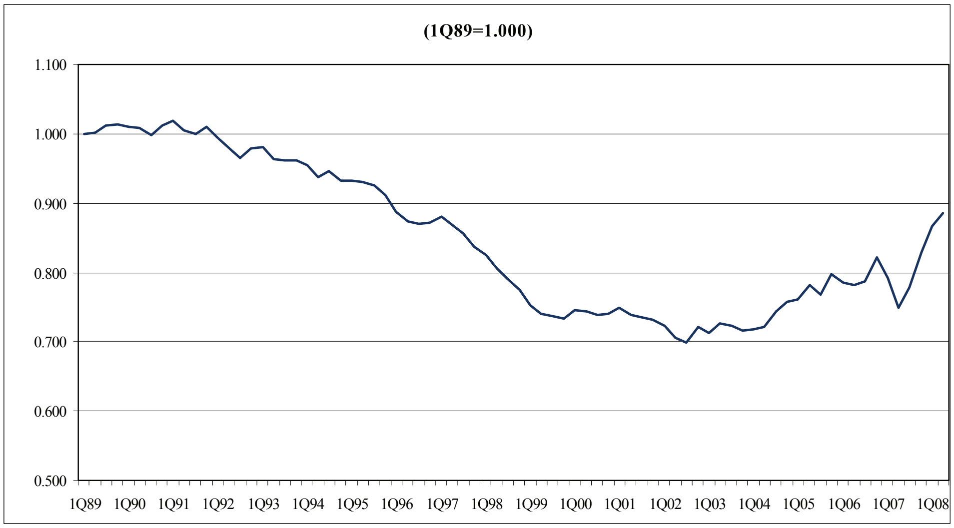


Table 8-5 shows the average annual growth rates for RCAF-A and its components, RCAF-U and PAF, over the entire 1Q89-2Q08 period, and for the sub-periods, 1Q89-3Q02, 3Q02-2Q08, and 1Q00-2Q08.

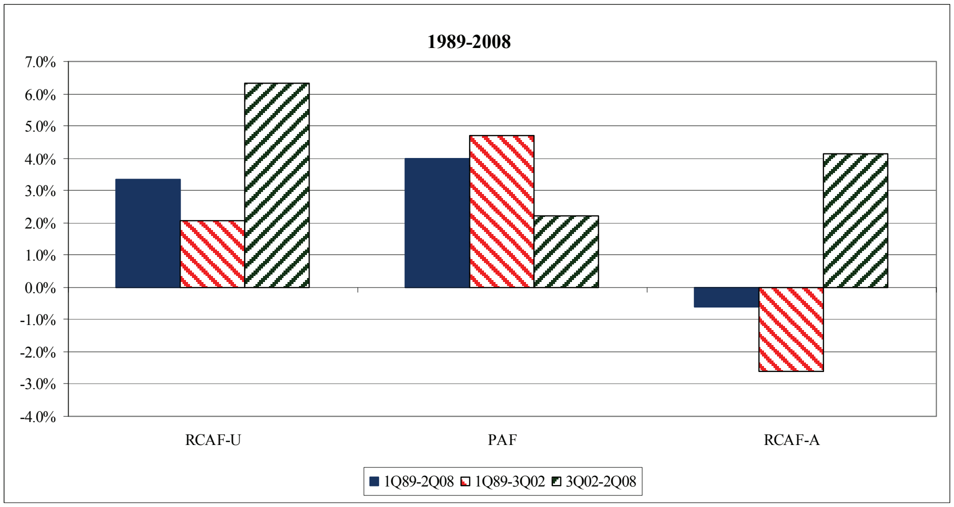
TABLE 8-5
GROWTH IN RCAF-U, PAF, AND RCAF-A
AVERAGE ANNUAL GROWTH, 1989Q1-2008Q2

	1Q89-2Q08 *1Q94-2Q08*	**1Q89-3Q02** *1Q94-3Q02*	**3Q02-2Q08**	**1Q00-2Q08**
RCAF-U	3.3%	2.1%	6.3%	4.5%
	3.4%	*1.5%*		
PAF	4.0%	4.7%	2.2%	2.5%
	4.0%	*5.1%*		
RCAF-A	-0.6%	-2.6%	4.1%	2.0%
	-0.5%	*-3.6%*		

Numbers in italics represent the use of 1Q94 as the starting point for consistent comparison to RCAF-U components below.

This information is depicted graphically in Figure 8-11. It is apparent that 1Q89-3Q02 is very different from 3Q02-2Q08. While RCAF-A declined at an average annual rate of -2.6 percent from 1Q89 through 3Q02, it has since increased at an average annual rate of 4.1 percent.

FIGURE 8-11
RCAF-U, PAF, AND RCAF-A—AVERAGE ANNUAL GROWTH



From Table 8-5 and Figure 8-11, it can be seen that this reversal for the RCAF-A is due to divergent trends in productivity and input price growth. In the 1Q89-3Q02 sub-period, productivity (PAF) growth averaged 4.7 percent and input price (RCAF-U) growth averaged 2.1 percent. However, since 3Q02 productivity growth declined to an average of 2.2 percent—less than half its previous average growth—while input price growth tripled to an average of 6.3 percent.

In order to analyze in more detail what factors have contributed to the changing trend in input prices (represented by RCAF-U) since late 2002, information on the components of RCAF-U can be examined. Since detailed price information for the various components of RCAF-U is available only back to 1994, Table 8-5 above also presents growth rates for the 1Q94-2Q08 and 1Q94-3Q02 periods to allow for a consistent comparison to the RCAF-U components. Focusing on the two sub-periods, 1Q94-3Q02 and 3Q02-2Q08, the same pattern emerges of higher productivity growth and lower input price growth in the earlier sub-period than in the more recent sub-period. In fact, the contrast between periods is even greater, as productivity growth is greater and input price growth is lower in the 1Q94-3Q02 sub-period than they are in the longer 1Q89-3Q02 sub-period.

Table 8-6 and Figure 8-12 display the average annual growth in prices for each of the RCAF-U components for the time periods, 1Q94-2Q08, 1Q94-3Q02, and 3Q02-2Q08.

TABLE 8-6
GROWTH IN RCAF-U COMPONENTS
AVERAGE ANNUAL GROWTH IN PRICES, 1994Q1-2008Q2

	1Q94-2Q08	1Q94-3Q02	3Q02-2Q08	1Q00-2Q08
Labor	2.8%	2.4%	3.5%	3.0%
Fuel	11.4%	3.2%	23.9%	15.9%
M&S	3.2%	0.6%	7.0%	5.1%
Equip. Rents	1.3%	1.0%	1.8%	1.5%
Depreciation	2.3%	0.7%	4.8%	3.2%
Interest	-2.8%	-2.5%	-3.3%	-1.0%
Other	2.1%	1.0%	3.8%	2.7%
RCAF-U	3.4%	1.5%	6.3%	4.5%

Table 8-6 and Figure 8-12 illustrate that the growth in fuel costs has been much greater in the more recent sub-period. However, with the exception of interest (a cost weight of only 2.7 percent in the 2008 RCAF-U), all other categories of railroad input prices have also grown faster in the more recent sub-period. The rapid growth in fuel costs in recent years is evident in the increased cost weight of the fuel component in the RCAF-U measure.

FIGURE 8-12
RCAF-U COMPONENTS—AVERAGE ANNUAL GROWTH

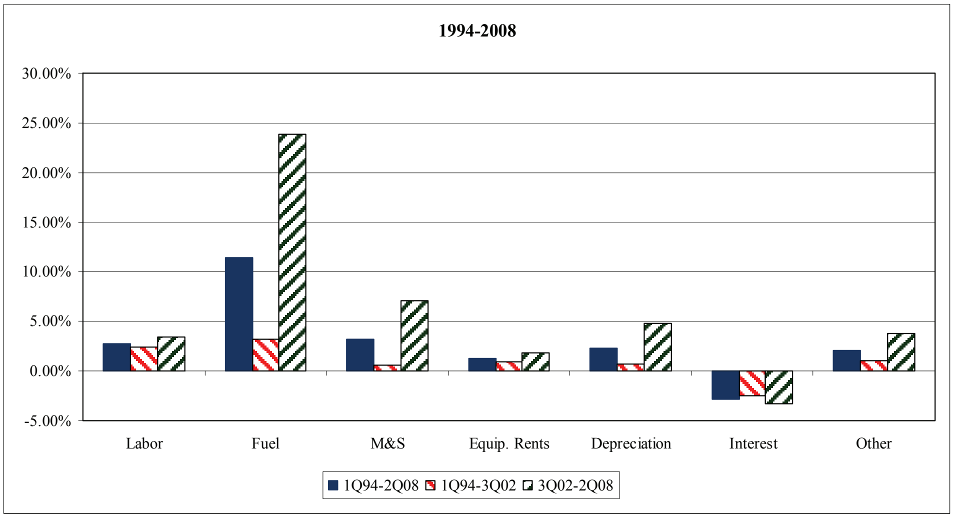


Table 8-7 presents the 1995-2006 cost weights of each component in the RCAF-U index. There is generally a two-year lag in applying the cost weights in the RCAF-U index—e.g., the 2006 weights are used in the 2008 RCAF-U. From Table 8-7, it can be seen that between 2002 and 2006, fuel's cost weight in the RCAF-U measure more than doubled, going from 9.0 percent to 19.2 percent.

TABLE 8-7
RCAF-U COMPONENT COST WEIGHTS (PERCENT)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Labor	38.6	39.6	41.0	39.9	39.3	36.5	37.8	38.0	37.5	36.0	35.3	34.5
Fuel	7.3	8.9	8.6	7.0	7.1	10.7	10.5	9.0	10.6	12.1	16.0	19.2
M&S	5.7	5.9	5.8	5.5	5.3	4.8	4.6	4.6	4.4	4.4	4.6	5.0
Equip. Rents	10.5	11.1	11.1	10.8	11.4	11.1	10.5	10.3	9.4	8.9	8.2	7.8
Depreciation	11.4	10.0	10.2	10.6	10.6	10.2	10.6	10.9	10.7	10.6	11.1	10.6
Interest	3.5	4.1	3.9	4.8	4.6	4.6	3.8	3.7	3.2	3.0	3.1	2.7
Other	23.0	20.4	19.4	21.4	21.7	22.1	22.2	23.5	24.2	25.0	21.7	20.2

For the period 1Q94-2Q08, Figure 8-13 depicts trends in RCAF-U, PAF, and RCAF-A, while Figure 8-14 shows fuel costs along with RCAF-U and PAF.

FIGURE 8-13
RCAF-U, PAF, AND RCAF-A

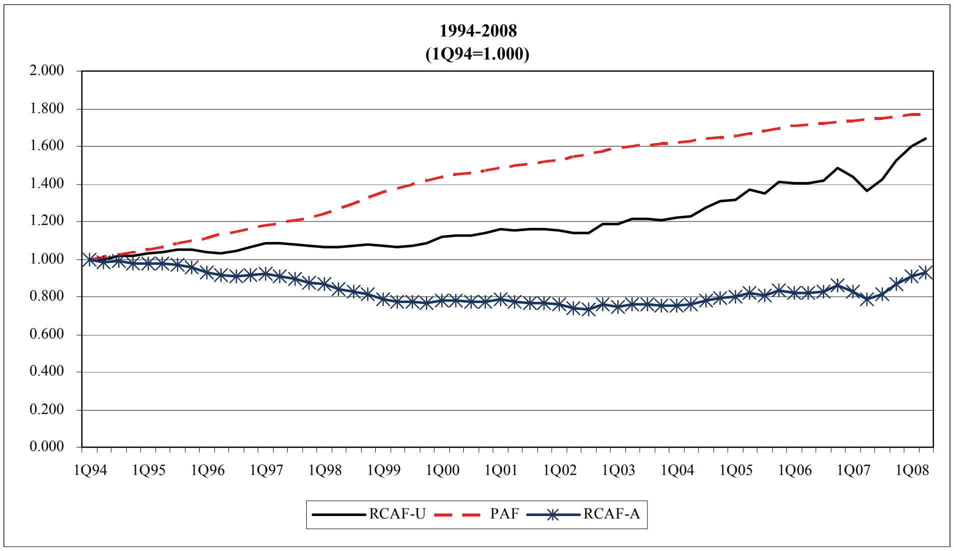
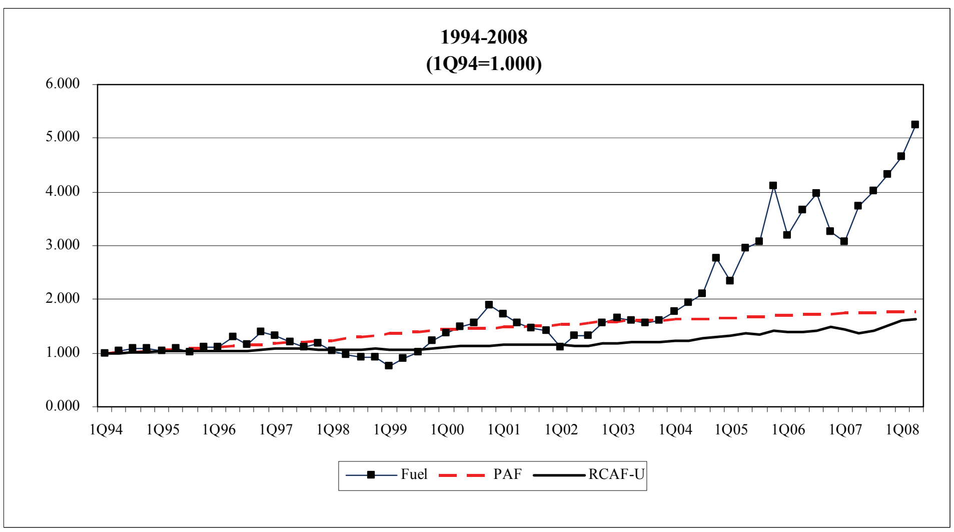


FIGURE 8-14
RCAF-U, PAF, AND FUEL COSTS



For the period 1Q94-2Q08, Figure 8-15 displays the price trends in railroad input components that have a cost weight of at least 10 percent in the 2008 RCAF-U. Figure 8-16 deletes fuel costs to better illustrate the price trends in the other three major input components.

FIGURE 8-15
PRICES FOR RCAF-U COMPONENTS WITH WEIGHTS GREATER THAN 10 PERCENT

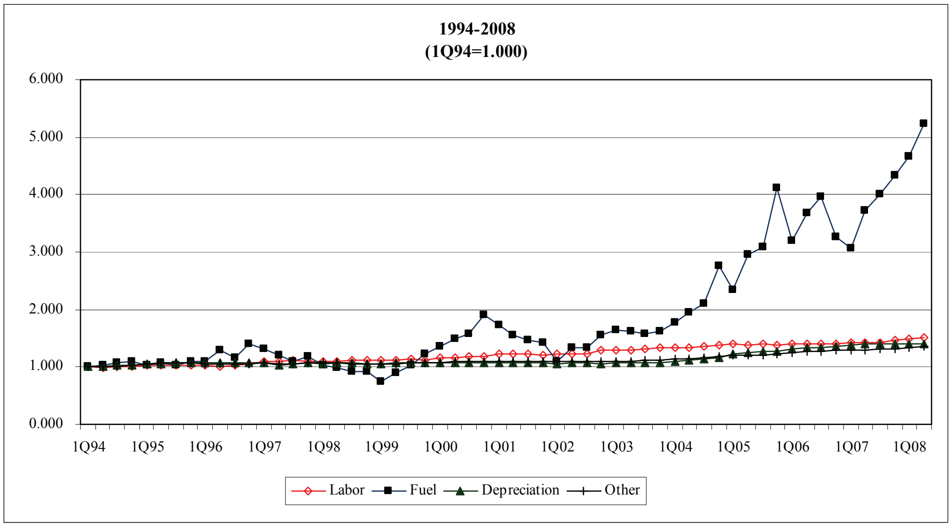
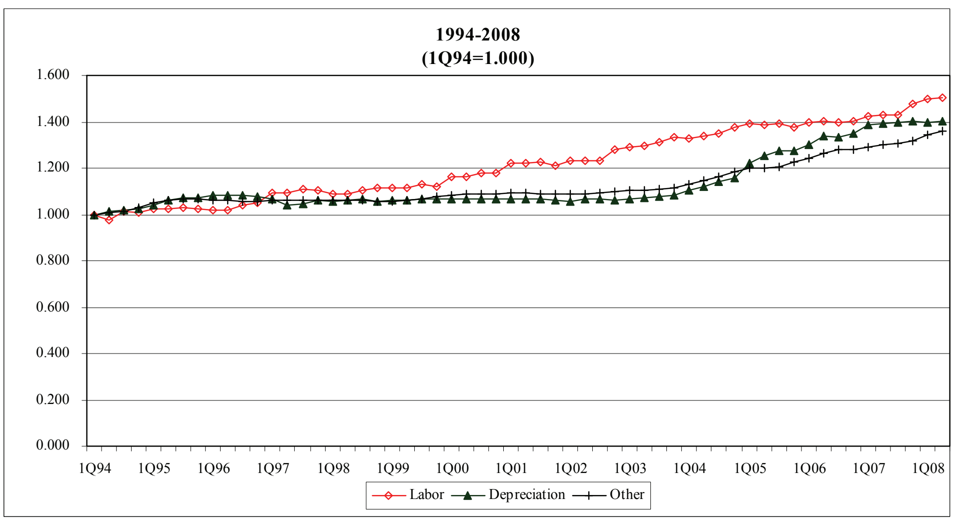


FIGURE 8-16
PRICES FOR RCAF-U NON-FUEL COMPONENTS WITH WEIGHTS GREATER THAN 10 PERCENT



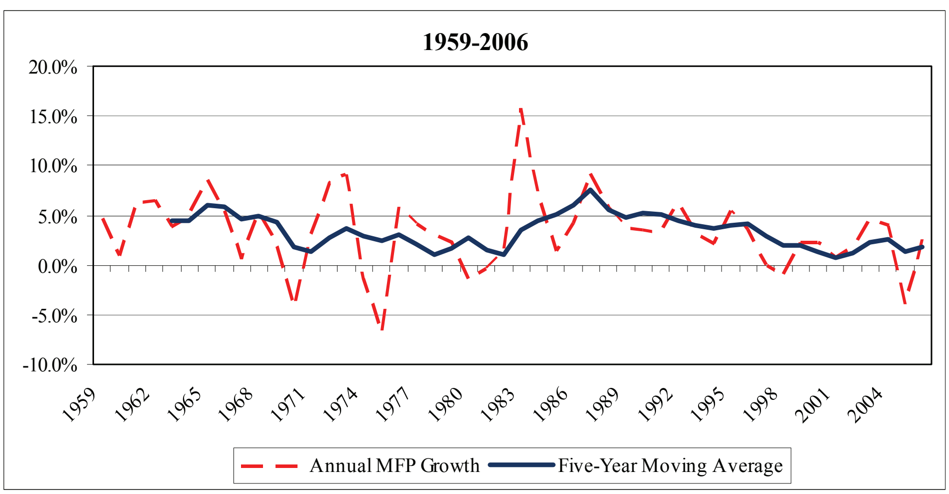
Exacerbating the divergence between the earlier and more recent sub-periods, all of these components—particularly depreciation and the "other" category—display more pronounced increases in more recent years after modest upward trends in the 1990s and early 2000s. This pattern is reflected in the larger differences in the growth in prices for depreciation and "other" as shown in Table 8-6 and Figure 8-12 above. On the other hand, growth in the price of labor has been more consistent over time.

In summary, our analysis of the trends in RCAF-U, RCAF-A, and PAF are consistent with the general pattern in railroad rates found in the GAO study: rates began to increase in the early 2000s after a long period of post-Staggers Act decline. As demonstrated here, this pattern in rates coincides with a recent reversal in the railroad industry's productivity and input price trends. Since late 2002, the railroad industry's productivity growth has fallen below its input price growth, implying an increase in railroad unit costs. Regarding input price growth, it has been demonstrated here that not only fuel, but most other significant components of RCAF-U have experienced greater price increases in recent years.

Trends in MFP, 1958-2006

As noted above, the BLS measure of MFP is based on a conceptual framework that is somewhat different than the framework used to measure the PAF. However, it is useful to compare the historical trends of both these measures to see if they present a similar story concerning railroad productivity. Currently, MFP is available for the railroad industry through 2006. The historical series for railroad MFP goes back to at least 1958. We first examine the historical performance of railroad MFP and then compare it to the PAF results discussed above. Figure 8-17 presents Railroad MFP growth from 1959 through 2006.[13] Because of the volatility in annual growth rates, we also present the five-year moving average of the annual growth rates.

FIGURE 8-17
RAILROAD INDUSTRY MFP GROWTH



In general, focusing on the five-year moving average, it can be seen that railroad MFP growth peaked in the late 1980s (surpassing the

[13] 1959 growth rate is based on change from 1958.

five-year average peak of the late 1960s), and recent growth rates are similar to those of the late 1970s and early 1980s. For the pre-Staggers' period (1958-1980), the railroad industry's average annual MFP growth was 3.2 percent. For the post-Staggers' period (1980-2006), there was a slight increase in the average annual MFP growth to 3.4 percent.

Table 8-8 and Figure 8-18 report the railroad industry's MFP growth by decades and five-year sub-periods within each decade (with the exception of the 2000-2006 period, which is broken into three-year sub-periods). Although the current decade is not yet complete, it can be seen that average annual MFP growth for the railroad industry over the 2000-2006 period is substantially lower than for any other decade reported, with the average for the 2003-2006 sub-period being among the lowest over the 46-year time period.

TABLE 8-8
RAILROAD INDUSTRY MFP GROWTH, 1960-2006

Pre-Staggers		**Post-Staggers**	
Years	**Average Annual Growth**	**Years**	**Average Annual Growth**
1960-1970	3.9%	1980-1990	5.2%
1960-1965	*6.0%*	*1980-1985*	*5.1%*
1965-1970	*1.8%*	*1985-1990*	*5.2%*
1970-1980	2.6%	1990-2000	2.7%
1970-1975	*2.4%*	*1990-1995*	*4.0%*
1975-1980	*2.8%*	*1995-2000*	*1.4%*
		2000-2006	1.6%
		2000-2003	*2.3%*
		2003-2006	*0.9%*

FIGURE 8-18
RAILROAD INDUSTRY AVERAGE ANNUAL MFP GROWTH BY DECADE

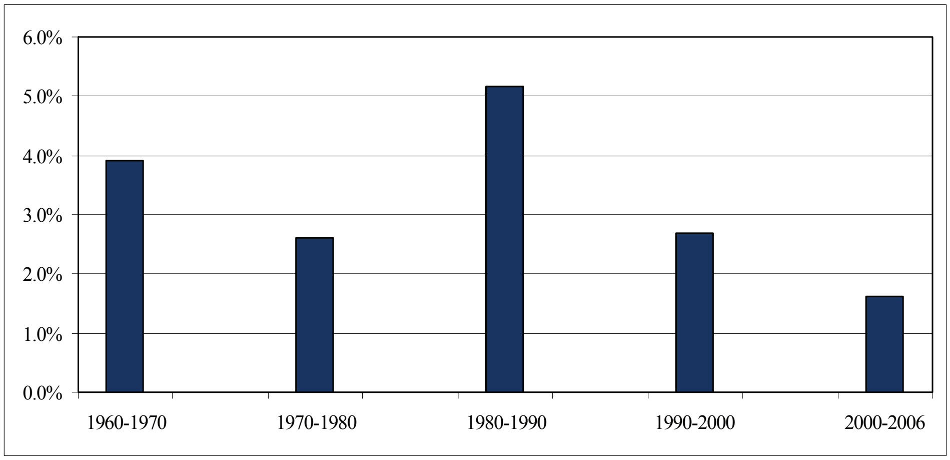


Table 8-9 compares the railroad industry's average annual MFP growth for each decade since 1960 to average annual MFP growth for the private business sector of the U.S. economy and for the air transportation industry (available only back to 1987). Compared to the overall U.S. economy, it can be seen that the railroad industry's MFP growth has historically outpaced that of the overall economy. However, the gap (which reached its peak in the 1980s) has narrowed considerable in recent years.

TABLE 8-9
MFP GROWTH COMPARISON

	Private Business	Air Trans	Railroad
1960-1970	2.1%		3.9%
1970-1980	1.0%		2.6%
1980-1990	0.7%		5.2%
1990-2000	0.9%	0.4%	2.7%
2000-2006	1.5%	3.5%	1.6%

The productivity gap between the railroad industry and the private business sector is illustrated in Figure 8-19, which displays the differential between railroad and private business sector MFP growth rates. Not only has the railroad industry's productivity growth slowed absolutely in recent years, but Figure 8-19 shows that it has also slowed relative to that of the overall economy to the point where the railroad MFP growth differential is less than it was in the pre-Staggers' period and almost non-existent in the most recent years.

FIGURE 8-19
MFP GROWTH DIFFERENTIAL: RAILROAD INDUSTRY V. PRIVATE BUSINESS SECTOR

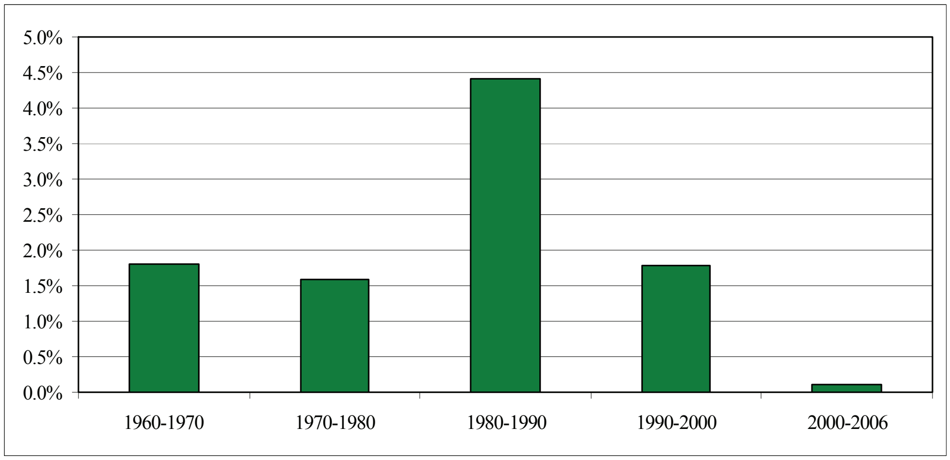


Table 8-10 compares the railroad industry's MFP to its PAF over the 1989-2006 period and two sub-periods. Because PAF is constructed as a five-year moving average, Table 8-10 reports MFP growth as its five-year moving average over the periods listed. Due largely to the methodological differences discussed above, it can be seen that PAF growth is much higher than MFP growth. However, the patterns are the same: higher average growth in the 1989-2002 sub-period and much lower growth in the 2002-2006 sub-period.

TABLE 8-10
COMPARISON OF RAILROAD INDUSTRY MFP AND PAF
1989-2006

	MFP	PAF
1989-2006	2.9%	4.2%
1989-2002	3.1%	4.7%
2002-2006	2.0%	2.4%

Summary

Our analysis of RCAF-U, PAF, and RCAF-A reveals trends in the railroad industry's input prices and productivity that are consistent with the general pattern in railroad rates found in the GAO study. Rates began to increase in the early 2000s after a long period of decline after the Staggers Act and, since late 2002, the railroad industry's productivity growth has fallen below its input price growth, implying an increase in railroad unit costs. Regarding input price growth, it has been demonstrated here that not only fuel, but most other significant components of RCAF-U have experienced greater price increases in recent years.

However, had productivity growth not slowed to the extent it did, a portion of the input price growth would have been mitigated and there would have been less upward pressure on railroad rates. For example, if PAF had grown at the same average rate over the 3Q02-2Q08 period as it did in the 1Q94-3Q02 period (5.1 percent instead of 2.2 percent), then RCAF-A growth would have averaged only 1.3 percent in the later period instead of its actual 4.1 percent, resulting in less upward pressure on railroad rates.

Longer-term trends in productivity provided by the BLS measure of MFP for the railroad industry show that railroad MFP growth peaked in the late 1980s (surpassing the five-year average peak of the late 1960s) and recent growth rates are similar to those of the late 1970s and early 1980s. For the pre-Staggers' period (1958-1980), the railroad industry's average annual MFP growth was 3.2 percent. For the post-Staggers' period (1980-2006), there was a slight increase in the average annual MFP growth to 3.4 percent. Furthermore, the MFP measure confirms that recent productivity growth for the railroad industry has declined both absolutely and relative to economy-wide productivity growth.

Both the STB and BLS measures of railroad industry productivity confirm a slowdown in industry productivity growth in this decade. One effect of this slowing productivity growth is a diminished ability of railroads to absorb increases in input prices in recent years.

8C. Overview of Railroad Industry Financial Performance and Capital Spending

An understanding of railroad profitability is important for evaluating the industry's pricing in captive markets and understanding the industry's investment behavior. Our stakeholder interviews provide considerable anecdotal evidence that railroads engage in differential pricing, where the railroads may charge substantially different rates for services that have nearly the same marginal costs. Many previous academic studies have concluded that railroads have significant economies of density, which would imply that marginal cost pricing on all services would not be sustainable. From a social welfare perspective, differential pricing may be desirable as long as the railroads do not earn monopoly profits. Our stakeholder interviews also reveal that some parties hold the opinion that railroad capacity and congestion issues are the result of railroads purposely withholding capacity from the market as a means of extracting higher prices.

While an overview of industry financial performance may not be definitive with respect to answering the economic question of whether the railroad industry is exercising market power, it provides an indication of the degree to which concern is warranted over the exercise of market power (and monopoly profits) in the railroad industry. For purposes of the present study, it also provides useful background information on railroad earnings as we investigate more closely the issue of competition in the railroad industry.

In this section, we examine a number of financial performance metrics for the Class I railroads and a group of benchmark industries (defined below) for the 1997-2006 period. The financial data are obtained primarily from Value Line.[14] The railroad industry's performance is also compared with the STB's cost of capital determinations for the industry that are used to determine revenue adequacy. We also examine these financial performance metrics relative to capital spending behavior over this time period for railroad and benchmark industries to provide background perspective on the issue of whether railroads are undertaking sufficient investment. In addition, the railroad industry's financial performance is compared to the trends in industry productivity and input prices that were examined above.

Description of Data and Benchmark Industries

Data for the most recent ten years (1997-2006) were obtained from Value Line for firms in the railroad industry and selected benchmark industries. Four industries were chosen to benchmark the railroad industry's performance—electric utilities, freight transportation, chemicals, and food processing. Table 8-11 lists the railroads included in the analysis and the years for which Value Line data were available for each.[15]

TABLE 8-11
RAILROADS INCLUDED IN FINANCIAL ANALYSIS

	Years of Value Line Data
BNSF	1997-2006
Canadian National	1997-2006
Canadian Pacific	2000-2006
CSX	1997-2006
Kansas City Southern	1999-2006
Norfolk Southern	1997-2006
Union Pacific	1997-2006

[14] *Value Line Investment Survey.* The Value Line data available to us go back to 1997. This is sufficient for the purposes of this overview, which is to examine the recent trend in the railroad industry's earnings. Furthermore, with the exception of the split of Conrail between CSX and Norfolk Southern, beginning the analysis in 1997 eliminates the need to account for or adjust data for mergers. Although the Value Line dataset contains some data for 2007, there were some data items across firms that were not available for 2007. Therefore, we use the ten-year period ending in 2006 for consistency.

[15] Value Line data are not available for all firms for all years. Kansas City Southern data were available beginning in 1999, and Canadian Pacific data were available beginning in 2000.

Railroad Industry Financial Performance, 1997-2006

First, we present an overview of various measures of the railroad industry's financial performance over the 1997-2006 period. We then compare industry financial performance to the industry's cost of capital as determined by the STB.

Overview of Railroad Industry Financial Performance

Table 8-12 presents a number of financial performance measures for the railroad industry for the 1997-2006 period. Annual values are shown for revenue; EBITDA (earnings before interest, taxes, depreciation, and amortization) and EBIT (earnings before interest and taxes); net profit;[16] and EPS (earnings per share). The average annual growth rate for each measure over this period is also shown.

TABLE 8-12
RAILROAD INDUSTRY FINANCIAL PERFORMANCE

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Revenue*	$37.4	$36.3	$40.6	$42.1	$41.9	$42.6	$43.0	$47.8	$54.9	$61.8	5.6%
EBITDA*	$9.9	$8.6	$10.3	$11.2	$11.5	$12.0	$11.8	$12.6	$16.3	$19.9	7.8%
EBIT*	$6.7	$5.4	$6.8	$7.5	$7.6	$8.0	$7.9	$8.3	$11.4	$14.8	8.8%
Net Profit*	$3.4	$2.5	$3.0	$3.2	$3.4	$3.8	$3.8	$4.5	$6.2	$8.2	9.9%
EPS	$1.63	$1.20	$1.38	$1.40	$1.48	$1.65	$1.68	$1.99	$2.68	$3.58	8.8%

*billions of dollars

While net profit and EPS are widely cited financial measures, EBITDA and EBIT have certain advantages and are commonly used when making cross-industry comparisons. EBITDA is useful as a measure for analyzing and comparing profitability between companies and industries because it eliminates many of the effects of financing and accounting decisions that are influenced by tax considerations. Tax-driven measures of accounting depreciation, interest, and tax payments can vary considerably and affect net income of companies that are, otherwise, in similar economic circumstances.[17] EBIT deducts depreciation and amortization expense, but not interest or taxes. Therefore, relative to EBITDA, EBIT accounts for differences in depreciation charges, which

[16] Before deduction of preferred dividends and any non-recurring, special, or extraordinary items.

[17] Morningstar uses operating income before depreciation, which is EBITDA, as its measure of earnings because: (1) it is the most common method used by analysts; (2) depreciation is an accounting charge that does not represent any movement of cash and firms use different depreciation methodologies, so that operating income before depreciation provides a better measure of cash-related profitability; and (3) focusing on operating income before depreciation avoids the comparison of companies using different depreciation methodologies. See *Cost of Capital Yearbook, 2007*, Morningstar, p. 12.

could be significant across industries or firms and are affected by capital intensity.

Figure 8-20 displays the railroad industry's EBITDA, EBIT, and net profits from 1997 to 2006. All three metrics exhibit the same upward pattern, with modest growth through 2004 and noticeably greater growth from 2004 to 2006. Between 1997 and 2004, average annual growth rates were 3.5 percent for EBITDA, 3.0 percent for EBIT, and 4.4 percent for net profit. Between 2004 and 2006, average annual growth rates were 22.7 percent for EBITDA, 29.0 percent for EBIT, and 29.4 percent for net profit. Because it closely corresponds with other measures of the railroad industry's profitability and because of the advantages noted above for making cross-industry/firm comparisons where capital intensity varies, we will focus on EBIT in our comparison of railroad to benchmark industries below.

FIGURE 8-20
MEASURES OF RAILROAD INDUSTRY PROFITABILITY
1997-2006

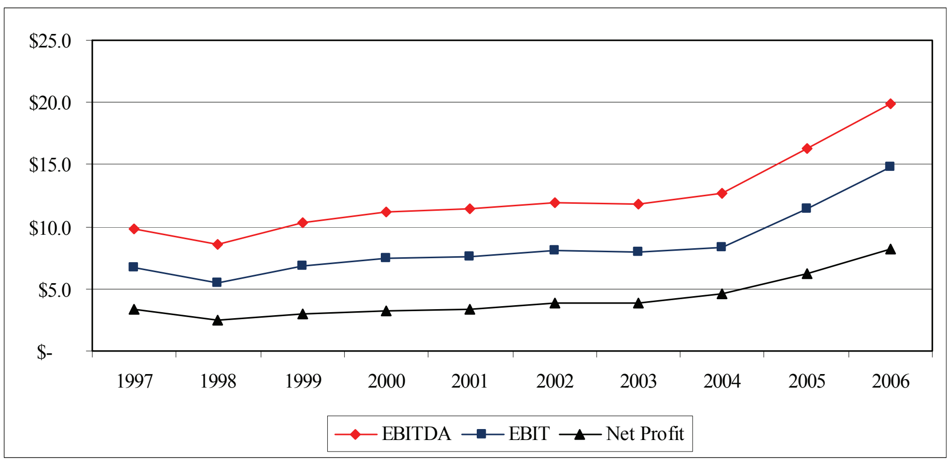
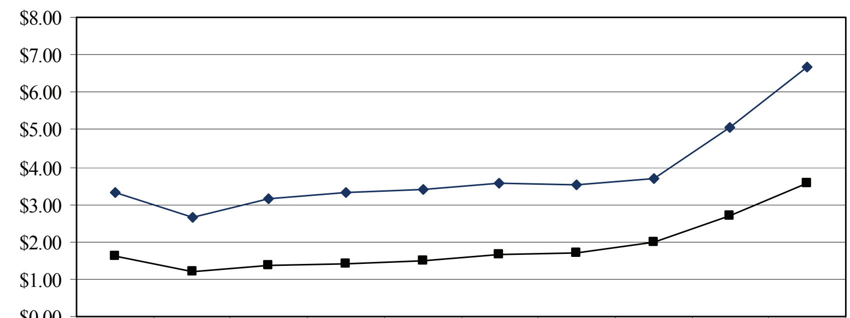


Figure 8-21 shows EBIT on a per-share basis and compares it to the widely cited EPS. Again, the same general pattern emerges with modest growth through 2004 and significantly greater growth after 2004.

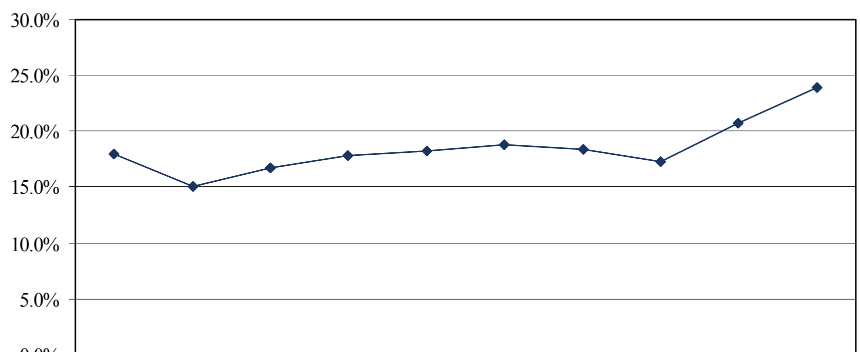
Figure 8-22 shows the EBIT "profit margin"—i.e., the EBIT to revenue ratio—for the railroad industry. While its growth was fairly flat between 1997 and 2004, the EBIT margin increased at an annual average of 16.2 percent between 2004 and 2006.

FIGURE 8-21
RAILROAD INDUSTRY EARNINGS—EBIT/SHARE AND EPS
1997-2006



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
EBIT/Share	$3.30	$2.63	$3.16	$3.31	$3.41	$3.57	$3.53	$3.69	$5.05	$6.67
EPS	$1.63	$1.20	$1.38	$1.40	$1.48	$1.65	$1.68	$1.99	$2.68	$3.58

FIGURE 8-22
RAILROAD INDUSTRY EARNINGS—EBIT/REVENUE
1997-2006



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
EBIT/Rev	18.0%	15.0%	16.8%	17.8%	18.2%	18.9%	18.4%	17.3%	20.8%	24.0%

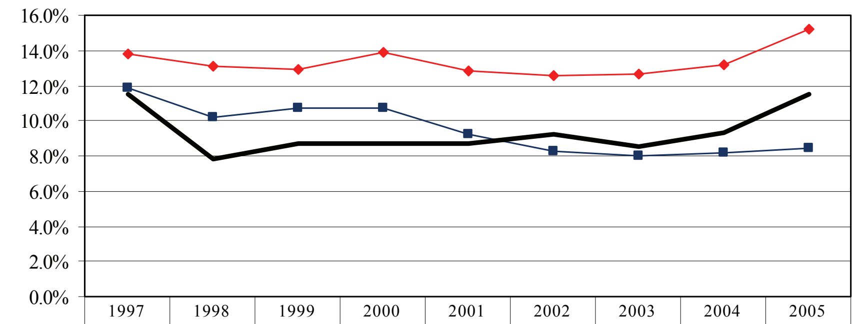
STB Cost of Capital Determination

In its Ex Parte 558 proceedings, the STB makes an annual determination of the railroad industry's cost of capital, which includes both debt and equity components. Figure 8-23 compares the industry's return on shareholders' equity (RSE) to the equity component of the railroad industry's cost of capital computed under both the STB's old discounted cash flow (DCF) basis and its recently adopted capital asset pricing model (CAPM) approach.[18] Value Line defines RSE as net profit divided by net worth. Thus, relating RSE to these measures provides an

[18] Surface Transportation Board, *Methodology to be Employed in Determining the Railroad Industry's Cost of Capital*, Ex Parte 664, August 20, 2007.

indication of whether the railroad industry is earning its cost of equity (as determined by the STB): RSE greater than the cost of equity capital implies greater investment incentives.

FIGURE 8-23
RAILROAD INDUSTRY COST OF EQUITY AND RETURN ON SHAREHOLDERS' EQUITY
1997-2005



	1997	1998	1999	2000	2001	2002	2003	2004	2005
STB-DCF	13.8%	13.1%	12.9%	13.9%	12.8%	12.6%	12.7%	13.2%	15.2%
STB-CAPM	11.9%	10.2%	10.7%	10.7%	9.2%	8.3%	8.0%	8.2%	8.4%
RSE	11.5%	7.9%	8.7%	8.7%	8.7%	9.3%	8.6%	9.3%	11.5%

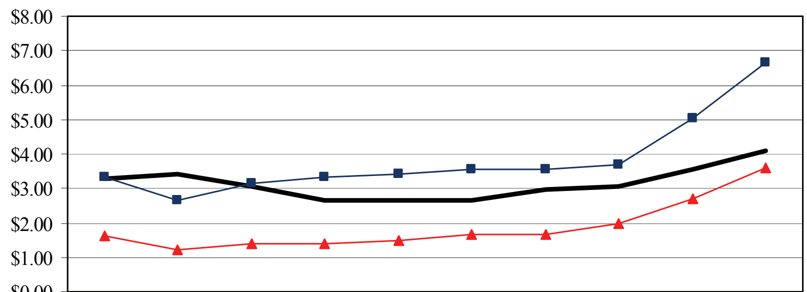
Recognizing there are controversial aspects to the STB-determined cost of equity, regardless of whether the DCF or CAPM method is employed, a number of observations emerge from Figure 8-23. First, similar to the other measures of the railroad industry's financial performance discussed above, RSE growth has increased in recent years, although in 2005 it was close to its 1997 level. Second, regarding the question of whether the railroad industry is earning its cost of equity, divergent answers emerge depending on the cost of equity measure used. Comparing RSE to the STB-DCF cost of equity, the industry did not earn its cost of capital over this entire period. However, when the recently adopted CAPM method is used, the industry has earned at least its cost of equity after 2001 and the excess has widened in recent years. It is important to note that these industry-wide results vary significantly with respect to individual railroads. Appendix 8-B compares the RSE for each of the seven Class I railroads to the STB measures of the cost of equity.

By the STB's current standard (CAPM), there is recent evidence of that the industry has become revenue adequate and may have exceeded that standard. However, it is difficult to draw conclusions from only a few observations, particularly when the earlier observations show the opposite result.

Railroad Industry Financial Performance and Capital Spending, 1997-2006

The Value Line dataset contains capital spending per share information.[19] Figure 8-24 compares the Value Line measure of capital spending per share to EPS and EBIT per share.

FIGURE 8-24
RAILROAD INDUSTRY FINANCIAL PERFORMANCE AND CAPITAL SPENDING
1997-2006



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cap Spend/Share	$3.27	$3.44	$3.08	$2.66	$2.65	$2.67	$2.96	$3.07	$3.55	$4.10
EBIT/Share	$3.30	$2.63	$3.16	$3.31	$3.41	$3.57	$3.53	$3.69	$5.05	$6.67
EPS	$1.63	$1.20	$1.38	$1.40	$1.48	$1.65	$1.68	$1.99	$2.68	$3.58

Table 8-13 shows average annual growth for these measures for the 1997-2006 period, and the 1997-2004 and 2004-2006 sub-periods. It shows that, although capital spending per share growth has increased in recent years, its average growth rate for the 2004-2006 period is only half that of the railroad industry's earnings per share.

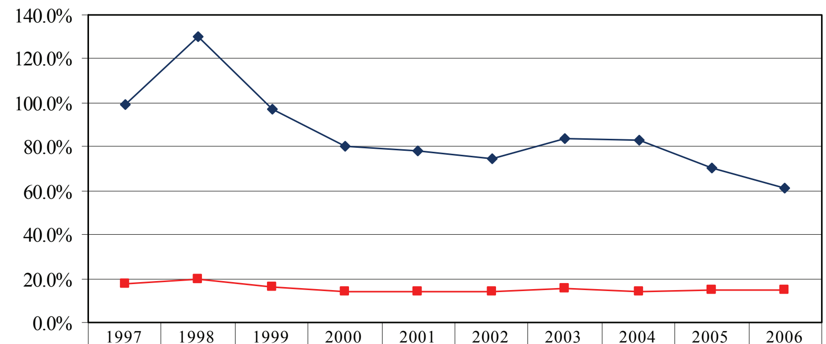
TABLE 8-13
RAILROAD INDUSTRY EARNINGS AND CAPITAL SPENDING
AVERAGE ANNUAL GROWTH RATES

	1997-2006	1997-2004	2004-2006
Cap Spend/Share	2.5%	-0.9%	14.5%
EBIT/Share	7.8%	1.6%	29.6%
EPS	8.8%	2.9%	29.4%

[19] Value Line defines capital spending per share as total expenditures for plant and equipment outlays for the year divided by the weighted average number of common shares outstanding at year end (p. 216). The Value Line capital spending figures were compared to the Total Expenditures for additions to Road and Equipment from Schedule 330 of the R-1 annual reports filed by the railroads with the STB. Over the 1970-2006 period, the Value Line and R-1 measures for the railroad industry were generally consistent with each other, with the Value Line measure of capital spending being, on average, eight percent greater than the R-1 figures.

Figure 8-25 relates the railroad industry's capital spending to its EBIT and revenues. After peaking in 1998, the capital spending to EBIT ratio has subsequently declined, with a more pronounced decline since 2004, as capital spending growth has not kept pace with EBIT growth. The capital spending to revenue ratio has also declined somewhat from the late 1990s, but has stabilized in a range between 14 to15 percent. Thus, railroads continue to spend a nearly constant percentage of their revenues on capital, unaffected by increases in earnings.

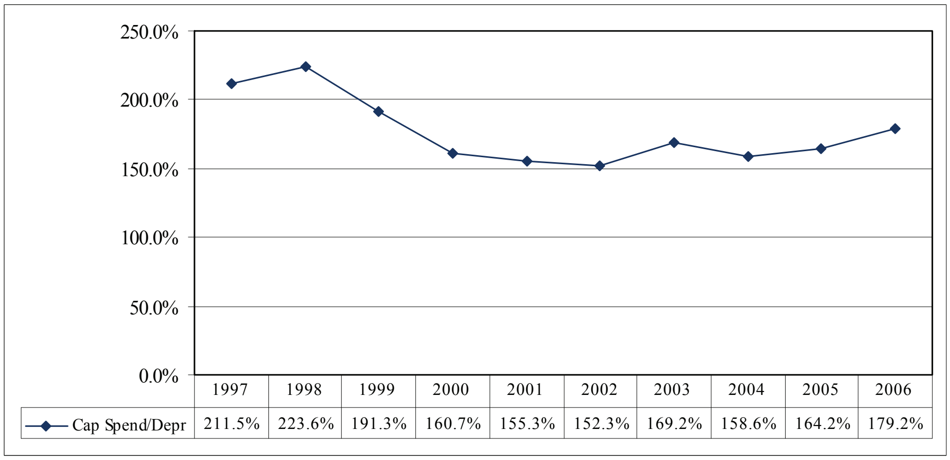
FIGURE 8-25
RAILROAD INDUSTRY CAPITAL SPENDING/EBIT AND CAPITAL SPENDING/REVENUE
1997-2006



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Cap Spend/EBIT	99.0%	130.5%	97.4%	80.4%	77.8%	74.9%	83.7%	83.0%	70.3%	61.4%
Cap Spend/Rev	17.8%	19.6%	16.4%	14.3%	14.2%	14.1%	15.4%	14.4%	14.6%	14.7%

Figure 8-26 relates the railroad industry's capital spending to its depreciation charges. After declines from the late 1990s, the railroad industry's ratio of capital spending to depreciation charges has increased somewhat in recent years.

FIGURE 8-26
RAILROAD INDUSTRY CAPITAL SPENDING/DEPRECIATION
1997-2006



An important question that arises from these charts of the railroad industry's financial performance and capital spending is whether capital spending relative to earnings was "too high" in 1997 and has fallen to "normal" levels more recently, or is it the case that capital spending has fallen below economically optimal levels? One perspective is that, after a period of unusual activity, the charts reflect that the industry is settling into a rate of capital expenditures ("capex") that allows for maintenance and slow, steady growth:

> After the 1980 passage of the Staggers Act, which partially deregulated the railroad industry, railroad consolidation led to greater efficiencies through cost reductions and optimal routes. This resulted in an increase in capex as the railroads embarked upon much needed network maintenance. Capex peaked in the late 1990s during the height of the mega-mergers, and now seems to have leveled off to a point that keeps the routes maintained at the status quo and allows for slow, but steady growth.[20]

We attempt to partially answer the aforementioned question with our analysis of benchmark industries below and, later, with the results of our econometric analysis of the railroad industry's economic cost functions. With respect to benchmark industry comparisons, as discussed below, not only has the railroad industry's capital spending slowed with respect to the railroad industry's earnings, but it has also lagged somewhat

[20]John G. Larkin and Daniel S. Taylor, *Railroads: Striving to Drive Improved Return on Invested Capital,* Legg Mason Wood Walker, Inc., Summer 2004, p. 24.

with respect to benchmark industries' capital spending, in spite of improved earnings in the railroad industry.

Railroad Industry Earnings, Capital Spending, Input Prices, and Productivity

Figure 8-27 compares trends in the railroad industry's ratio of EBIT to revenue and the Productivity-Adjusted Rail Cost Adjustment Factor (RCAF-A) since 1997. It is apparent that the gap between the railroad industry's EBIT to revenue ratio and productivity-adjusted input prices represented by RCAF-A has been widening since the late-1990s and became increasingly pronounced after 2004: since 2004, the annual growth for the EBIT to revenue ratio has averaged 16.2 percent, while the annual growth in RCAF-A has averaged 4.5 percent.

FIGURE 8-27
RAILROAD INDUSTRY EARNINGS AND RCAF-A
1997 = 1.00

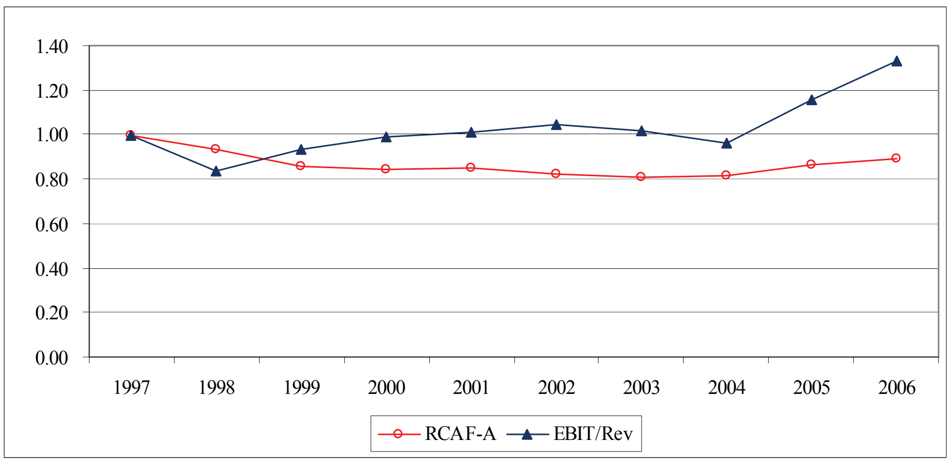
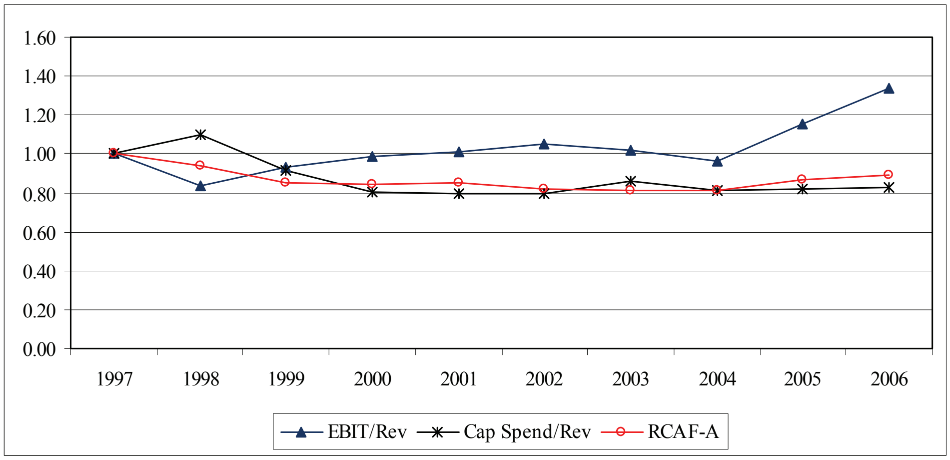


Figure 8-28 compares the railroad industry's earnings (EBIT/Revenue), capital spending (Capital Spending/Revenue), and productivity-adjusted input prices (RCAF-A). Capital spending and productivity-adjusted input prices closely correspond over most of the period, but productivity-adjusted input prices have grown more quickly in recent years (averaging 4.5 percent per year since 2004 versus 1.1 percent for capital spending). However, growth in both of these measures has been dwarfed in recent years by earnings growth (16.2 percent since 2004). The implication is that the railroad industry's output prices are increasing faster than its productivity-adjusted input prices. However, as we discuss below and in later chapters (e.g., Chapters 10 and 18), from both financial market and economic perspectives, these price increases have occurred during a time when the railroad industry has been earning near normal profits.

FIGURE 8-28
RAILROAD INDUSTRY EARNINGS, RCAF-A AND CAPITAL SPENDING
1997 = 1.00



Comparison to Benchmark Industries

In this section, we compare the railroad industry to four benchmark industries—electric utilities, transportation, food processing, and chemicals—to determine whether the observed patterns in the railroad industry are similar to or different than the patterns in these benchmark industries. The electric utilities industry was chosen because its capital intensity is similar to that of railroads. Freight transportation was chosen because of its close relationship to railroads, both as a substitute and a complement to rail transportation. Chemicals and food processing were chosen because they represent industries that are significant railroad customers. For our analysis, we used the top twenty firms (in terms of market capitalization) in each benchmark industry that had data in the Value Line dataset for at least the years 2000 through 2006.[21] Appendix 8-A contains information for the firms in the benchmark industries.[22] To the extent the railroad industry's performance is similar to that of the benchmark industries, it is an indication that underlying economic trends or general market conditions have had an impact across industries. To the

[21] There are a few exceptions to these selection rules. For example, in freight transportation, obvious mismatches included in Value Line's dataset for the transportation industry—Hertz, Ryder, and Dollar—were eliminated. Also in freight transportation, we made an exception for Pacer, which only had data in the Value Line dataset back to 2002. The electric utility industry only contains 19 firms as the data for Duke Energy is not found in the Value Line dataset. Appendix 8-A contains a listing of the firms in each benchmark industry.

[22] We also performed a screen on all Value Line industry segments for capital spending/revenue and net plant/revenue ratios to determine if other industries should be included in the benchmarks. The electric utilities industry was closest to the railroad industry with respect to both of these measures and, therefore, no additional industries were selected for the benchmark group.

extent the railroad industry's performance is different than that of these industries, it is an indication that railroad industry-specific factors are responsible for explaining performance.

Comparison of Financial Performance

Table 8-14 presents EPS for the railroad and benchmark industries as well as the (simple) average for the benchmark industries. Over the 1997-2006 period, EPS growth for the railroad industry averaged 8.8 percent, second only to freight transportation. In terms of level, railroad had the highest EPS by 2006. As will be demonstrated, there are many similarities between the railroad and electric utilities industries.

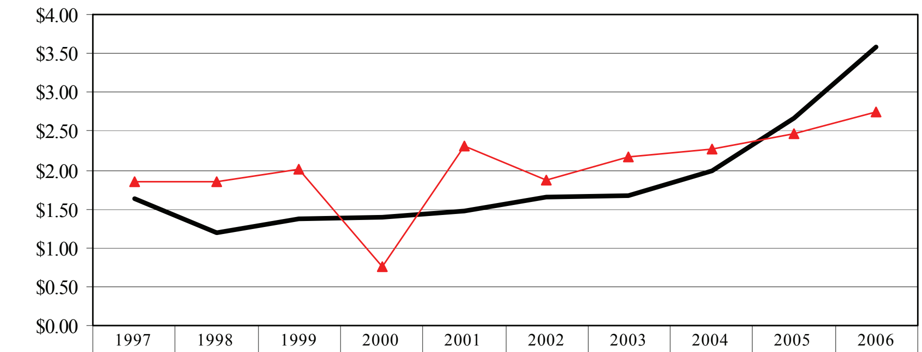
TABLE 8-14
EARNINGS PER SHARE

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	$1.63	$1.20	$1.38	$1.40	$1.48	$1.65	$1.68	$1.99	$2.68	$3.58	8.8%
Trans	$0.42	$0.52	$0.60	$0.62	$0.39	$0.57	$0.76	$1.15	$1.58	$1.71	15.6%
Util	$1.85	$1.86	$2.02	$0.75	$2.30	$1.87	$2.18	$2.27	$2.47	$2.74	4.4%
Chem	$1.96	$1.62	$1.59	$1.75	$1.07	$1.22	$1.55	$2.11	$2.66	$3.09	5.1%
Food	$1.01	$1.04	$1.10	$1.15	$1.13	$1.44	$1.80	$1.76	$1.61	$1.69	5.7%
Non-Rail Avg	$1.41	$1.33	$1.40	$1.20	$1.35	$1.45	$1.79	$1.96	$2.09	$2.37	5.8%

Figure 8-29 illustrates that until 2004, the trends in EPS for these two industries were very similar, with the railroad industry generally having lower EPS until 2005.[23] However, while earnings accelerated for the railroad industry from 2004 forward (as documented above), growth has been more modest for electric utilities since 2004.

[23] The 2000 performance of the electric utilities industry reflects the extraordinary circumstances that affected PG&E and SCE in California. We decided not to smooth this industry's performance.

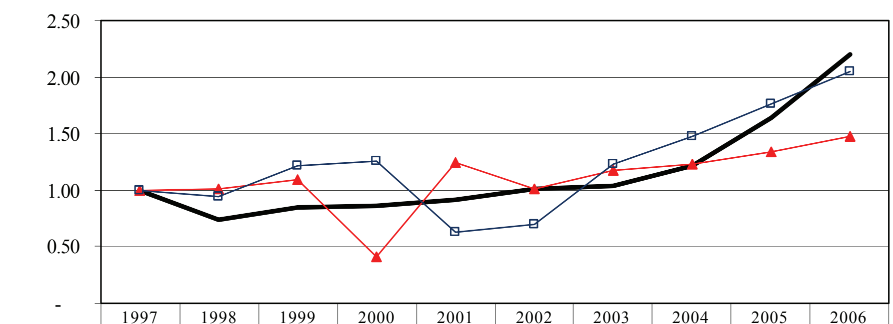
FIGURE 8-29
EARNINGS PER SHARE
1997-2006



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Rail	$1.63	$1.20	$1.38	$1.40	$1.48	$1.65	$1.68	$1.99	$2.68	$3.58
Util	$1.85	$1.86	$2.02	$0.75	$2.30	$1.87	$2.18	$2.27	$2.47	$2.74

Figure 8-30 adds EPS for the S&P 500 companies to Figure 8-29. Because of differences in levels, the EPS values are indexed to 1997 = 1.00. Over the 1997-2006 period, the trend in the railroad industry's EPS was very similar to that of the S&P 500 companies.

FIGURE 8-30
EARNINGS PER SHARE
1997 = 1.0



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Rail	1.00	0.74	0.85	0.86	0.91	1.02	1.03	1.22	1.64	2.20
Util	1.00	1.01	1.09	0.41	1.25	1.01	1.18	1.23	1.34	1.48
S&P 500	1.00	0.95	1.21	1.26	0.62	0.69	1.23	1.47	1.76	2.05

Table 8-15 presents the EBIT to revenue ratios for the railroad and benchmark industries. As with EPS, rail's average growth for the EBIT to revenue ratio was second only to that of freight transportation over the study period. In terms of the EBIT to revenue ratio, railroad was below electric utilities until 2000 but has since been the highest.

TABLE 8-15
EBIT/REVENUE

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	18.0%	15.0%	16.8%	17.8%	18.2%	18.9%	18.4%	17.3%	20.8%	24.0%	3.2%
Trans	4.8%	5.3%	5.4%	5.1%	4.0%	4.9%	5.8%	7.4%	8.2%	8.1%	5.7%
Util	20.0%	18.7%	18.9%	9.7%	14.3%	16.3%	16.8%	16.6%	15.2%	16.6%	-2.1%
Chem	16.7%	12.6%	12.7%	13.3%	9.6%	11.1%	11.2%	14.0%	16.0%	16.2%	-0.4%
Food	9.0%	10.8%	10.7%	11.2%	11.4%	12.0%	11.6%	9.0%	10.4%	9.6%	0.7%
Non-Rail Avg	13.7%	13.0%	13.1%	11.1%	11.8%	12.7%	12.6%	12.2%	13.1%	13.4%	-0.2%

Figure 8-31 shows the EBIT to revenue ratios for the railroad and electric utilities industries.

FIGURE 8-31
EBIT/REVENUE
1997-2006

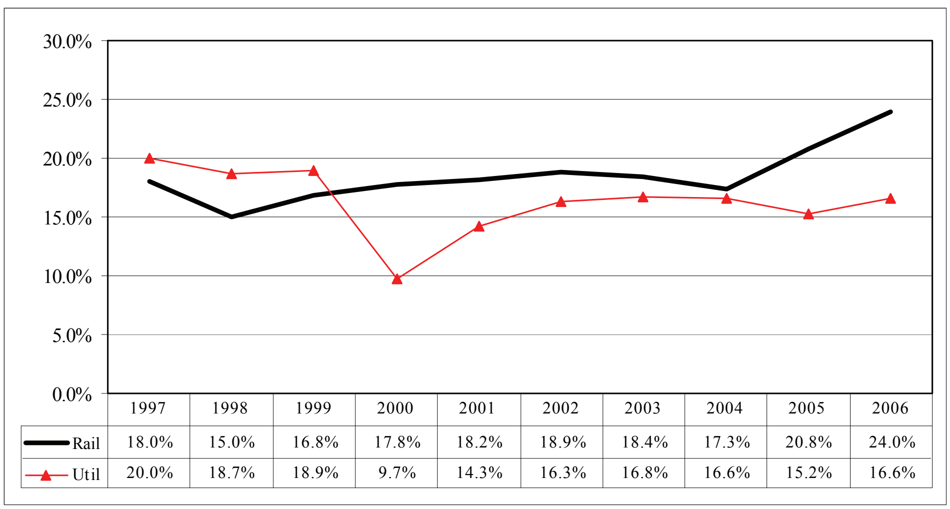


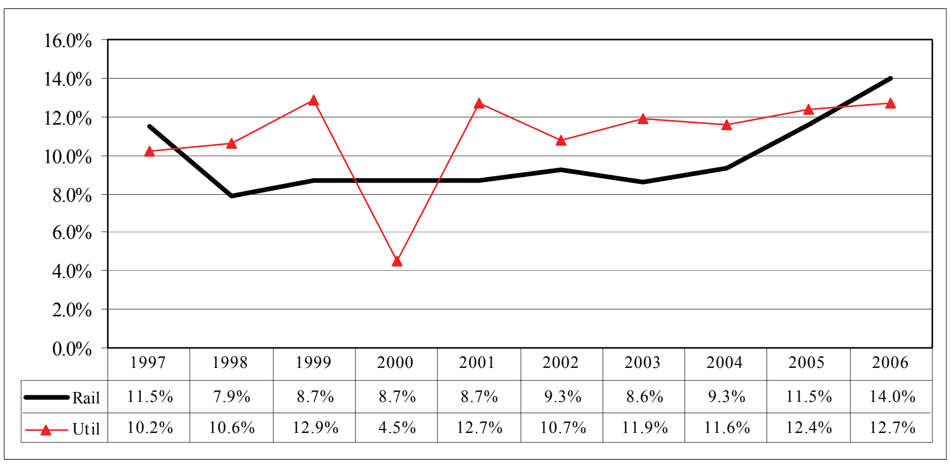
Table 8-16 presents RSE for the railroad and benchmark industries. In terms of average growth, the railroad industry trailed freight transportation and electric utilities over the 1997-2006 period. In terms of RSE levels, railroad and electric utilities were at the low end of the range over the entire period.

TABLE 8-16
RETURN ON SHAREHOLDERS' EQUITY

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	11.5%	7.9%	8.7%	8.7%	8.7%	9.3%	8.6%	9.3%	11.5%	14.0%	2.2%
Trans	13.2%	15.1%	15.1%	13.5%	8.6%	11.4%	12.3%	16.8%	19.2%	19.1%	4.1%
Util	10.2%	10.6%	12.9%	4.5%	12.7%	10.7%	11.9%	11.6%	12.4%	12.7%	2.4%
Chem	24.7%	19.0%	17.8%	18.1%	11.0%	14.4%	15.8%	17.8%	22.0%	22.4%	-1.1%
Food	18.3%	20.3%	21.5%	27.9%	19.3%	23.9%	27.5%	24.5%	21.7%	17.9%	-0.3%
Non-Rail Avg	16.3%	15.8%	16.8%	14.0%	14.0%	15.6%	17.5%	17.1%	17.8%	16.9%	0.4%

Figure 8-32 illustrates that the railroad industry's RSE was generally lower than that of the electric utilities industry over the 1997-2006 period.

FIGURE 8-32
RETURN ON SHAREHOLDERS' EQUITY
1997-2006



A common measure of the financial market's assessment of company/industry performance and earnings is given by the price-earnings ratio (P/E), defined as stock price divided by earnings. Table 8-17 presents price-earnings ratios for the railroad and benchmark industries, and also for the S&P 500 companies over the 1997-2006 period.

TABLE 8-17
PRICE-EARNINGS RATIOS

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	17.21	21.95	17.69	11.85	15.12	14.54	14.37	14.54	14.52	14.82	-1.7%
Trans	17.51	15.43	13.53	13.81	26.85	22.24	19.56	17.43	15.90	17.25	-0.2%
Util	12.90	15.50	11.94	35.14	12.59	14.54	12.81	14.25	15.82	15.46	2.0%
Chem	16.92	20.79	20.68	15.85	27.43	24.06	19.35	17.39	15.36	14.33	-1.8%
Food	20.51	22.77	19.82	14.65	20.04	17.30	13.14	14.89	17.31	17.95	-1.5%
Non-Rail Avg	17.15	20.07	17.53	17.78	18.83	18.06	14.55	15.46	16.20	15.82	-0.9%
S&P 500	24.43	32.60	30.50	26.41	46.50	31.89	22.81	20.70	17.88	17.40	-3.8%

The railroad industry's P/E has trended slightly downward over the period while the P/E for electric utilities has increased. The P/E for S&P 500 companies peaked in 2001 and dropped sharply afterward, approaching but still above the 2006 P/E's for railroad and electric utilities. By 2006, railroad had the second-lowest P/E relative to the benchmark industries. Therefore, despite the increase in the railroad industry's financial performance since 2004, as documented above, railroad stocks were relatively better values. To many, this represents the expectation that railroad earnings will be on-par with a number of industries and not significantly exceed the financial performance of other industries, such as electric utilities and those represented in the S&P 500. Figure 8-33 displays P/E ratios for the railroad and electric utilities industries as well as for the S&P 500 companies.

FIGURE 8-33
PRICE-EARNINGS RATIOS
1997-2006

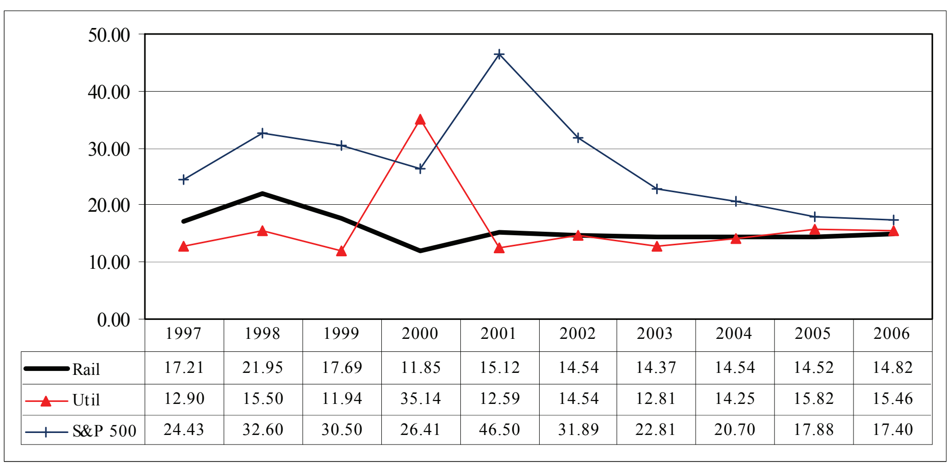
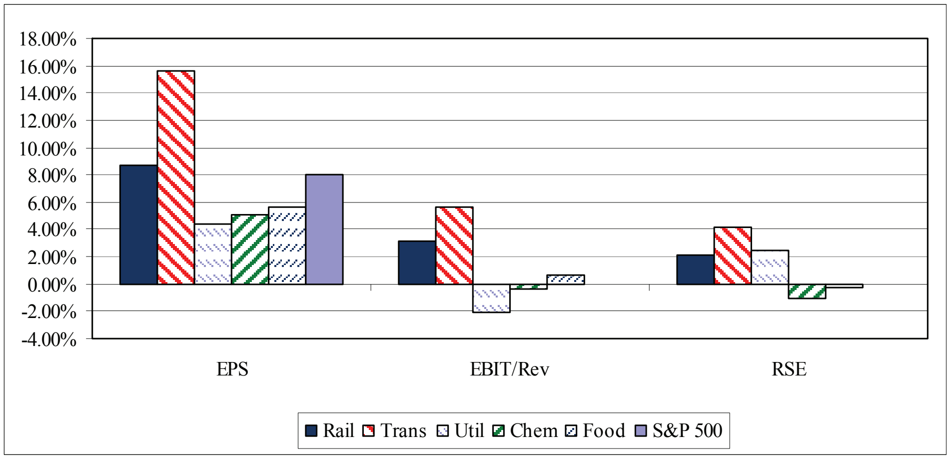


Figure 8-34 summarizes the earnings growth in the various financial measures for the railroad and benchmark industries (and the S&P 500 for

EPS). The railroad industry's growth for these various measures was generally above the average (usually second behind freight transportation) and its EPS growth was close to that of the S&P 500 over the 1997-2006 period.

FIGURE 8-34
EARNINGS MEASURES – AVERAGE ANNUAL GROWTH
1997-2006



Comparison of Capital Spending

Table 8-18 presents capital spending per share for the railroad and benchmark industries. The railroad industry's level of capital spending per share is at or near the top of the industries, but its average growth over the 1997-2006 period is near the bottom. This is consistent with the view noted above that railroad industry capital spending has stabilized after a period of high growth.

TABLE 8-18
CAPITAL SPENDING/SHARE

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	$3.27	$3.44	$3.08	$2.66	$2.65	$2.67	$2.96	$3.07	$3.55	$4.10	2.5%
Trans	$0.99	$1.28	$1.48	$1.40	$1.04	$1.13	$1.20	$1.75	$1.97	$2.71	11.2%
Util	$2.37	$2.54	$3.07	$3.73	$4.60	$4.44	$3.65	$3.63	$4.15	$5.12	8.6%
Chem	$2.29	$1.89	$1.67	$1.55	$1.44	$1.41	$1.35	$1.39	$1.62	$1.98	-1.6%
Food	$0.62	$0.60	$0.67	$0.53	$0.51	$0.69	$0.73	$0.65	$0.66	$0.85	3.6%
Non-Rail Avg	$1.43	$1.32	$1.47	$1.50	$1.69	$1.75	$1.61	$1.61	$1.82	$2.45	6.0%

Figure 8-35 presents capital spending per share for the railroad and electric utilities industries. In contrast to the EPS patterns, where railroad started below electric utilities in 1997 and overtook it, railroad starts with higher capital spending per share but falls below electric utilities by 1999 and continues lower through 2006 (although both industries do exhibit an upward trend).

FIGURE 8-35
CAPITAL SPENDING PER SHARE
1997-2006

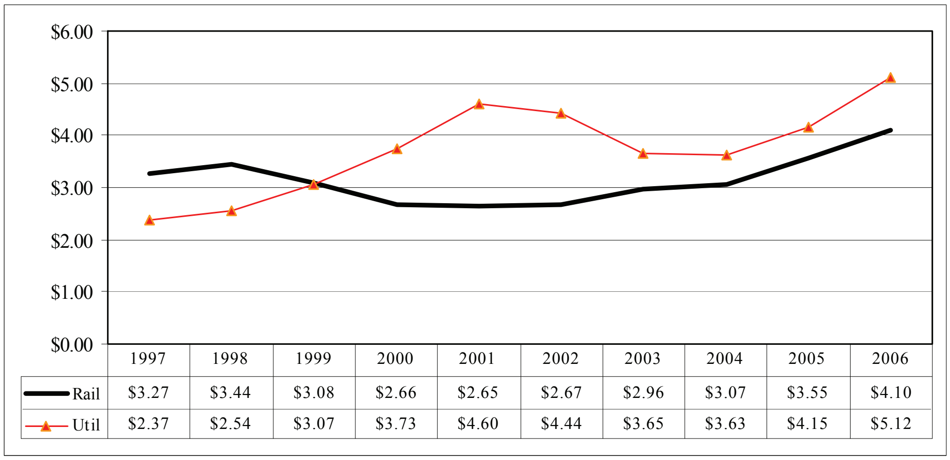


Table 8-19 presents data on the capital spending to revenue ratios for the railroad and benchmark industries. With the exceptions of 2002 and 2006, the railroad industry had the highest percent of its revenues devoted to capital spending. However the gap between the railroad and electric utilities industries considerably narrowed over time, evidenced by the fact that railroad's growth rate is near the lowest while the electric utilities industry's growth rate is the highest over the 1997-2006 period.

TABLE 8-19
CAPITAL SPENDING/REVENUE

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	17.8%	19.6%	16.4%	14.3%	14.2%	14.1%	15.4%	14.4%	14.6%	14.7%	-2.1%
Trans	5.2%	6.2%	6.4%	5.4%	4.3%	4.6%	4.6%	5.8%	5.6%	7.0%	3.3%
Util	10.6%	10.5%	12.6%	12.3%	11.5%	16.3%	13.0%	12.8%	13.2%	15.8%	4.5%
Chem	9.2%	8.9%	7.8%	6.8%	6.7%	6.4%	5.5%	5.1%	5.5%	6.1%	-4.5%
Food	3.4%	3.4%	3.6%	2.8%	2.3%	3.0%	3.0%	2.5%	2.5%	2.9%	-1.9%
Non-Rail Avg	6.9%	6.6%	7.1%	6.6%	6.5%	7.4%	6.3%	5.9%	6.3%	7.8%	1.4%

Figure 8-36 presents capital spending to revenue ratios for the railroad and electric utilities industries.

FIGURE 8-36
CAPITAL SPENDING/REVENUE
1997-2006

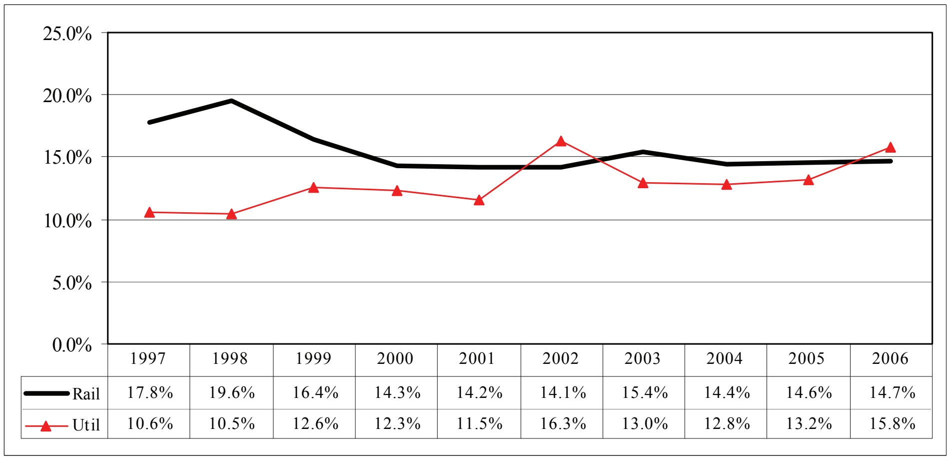


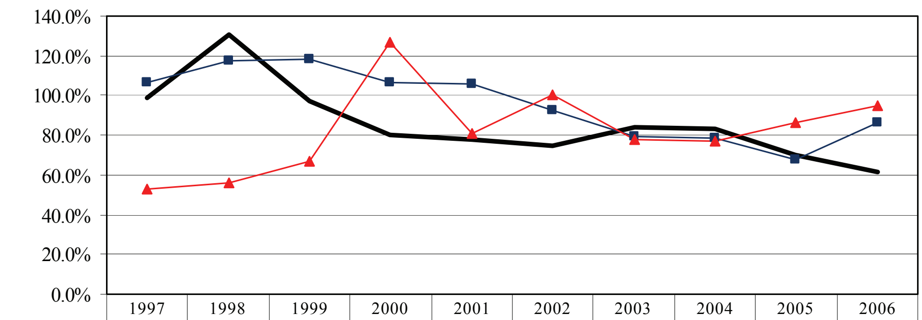
Table 8-20 presents capital spending to EBIT ratios for railroad and benchmark industries. The railroad industry's ratio of capital spending to EBIT was second only to that of transportation in 1997, and well above the values for other benchmark industries. However, as evidenced by the average annual growth rates, the railroad industry lost ground to these industries over time.

TABLE 8-20
CAPITAL SPENDING/EBIT

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	99.0%	130.5%	97.4%	80.4%	77.8%	74.9%	83.7%	83.0%	70.3%	61.4%	-5.3%
Trans	106.9%	117.4%	118.5%	106.2%	105.8%	92.9%	79.4%	78.5%	67.4%	86.6%	-2.3%
Util	52.8%	56.1%	66.7%	126.7%	80.9%	100.2%	77.5%	77.1%	86.7%	95.3%	6.5%
Chem	54.9%	70.7%	61.7%	51.2%	69.9%	57.5%	49.0%	36.5%	34.2%	37.9%	-4.1%
Food	38.2%	31.1%	34.2%	25.0%	20.0%	24.9%	25.5%	27.5%	24.2%	30.5%	-2.5%
Non-Rail Avg	50.2%	51.1%	54.5%	59.9%	55.4%	58.3%	49.7%	48.7%	48.3%	58.2%	1.7%

Figure 8-37 presents capital spending to EBIT ratios for the railroad, electric utilities and transportation industries.

FIGURE 8-37
CAPITAL SPENDING/EBIT
1997-2006



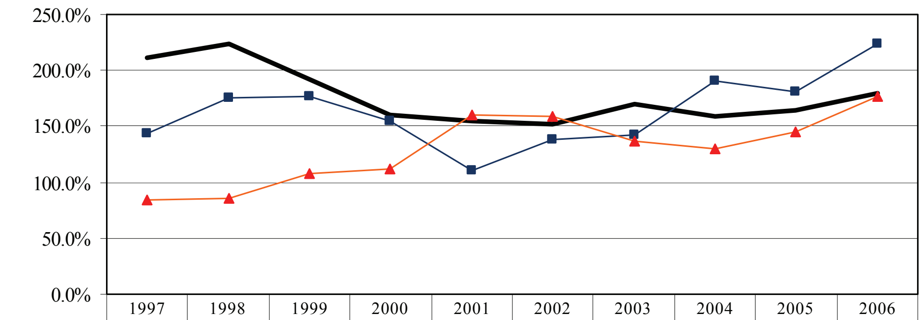
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Rail	99.0%	130.5%	97.4%	80.4%	77.8%	74.9%	83.7%	83.0%	70.3%	61.4%
Trans	106.9%	117.4%	118.5%	106.2%	105.8%	92.9%	79.4%	78.5%	67.4%	86.6%
Util	52.8%	56.1%	66.7%	126.7%	80.9%	100.2%	77.5%	77.1%	86.7%	95.3%

Table 8-21 presents ratios of capital spending to depreciation charges for the railroad and benchmark industries. Consistent with the other capital spending metrics, railroad's performance has slipped relative to the benchmarks over time, although it still does have a relatively high level for its capital spending to depreciation charges ratio. Figure 8-38 presents ratios of capital spending to depreciation charges for the railroad, electric utilities and freight transportation industries. Figure 8-39 summarizes the average annual growth in the capital spending metrics for the railroad and benchmark industries over the 1997-2006 period. For all of these metrics, railroad's average annual growth rates were below those of both the electric utilities and freight transportation industries. They were also lower than the growth rates of the chemicals and/or food processing industries in several instances.

TABLE 8-21
CAPITAL SPENDING/DEPRECIATION CHARGES

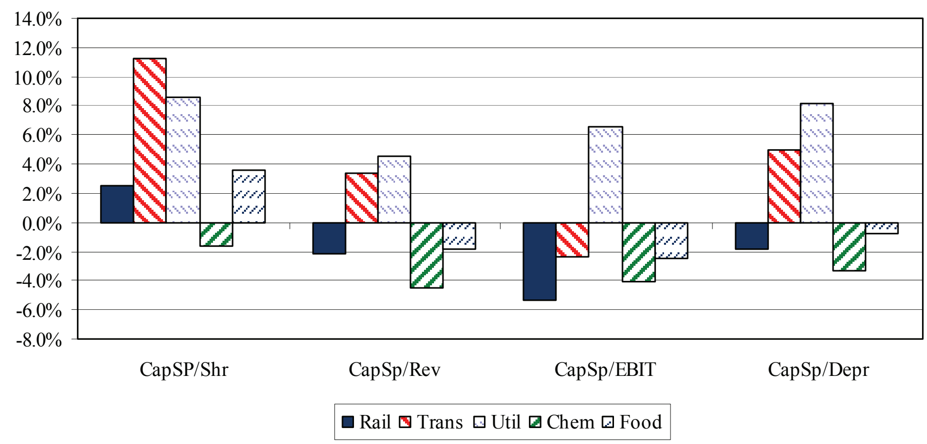
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average Growth
Rail	211.5%	223.6%	191.3%	160.7%	155.3%	152.3%	169.2%	158.6%	164.2%	179.2%	-1.8%
Trans	143.2%	175.4%	176.8%	154.5%	111.0%	137.8%	142.8%	190.4%	181.4%	224.3%	5.0%
Util	84.7%	85.3%	107.7%	111.3%	160.7%	159.1%	136.6%	130.4%	144.5%	176.4%	8.2%
Chem	151.3%	143.0%	119.7%	101.5%	96.3%	95.3%	86.5%	83.6%	99.1%	112.2%	-3.3%
Food	124.5%	117.7%	120.9%	79.2%	57.0%	83.0%	94.2%	73.1%	91.6%	116.3%	-0.8%
Non-Rail Avg	115.5%	110.2%	115.5%	102.3%	113.3%	120.9%	111.8%	103.7%	121.1%	148.4%	2.8%

FIGURE 8-38
CAPITAL SPENDING/DEPRECIATION CHARGES
1997-2006



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Rail	211.5%	223.6%	191.3%	160.7%	155.3%	152.3%	169.2%	158.6%	164.2%	179.2%
Trans	143.2%	175.4%	176.8%	154.5%	111.0%	137.8%	142.8%	190.4%	181.4%	224.3%
Util	84.7%	85.3%	107.7%	111.3%	160.7%	159.1%	136.6%	130.4%	144.5%	176.4%

FIGURE 8-39
CAPITAL SPENDING METRICS – AVERAGE ANNUAL GROWTH
1997-2006



Summary—Railroad Financial Performance and Capital Spending

Overall, the improved financial performance of the railroad industry for the 1997-2006 period has not resulted in increased capital spending growth, and this divergence is also evident relative to the benchmark industries. In particular, these divergent trends are readily apparent relative to electric utilities, which has similar characteristics to the railroad industry in terms of financial performance and capital intensity.

Based on the reversal of the railroad industry's productivity and input price patterns that occurred near the end of 2002 and the increasing rate of the railroad industry's earnings growth beginning in 2004, Table 8-22 breaks the financial and capital spending information into 1997-2004 and 2004-2006 sub-periods. Table 8-22 reveals that in the 2004-2006 sub-period, the railroad industry's divergence between financial performance and capital spending metrics increased, both absolutely and relative to the benchmark industries.

TABLE 8-22
COMPARISON OF FINANCIAL PERFORMANCE AND CAPITAL SPENDING METRICS
AVERAGE ANNUAL GROWTH, 1997-2004 AND 2004-2006

Average Annual Growth, 1997-2004

	Rail	Trans	Util	Chem	Food	Non-Rail Average	Rail Rank
EPS	2.9%	14.4%	2.9%	1.1%	7.9%	4.7%	3
EBIT/Rev	-0.5%	6.1%	-2.7%	-2.6%	0.0%	-1.7%	3
RSE	-3.0%	3.5%	1.8%	-4.6%	4.2%	0.7%	4
CapSP/Shr	-0.9%	8.1%	6.1%	-7.1%	0.8%	1.7%	4
CapSp/Rev	-3.0%	1.7%	2.7%	-8.4%	-4.7%	-2.2%	3
CapSp/EBIT	-2.5%	-4.4%	5.4%	-5.8%	-4.7%	-0.4%	2
CapSp/Depr	-4.1%	4.1%	6.2%	-8.5%	-7.6%	-1.5%	3

Average Annual Growth, 2004-2006

	Rail	Trans	Util	Chem	Food	Non-Rail Average	Rail Rank
EPS	29.4%	19.7%	9.4%	19.1%	-2.3%	9.6%	1
EBIT/Rev	16.2%	4.2%	0.0%	7.3%	3.1%	5.0%	1
RSE	20.4%	6.5%	4.6%	11.3%	-15.8%	-0.8%	1
CapSP/Shr	14.5%	21.9%	17.2%	17.7%	13.2%	20.9%	4
CapSp/Rev	1.1%	9.1%	10.6%	9.3%	8.2%	13.9%	5
CapSp/EBIT	-15.1%	4.9%	10.5%	1.9%	5.2%	8.9%	5
CapSp/Depr	6.1%	8.2%	15.1%	14.7%	23.2%	17.9%	5

As discussed above, one perspective is that, after a period of unusual activity, financial metrics reflect the railroad industry settling into a rate of capital expenditures ("capex") that allows for maintenance and slow, steady growth.[24]

A summary of the industry from the summer of 2004 recognized that railroads were beginning to have the ability to raise rates due, in part, to railroad's cost advantage over trucks, the introduction of premium services by railroads, and the consolidation of the railroad industry:

[24]John G. Larkin and Daniel S. Taylor, *Railroads: Striving to Drive Improved Return on Invested Capital,* Legg Mason Wood Walker, Inc., Summer 2004, p. 24.

After many years of declining prices for rail services, the railroads appear to be finally able to increase prices. Most of the rails are increasing prices by 1%-2% per year and are forecasting similar levels of increases in future years. Interestingly, these increases fall below the 2%-5% levels of the truckload carriers. Price increases and yield management are key areas of focus for all the rails. The rails are in a position to raise rates due to a variety of factors. One is that rails are more competitive as an alternative to trucks. Rail service, which was not great before, worsened after all of the mergers in the 1990s. However, there have been no big mergers since the STB blocked the Burlington Northern/Canadian National merger in 2000 and imposed a 15-month moratorium on rail mergers. This forced the rails to focus on improving their own networks and improving service, growing internally rather than by acquisition. This has led to higher velocity and better service and reliability.

Another factor making rails more competitive with trucks is the cost differential from the shipper's perspective. Rail transportation often costs less depending on the service and length of haul. … As truck rates rise, the railroads can raise their rates in conjunction with the truckers without the risk of losing their relative attractiveness. …

The rails also have focused more on service to their customers, introducing premium services. These products are higher priced than traditional rail services and lead to higher margins. … These are attractive alternatives to many customers, as they are still less expensive than the trucking option. These services work best for cargo that is more cost efficient for the rails, which is primarily long-haul freight.

Another recent advantage for the rails comes from the structure of its industry. … [T]here has been tremendous consolidation in the industry. There are now only seven Class 1 railroads in the United States, with four clearly being the dominant players. In essence, what remains in the industry are regional duopolies … This gives them more pricing leverage as there is less undercutting, as they are dominant in

> their own regions, allowing for greater focus on pricing and yield. This also gives fewer alternatives to their customers, as there is little choice about which rail to use, although the price is regulated.[25]

Our analysis of financial measures shows that railroad's profitability has improved and that improvement is the result of higher prices for rail services rather than improved productivity or lower prices for fuel and other inputs. We see that capital spending has remained a near-constant share of revenue, consistent with capital investment in electric utilities. There has been no increase in the railroad industry's capital spending to revenue ratio induced by higher profits. There is some evidence that the current increases in the railroad industry's profits are just the fulfillment of market expectations inasmuch as its price-earnings ratio has been very steady in recent years, in spite of declines in the price-earnings ratio for the S&P 500 companies overall.

Market analysts and our stakeholder interviews all suggest that at least a portion of the improved profitability is due to increased pricing power. This financial analysis does not enable us to discern what portion, if any, of the increase in prices is due to increased exercise of market power versus increased competitive advantage of railroads over alternative transportation modes, or simply increases in overall demand that have allowed railroads to use price to ration its service. We will address the issue of market power in subsequent chapters.

Conclusion

Regarding railroad rate trends, the aggregate Producer Price Index for line-haul rail transportation has shown more substantial price growth than either the GAO or STB industry-wide indexes. Between 1985 and 2005, the Producer Price Index for line-haul rail transportation increased 40 percent; while it increased 22 percent between 2000 and 2005. Because the different price indexes discussed each have their potential biases, we constructed a new set of rate indexes that attempt to capture the relevant cost differences of shipments and use chain-weighting techniques.

The rate indexes we developed using the Carload Waybill Sample show rates of increase that lie between the indexes reported by the GAO and the Producer Price Indexes. We conclude that they provide useful evidence of recent rate trends. The indexes show that rate increases have by and large been moderate until very recently, but between 2004 and 2006, the rate increases were substantial, as the indexes we constructed

[25] John G. Larkin and Daniel S. Taylor, *Railroads: Striving to Drive Improved Return on Invested Capital,* Legg Mason Wood Walker, Inc., Summer 2004, p. 31 (emphasis added).

show rate increases on the order of seven to eight percent per year during this period.

Trends in the railroad industry's rates are driven by three primary factors: changes in the prices that the railroads pay for their inputs, changes in railroad total factor productivity, and changes in market structure that increase or decrease railroad pricing margins. Changes in input prices and changes in productivity determine the rate at which railroad unit costs increase over time. Any differences between the rate at which railroad output prices change and the rate at which railroad unit costs change flow through to the profit margins that the railroad industry generates.

Our analysis of the trends in the STB's measures of input price and productivity growth are consistent with the general pattern in railroad rates found in the GAO study: rates began to increase in the early 2000s after a long period of post-Staggers Act decline. As demonstrated here, this pattern in rates coincides with a recent reversal in the railroad industry's productivity and input price trends. Since late 2002, the railroad industry's productivity growth has fallen below its input price growth, implying an increase in railroad unit costs. Regarding input price growth, it has been demonstrated here that not only fuel, but most other significant input categories have experienced greater price increases in recent years.

Longer-term trends in productivity provided by the BLS measure of MFP for the railroad industry show that railroad MFP growth peaked in the late 1980s (surpassing the five-year average peak of the late 1960s) and recent growth rates are similar to those of the late 1970s and early 1980s. Furthermore, the MFP measure confirms that recent productivity growth for the railroad industry has declined both absolutely and relative to economy-wide productivity growth.

Both the STB and BLS measures of railroad industry productivity confirm a slowdown in industry productivity growth in this decade. One effect of this slowing productivity growth is a diminished ability of railroads to absorb increases in input prices in recent years.

Recognizing there are controversial aspects to the STB-determined cost of equity, when the recently adopted CAPM method is used, the industry has earned at least its cost of equity after 2001 and the excess has widened in recent years. It is important to note that these industry-wide results vary significantly with respect to individual railroads. Furthermore, it is difficult to draw conclusions from only a few observations, particularly when the earlier observations show the opposite result.

Overall, the improved financial performance of the railroad industry for the 1997-2006 period has not resulted in increased capital spending growth, and this divergence is also evident relative to the benchmark industries. In particular, these divergent trends are readily apparent relative to electric utilities, which is the industry that most closely resembles the railroad industry in terms of financial and capital spending performance. We see that capital spending has remained a near-constant share of revenue, consistent with capital investment in electric utilities. There has been no increase in the railroad industry's capital spending to revenue ratio induced by higher profits. One perspective is that, after a period of unusual activity, financial metrics reflect the railroad industry settling into a rate of capital expenditures ("capex") that allows for maintenance and slow, steady growth. There is some evidence that the current increases in the railroad industry's profits are just the fulfillment of market expectations inasmuch as its price-earnings ratio has been very steady in recent years, in spite of declines in the price-earnings ratio for the S&P 500 companies overall.

APPENDIX 8-A
FIRMS IN VALUE LINE BENCHMARK INDUSTRIES

Freight Transportation Industry

	Company	**Ticker**	**Years of Data**
1	Hunt (J.B.)	JBHT	1997-2006
2	C.H. Robinson	CHRW	1997-2006
3	Landstar Sys.	LSTR	1997-2006
4	Con-way Inc.	CNW	1997-2006
5	Heartland Express	HTLD	1997-2006
6	Knight Transportation Inc.	KNX	1997-2006
7	Werner Enterprises	WERN	1997-2006
8	Hub Group Inc.	HUBG	1997-2006
9	Old Dominion Freight	ODFL	1997-2006
10	Forward Air	FWRD	1997-2006
11	YRC Worldwide	YRCW	1997-2006
12	Arkansas Best	ABFS	1997-2006
13	Pacer International Inc.	PACR	2002-2006
14	Marten Transport Ltd.	MRTN	1997-2006
15	Celadon Group	CLDN	1997-2006
16	Vitran Corporation Inc.	VTN.TO	1997-2006
17	P.A.M. Transport Svcs	PTSI	1997-2006
18	USA Truck	USAK	1997-2006
19	Trailer Bridge	TRBR	2000-2006
20	Frozen Food Express	FFEX	1997-2006

Food Processing Industry

	Company	**Ticker**	**Years of Data**
1	Unilever PLC ADR	UL	1997-2006
2	Unilever NV (NY Shs)	UN	1997-2005
3	Kraft Foods	KFT	1998-2006
4	Archer Daniels Midland	ADM	1997-2006
5	Kellogg	K	1997-2006
6	General Mills	GIS	1997-2006
7	Wrigley (Wm.) Jr.	WWY	1997-2006
8	Heinz (H.J.)	HNZ	1997-2006
9	Bunge Ltd.	BG	2000-2006
10	Campbell Soup	CPB	1997-2006
11	ConAgra Foods	CAG	1997-2006
12	Sara Lee Corp.	SLE	1997-2006
13	Hershey Co.	HSY	1997-2006
14	Hormel Foods	HRL	1997-2006
15	Tyson Foods 'A'	TSN	1997-2006
16	McCormick & Co.	MKC	1997-2006
17	Smithfield Foods	SFD	1997-2006
18	Dean Foods	DF	1997-2006
19	Smucker (J.M.)	SJM	1997-2006
20	Corn Products International	CPO	1997-2006

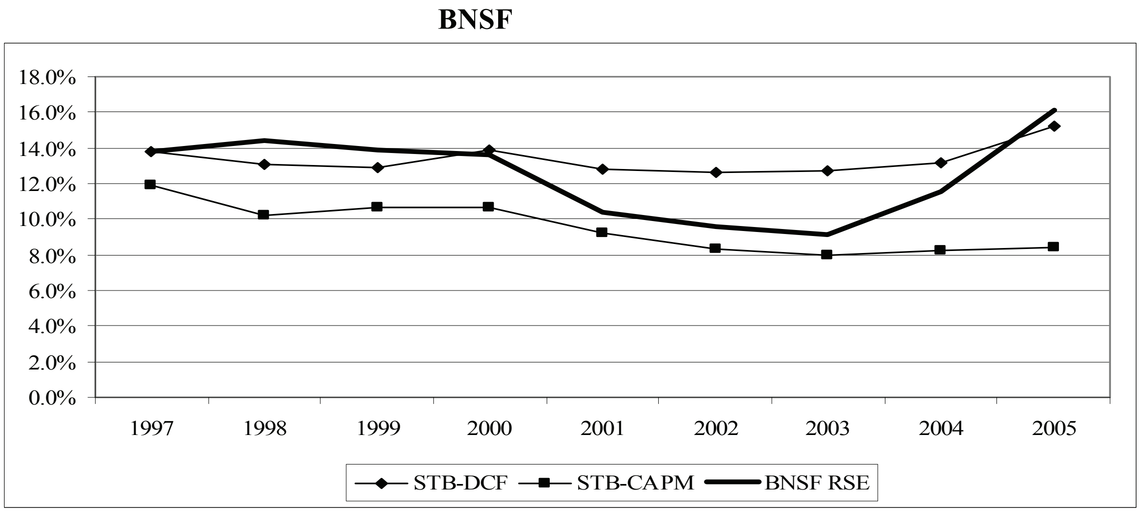
Electric Utilities Industry

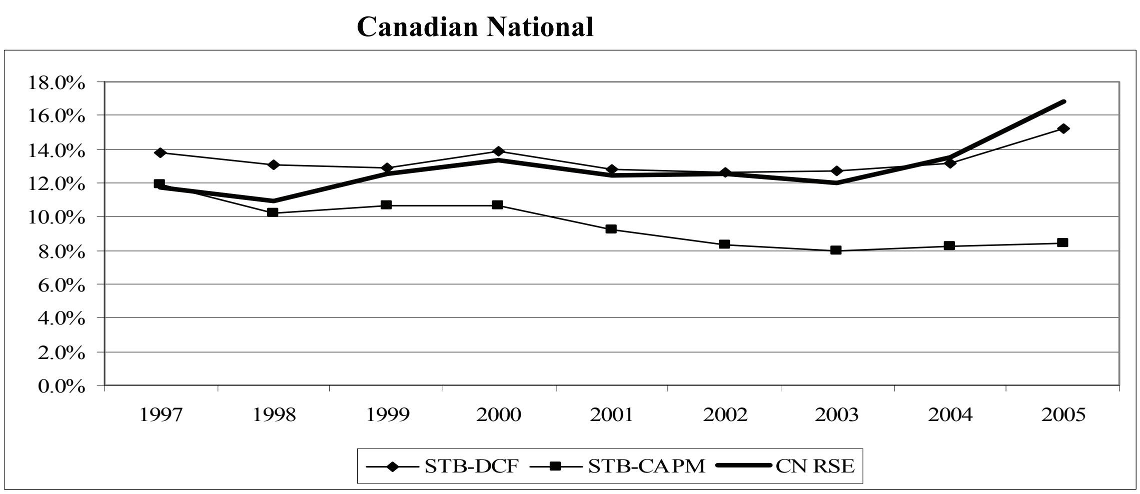
	Company	Ticker	Years of Data
1	Exelon Corp.	EXC	1999-2006
2	Southern Co.	SO	1997-2006
3	FPL Group	FPL	1997-2006
4	Dominion Resources	D	1997-2006
5	Public Serv. Enterprise	PEG	1997-2006
6	FirstEnergy Corp.	FE	1997-2006
7	Entergy Corp.	ETR	1997-2006
8	PPL Corp.	PPL	1997-2006
9	Amer. Elec. Power	AEP	1997-2006
10	Constellation Energy	CEG	1997-2006
11	Edison Int'l	EIX	1997-2006
12	Sempra Energy	SRE	1997-2006
13	PG&E Corp.	PCG	1997-2006
14	Consolidated Edison	ED	1997-2006
15	Progress Energy	PGN	1997-2006
16	Ameren Corp.	AEE	1997-2006
17	Allegheny Energy	AYE	1997-2006
18	Xcel Energy Inc.	XEL	1997-2006
19	DTE Energy	DTE	1997-2006

Chemicals Industry

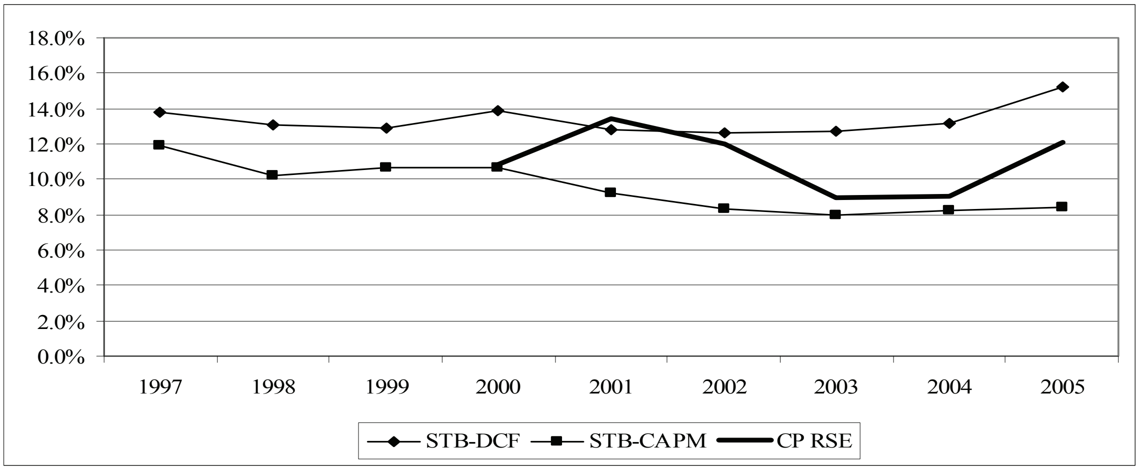
	Company	Ticker	Years of Data
1	Monsanto Co.	MON	2000-2006
2	3M Company	MMM	1997-2006
3	Potash Corp.	POT	1997-2006
4	Du Pont	DD	1997-2006
5	Dow Chemical	DOW	1997-2006
6	Praxair Inc.	PX	1997-2006
7	Air Products & Chem.	APD	1997-2006
8	Norsk Hydro ADR	NHYDY	1997-2006
9	Imperial Chemical. ADR	ICIYY	1997-2005
10	Ecolab Inc.	ECL	1997-2006
11	Rohm and Haas	ROH	1997-2006
12	PPG Industries	PPG	1997-2006
13	Agrium Inc.	AGU	1997-2006
14	Sigma-Aldrich	SIAL	1997-2006
15	Sherwin-Williams	SHW	1997-2006
16	Eastman Chemical	EMN	1997-2006
17	Sociedad Quimica y Minerea	SQM	2000-2006
18	Avery Dennison	AVY	1997-2006
19	Pall Corp.	PLL	1997-2006
20	FMC Corp.	FMC	1997-2006

APPENDIX 8-B
COMPARISON OF RSE AND STB COST OF EQUITY CAPITAL FOR CLASS I RAILROADS

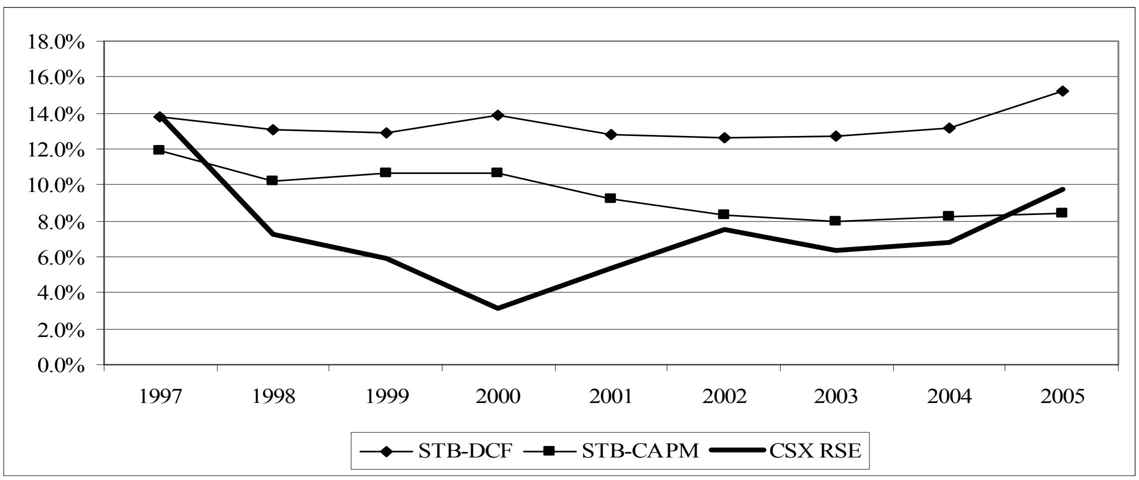




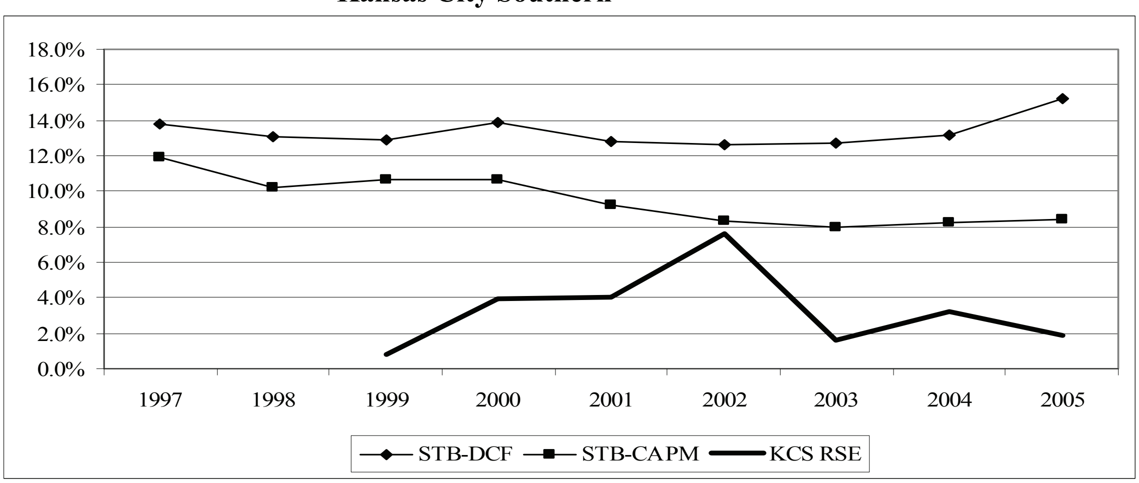
Canadian Pacific



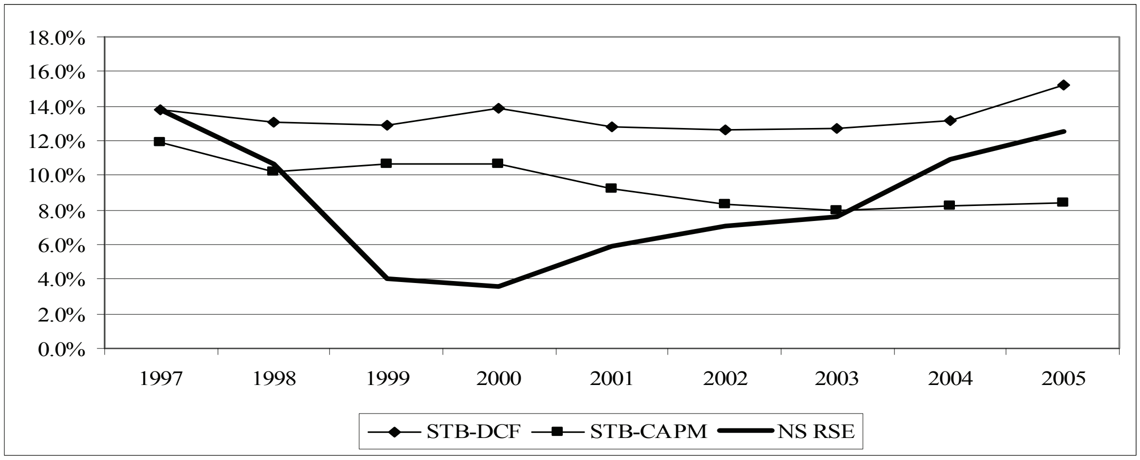
CSX



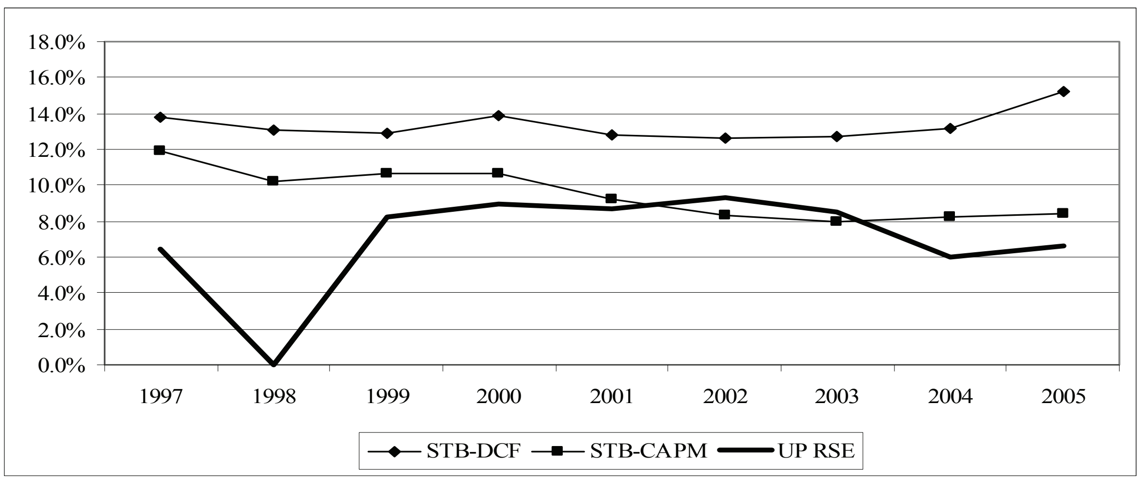
Kansas City Southern



Norfolk Southern



Union Pacific



Chapter 9 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 9. RAILROAD COSTS AND TECHNOLOGY

INTRODUCTION

In this chapter, we provide information about the rail freight production process by estimating a variable cost function. The estimated function applies to the Class I freight railroad industry as a whole, although the estimated function is used to generate year-specific and railroad-specific estimates of marginal costs and other relevant technological concepts. The estimated cost function is a "variable cost" function because it assumes that variable inputs are employed at cost-minimizing levels, but that way and structures capital is a "quasi-fixed input" that might not be employed at its long-run, cost-minimizing level.[1]

We chose to estimate a cost function for several reasons. First, this approach allows us to rely on economic theory to recover information about the production process of freight railroad transportation and how this process has been changing over time. Second, this approach lets us undertake analyses of how the marginal cost of rail transport has been changing over time and the factors underlying the changes. These analyses will provide a baseline from which to bifurcate rail rate changes into "competitive response" and "market power" components. Third, by using the "constrained" or "variable" cost function we can examine the incentives for railroads to undertake investment in additional capacity and infrastructure. Finally, the cost function provides a foundation for analyzing the impacts of the various policy options discussed in Volume 3 of this report.

9A. THE VARIABLE COST FUNCTION

We rely on the duality between the production and cost functions to retrieve technological information directly from cost data. Shephard established the duality between production and cost.[2] We summarize this duality relationship in the context of variable and quasi-fixed inputs. Let technology be represented by a production function

$$(9.1) \quad F(Y, X^V, X^F) \geq 0$$

[1] A "quasi-fixed" input is also called a conditional input, rather than a fixed input, because it may be adjusted over time, but not necessarily to its long-run, cost-minimizing level.

[2] R. Shephard, *Cost and Production Functions,* Princeton University Press, 1953, establishes the duality between production and cost.

where Y is the vector of outputs, X^V is a vector of variable inputs, and X^F is a vector of quasi-fixed inputs. If function F satisfies the following three properties,

f.1 F is continuous and twice differentiable in Y, X^V, and X^F

f.2 F is non-decreasing in Y, and F is non-increasing in X^V and X^F

f.3 F is quasi-convex in Y, and F is quasi-concave in X^V and X^F

then a firm that is a price taker in the variable input markets has a minimum variable cost function

(9.2) $C^V = C^V(Y, W^V, X^F)$

where W^V is a vector of input prices corresponding to X^V. C^V has the following properties or regularity conditions:

c.1 C^V is continuous and twice differentiable in Y, W^V, and X^F

c.2 $C^V(Y, W^V, X^F) > 0$ for all $Y > 0$, $W^V > 0$ and $X^F > 0$

c.3 $\partial C^V(Y, W^V, X^F)/\partial W_i = X_i(Y, W^V, X^F) > 0$ for all W_i

c.4 $\partial C^V(Y, W^V, X^F)/\partial X_j < 0$ for all X_j

c.5 $C^V(Y, W^V, X^F)$ is linearly homogeneous in W^V

c.6 $C^V(Y, W^V, X^F)$ is concave in W^V and convex in X^F

c.7 $\partial C^V(Y, W^V, X^F)/\partial Y_k > 0$ for all Y_k.

The duality result establishes that C^V and F are equivalent representations of technology, and as such, C^V can be used to capture technology even though the production function F is never explicitly specified.

Previous applications of the variable cost function approach include Indian agriculture,[3] U.S. agriculture,[4] U.S. hospitals,[5] U.S. telephones,[6] and U.S. railroads.[7]

9B. DATA AND ESTIMATION

We estimate a variable cost function for U.S. Class I railroads over the period 1987-2006. In 1987, there were 17 U.S. Class I railroads. As a result of mergers and reclassification, seven Class I railroads remained operating in the U.S. in 2006. Table 9-1 provides a summary of the Class I railroads used in our variable cost estimation.

We model the railroads as producing one output, revenue ton-miles, through a network measured in miles of road. There are four variable inputs: labor, equipment, materials, and fuel. We treat way and structures capital as a quasi-fixed factor in the variable cost function. We also include the average length of haul and network size as variables in the cost function estimation.

Most of the data used in the variable cost function estimation come from the Rail Form 1 (R-1 data), which Class I railroads submit to the STB. From these data we construct measures of variable cost, variable input cost shares, output, network size, average length of haul, variable input prices, and quasi-fixed capital stock. We also construct a time-trend variable. Except for the capital stock variable, we define and measure the cost function variables as done by Bitzan and Wilson.[8] We adopt the methodology of Vellturo and Friedlaender et al. to extend their capital stock series for the period

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[3] Lawrence Lau and Pan Yotopolus**,** "A Test for Relative Efficiency and an Application to Indian Agriculture," *American Economic Review*, March 1971, pp. 94-109**.**

[4] R. Brown and L. Christensen, "Estimating Elasticities of Substitution in a Model of Partial Static Equilibrium: An Application to U.S. Agriculture, 1947 to 1974," in Ernst R. Berndt and Barry C. Field, eds., *Measuring and Modelling Natural Resource Substitution*, (Cambridge, MA: MIT Press), 1981, pp. 209-229.

[5] T. Cowing and A. Holtmann, "The Multiproduct Short-run Hospital Cost Function: Empirical Evidence and Policy Implication from Cross-section Data," *Southern Economic Journal* 49, 1983, pp. 637-653.

[6] M. Schankerman and M. Nadiri, "A Test of Static Equilibrium Models and Rates of Return to Quasi-Fixed Factors, with an Application to the Bell System," *Journal of Econometrics* 33(1-2), 1986, pp. 97-118.

[7] D. Caves, L. Christensen, and J. Swanson, "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955–74," *American Economic Review*, 1981, pp. 994-1002; and A. Friedlaender, E. Berndt, J. Chiang, M. Showalter, and C. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-regulated Environment," *Journal of Transport Economics and Policy* 27 (2), pp. 131-152.

[8] J. Bitzan and W. Wilson, "A Hedonic Cost Function Approach to Estimating Railroad Costs," in Scott Dennis and Wayne K. Talley eds., *Research in Transport Economics: Railroad Economics*, 2007, pp. 119-152.

1987-2006.[9] A table of variable definitions, formulas, and sources is included in the appendix to this chapter. Variables in bold italics are the variables used in the cost function estimation.

TABLE 9-1
CLASS I RAILROADS USED IN VARIABLE COST FUNCTION ESTIMATION

Railroads	Years in Data	Notes
ATSF	1987-1995	Merged with BN to form BNSF
BN	1987-1995	Merged with ATSF to form BNSF
BNSF	1996-2006	Formed by merger of ATSF and BN
CNGT	2002-2006	Formed by merger of GTW and IC
CNW	1987-1994	Merged into UP
CR	1987-1998	Divided between NS and CSX
CSX	1987-2006	
DRGW	1987-1994	Merged into SP
GTW	1987-1998	Merged with IC to form CNGT
IC	1987-1998	Merged with GTW to form CNGT
KCS	1987-2006	
MKT	1987	Merged into UP
NS	1987-2006	
SOO	1987-2006	
SP	1987-1996	Includes former DRGW and SSW: Merged into UP
SSW	1987-1989	Merged into SP
UP	1987-2006	Includes former CNW, MKT, and SP

*Two railroads, Delaware & Hudson (DH) and Florida East Coast (FEC), are omitted from the sample. DH lost its Class I status after 1987 and FEC lost its Class I status after 1991. Observations for GTW and IC for 1999-2001 were also omitted. This was because of data reporting inconsistencies around the time of their mergers.

Variable cost, input prices, and the capital stock measure are converted into constant dollars (Year 2000 = 1.0) using the price index for gross domestic product. Finally, prior to estimation, the measures for variable cost, output, network size, average length of haul, input prices, and capital stock are divided by their sample mean values (mean-scaled).[10]

We choose a transcendental logarithmic specification (translog) for the variable cost function. The translog specification, developed by Christensen, Jorgenson, and Lau, is a second-order approximation to an unspecified

[9] C. Vellturo, *The Deregulation of the U.S. Rail Industry: Efficiency and Equity in Attaining Rail Viability*, Ph.D. Thesis, Massachusetts Institute of Technology, September 1989; and A. Friedlaender, E. Berndt, J. Chiang, M. Showalter, and C. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-regulated Environment," *Journal of Transport Economics and Policy* 27(2), 1993, pp. 131-152.

[10] Mean-scaling the data facilitates the interpretation and evaluation, at the point of approximation, of the estimated variable cost function and many estimated production concepts since the point of approximation is a vector of 1's. This normalization is especially convenient with the translog specification because second order terms are zero at the point of approximation.

technology.[11] When the second-order terms are zero, the translog specification reduces to a Cobb-Douglas first-order approximation of an unspecified technology.[12]

Our translog specification of variable cost is

$$
\begin{aligned}
\ln C^V = {} & \alpha_0 + \alpha_Y \ln Y + \alpha_N \ln N \\
& + 1/2\,\alpha_{YY}(\ln Y)^2 + \alpha_{YN} \ln Y \ln N + 1/2\,\alpha_{NN}(\ln N)^2 \\
& + \textstyle\sum_i \beta_1 \ln W_i \\
& + 1/2 \textstyle\sum_i \sum_j \beta_{ij} \ln W_i \ln W_j \\
& + \eta_K \ln K + \eta_H \ln ALOH \\
& + 1/2\eta_{KK}(\ln K)^2 + 1/2\eta_{HH}(\ln ALOH)^2 \\
& + \textstyle\sum_i \alpha_{Yj} \ln Y \ln W_i \\
& + \textstyle\sum_i \alpha_{Nj} \ln N \ln W_i \\
& + \tau_T\, Time + 1/2\tau_{TT}(Time)^2 \\
& + \tau_T\, Time\, \ln Y + \tau_N\, Time\, \ln N \\
& + \textstyle\sum_i \tau_i\, Time \ln W \\
& + \textstyle\sum_k d_k\, Firm_k
\end{aligned}
\tag{9.3}
$$

where ln is the natural logarithm operator, Y represents revenue ton-miles, N the network size measured in miles of road,[13] W_i the price of the ith variable input, K the quasi-fixed capital stock, and ALOH the average length of haul.

In addition to the independent variables and time trend, we have introduced the possibility of "firm effects" by including binary variables for each firm incarnation ($Firm_k$), taking into account the mergers that occurred over the sample period. We include these first-order binary terms in the cost function to control for unobserved railroad characteristics. Using the railroads listed in Table 9-1, there are 22 distinct Class I firm incarnations between 1987 and 2006. This results in 21 binary firm-indicator variables being included in equation (9.3).[14]

[11] L. Christensen, D. Jorgenson, and L. Lau, "Conjugate Duality and the Transcendental Logarithmic Production Function," *Econometrica*, 39, 1971, pp. 255-256; and L. Christensen, D. Jorgenson, and L. Lau, "Transcendental Logarithmic Production Frontiers," *Review of Economics and Statistics*, 55, pp. 28-45.

[12] C. Cobb and P. Douglas, "A Theory of Production," *American Economic Review*, 18, Supplement, 1928, pp. 139-165.

[13] The miles of road measure differs from the miles of track measure. A mile of road may have a single or multiple tracks. The miles of road variable captures the expanse of the railroad's network.

[14] The current UP organization is the excluded binary variable.

The translog specification automatically satisfies properties c.1 and c.2. In addition, symmetry of second derivatives can be easily imposed by specification.[15] Property c.3, called Shephard's lemma, gives the input demand expressions. In logarithmic form, Shephard's lemma yields the variable input share expressions. That is,

$$(9.4) \quad M_i = \beta_i + \sum_j \beta_{ij} \ln W_j + \alpha_{Yj} \ln Y + \alpha_{Nj} \ln N + \tau_j \, Time \, .$$

Equations (9.3) and (9.4) comprise the system of estimating equations. Homogeneity of C^V (property c.5) with respect to input prices is imposed by the following parameter restrictions:

$$(9.5) \quad \begin{aligned} &\sum_i \beta_i = 1; \\ &\sum_i \beta_{ij} = \sum_j \beta_{ji} = 0; \\ &\sum_i \alpha_{Yj} = 0; \\ &\sum_i \alpha_{Rj} = 0; \\ &\sum_i \tau_j = 0 \end{aligned} \quad .$$

The regularity conditions represented by properties c.4, c.6, and c.7 cannot be parsimoniously imposed via translog parameter restrictions. Instead, the cost function estimate must be evaluated at each observation to check these conditions.[16]

We introduce switching regression mechanisms for parameters associated with the first and direct second-order time trend terms. The reason for this is to allow the structure of technological change to differ over the sample period. The switching mechanisms are implemented by substituting the following expressions into the variable cost system:

$$(9.6) \quad \begin{aligned} \tau_T &= \tau_{T1} T_1 + \tau_{T2} T_2 + \tau_{T3} \\ \tau_{TT} &= \tau_{TT1} T_1 + \tau_{TT2} T_2 + \tau_{TT3} \end{aligned}$$

where T1 = 1 for years 1987-92 and T1 = 0 for other years; T2 = 1 for years 1993-98 and T2 = 0 for other years; and $\tau_{T1}, \tau_{T2}, \tau_{T3}, \tau_{TT1}, \tau_{TT2}$, and τ_{TT3} are parameters to be estimated. With the specification given by equation (9.6), a

[15] Symmetry of second derivatives is a basic calculus result, sometimes referred to as Young's theorem, implying that the order of differentiation does not matter.

[16] We end up imposing the restriction $\beta_{FF} = 0$ in order to obtain property c.6 with respect to the price of fuel. Similar restrictions were necessary in the variable cost function system estimated by Friedlaender and her co-authors in A. Friedlaender, E. Berndt, J. Chiang, M. Showalter, and C. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-regulated Environment," *Journal of Transport Economics and Policy* 27(2), 1993, pp. 131-152.

common time-trend structure across the 20-year period is a testable hypothesis represented by the special case $\tau_{T1} = \tau_{T2} = \tau_{TT1} = \tau_{TT2} = 0$.

We estimate a four-equation system consisting of the translog variable cost function given by equation (9.3) and three of the four input share equations given by equation (9.4),[17] with the switching parameter mechanisms embedded in equation (9.6). We estimate this system by the method of seemingly unrelated regressions.[18] This method allows for cross-equation correlation of error terms, which is appropriate because the share equations are first derivatives of the translog cost equation.[19]

Table 9-2 reports summary statistics for the estimated variable cost system model. Regularity conditions implied by theory (c.1 through c.7) are satisfied for 197 out of the 199 observations.[20]

TABLE 9-2
SUMMARY STATISTICS FOR VARIABLE COST SYSTEM MODEL

Equation	R-Square	Adjusted R-Square
ln Variable Cost	0.9858	0.9819
Labor Share	0.3906	0.3735
Equipment Share	0.2211	0.2162
Fuel Share	0.4049	0.4021

Parameter estimates for the variable cost function are reported in the appendix to this chapter. We first examine the firm-specific effects. These effects are relative to the omitted binary variable for UP in the 1997-2006 period. Fourteen of 21 firm-effect parameter estimates are statistically

[17] Because the share expressions must sum to one, only (any) three share equations are independent. In the estimation reported, we have dropped the materials share equation. However, parameter estimates are invariant to which share equation is omitted.

[18] A. Zellner, “An Efficient Method of Estimating Seemingly Unrelated Regression Equations and Tests for Aggregation Bias,” *Journal of the American Statistical Association* 57, 1962, pp. 348-368.

[19] We constructed an instrumental variable for revenue ton-miles (Y) to investigate the possible endogeneity of Y. We included the instrumental variable in the variable cost function system along with Y in exactly the same manner. We tested for differences across specifications wherein Y is treated as exogenous and endogenous, and found that there was no statistical bias introduced by treating Y as exogenous. See Jan Kmenta, *Elements of Econometrics,* Second Edition, Macmillan Publishing Company, pp. 634-635. We do not reject the null hypothesis of exogeneity for Y. Furthermore, when the model is estimated with the instrumental variable proxy for Y replacing Y, that is by iterated three-stage least squares, the resulting variable cost function estimate does a poor job of meeting the regularity conditions. Consequently, we base our analysis on the iterated seemingly unrelated regressions.

[20] GTW has negative estimates for the marginal cost of ton-miles for 1997 and 1998.

insignificant,[21] indicating no evidence of cost structure differences from the current incarnation of UP. Seven of the firm-effect parameters are statistically significant and negative. These indicate cost structure differences from the current UP, but should not necessarily be interpreted as cost efficiency differences, as the parameters may merely reflect differences in unobserved network conditions.[22] Notably, there is no statistically significant evidence of cost structure differences between any of the incarnations of the SP and UP firms.

Estimates of the cost function model with expressions (6) incorporated result in statistical rejection of the hypothesis of a common time-trend structure across the sample. However, estimates for τ_{T1} and τ_{T2} are similar and not statistically different. Likewise, estimates for $\tau_{TT1} = \tau_{TT2}$ are similar and not statistically different. Thus, we estimate the model with the embedded restrictions $\tau_{T1} = \tau_{T2}$ and $\tau_{TT1} = \tau_{TT2}$. The implications of the switching regression parameters will be addressed below in the discussion of technological change.

9C. RAILROAD TECHNOLOGY INFERRED FROM THE VARIABLE COST FUNCTION

Duality theory allows us to infer the essential characteristics of freight rail technology directly from the estimated variable cost function. These characteristics include: economies of density, economies of scale, technological change, and input substitution possibilities. We use several cost elasticity concepts in our analysis of density, scale, and technological change. In Table 9-3, we report the "industry average" for the key elasticity estimates for selected years.[23] The industry average is a weighted average of railroad-specific elasticity measures, with the weights being the railroads' shares of

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[21] Unless otherwise indicated, all statements of statistical significance are relative to a 10 percent significance level.

[22] The estimate of the difference in cost structures between any two of the included firms is simply the difference in their parameter estimates. The corresponding standard error estimate is the square root of the sum of the variances of the two binary variable estimates minus two times their covariance.

[23] We present 90 percent confidence intervals for many of the statistics reported in this chapter. The variable cost function system was re-estimated 1000 times using a bootstrap resampling method. The bootstrap estimates are used to construct confidence intervals by a simple percentile method. Details of this procedure can be found in B. K. Eakin, D. P. McMillen, and M. J. Buono, "Constructing Confidence Intervals Using the Bootstrap: An Application to a Multi-Product Cost Function," *The Review of Economics and Statistics*, 72(2), 1990, pp. 339-344.

total industry variable cost.[24] The elasticity measures for each railroad, which underlie these industry averages, are presented in the appendix to this chapter.

TABLE 9-3
KEY VARIABLE COST ELASTICITY ESTIMATES
(INDUSTRY AVERAGE*)

[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	1995	2000	2006
Ton-Mile Elasticity	0.719	0.638	0.789	0.798
($\partial \ln C^V / \partial \ln Y$)	[0.48 – 0.96]	[0.39 – 0.88]	[0.52 – 1.05]	[0.52 – 1.07]
Length-of-Haul Elasticity	-0.121	-0.050	0.037	0.088
($\partial \ln C^V / \partial \ln ALOH$)	[-0.30 – 0.06]	[-0.26 – 0.16]	[-0.21 – 0.28]	[-0.19 – 0.36]
Capital-Stock Elasticity	-0.127	-0.126	-0.129	-0.129
($\partial \ln C^V / \partial \ln K$)	[-0.23 – -0.03]	[-0.22 – -0.03]	[-0.24 – -0.03]	[-0.24 – -0.03]
Network-Size Elasticity	0.374	0.460	0.276	0.247
($\partial \ln C^V / \partial \ln N$)	[0.18 – 0.56]	[0.29 – 0.64]	[0.10 – 0.46]	[0.06 – 0.46]
Rate of Cost Change	-0.061	-0.023	-0.050	0.069
($\partial \ln C^V / \partial Time$)	[-0.07 – -0.05]	[-0.03 – -0.01]	[-0.07 – -0.03]	[0.05 – 0.09]

* Firm variable cost shares are used as weights in averaging.

The ton-mile elasticity measures the percentage change in variable cost as a result of a one percent increase in revenue ton-miles, all else constant. The industry average for the ton-mile elasticity in recent years has been stable at about 0.79 percent. However, in earlier years this elasticity was smaller.

The length-of-haul elasticity shows the percentage change in variable cost resulting from increasing the average length of haul by one percent. The length-of-haul elasticity estimates indicate that, early in the sample period, variable cost could be reduced considerably by increasing the average length of haul. However, by about 1995, this source of cost saving appears to have been tapped out. In recent years, the industry length-of-haul elasticity is positive and has been increasing.

The elasticity of variable cost with respect to the way and structures capital is stable and statistically significant across the entire sample period. The capital-stock elasticity is negative, as implied by theory. That is, an increase in capital would lower variable cost.

The network-size elasticity shows the impact on variable cost from increasing the miles of road by one percent. This elasticity measure is positive and statistically significant, as suggested by theory. The industry average

[24] Throughout this chapter, firm variable cost shares are used as weights in averaging. For 1987 through 1995, the industry averages are calculated using data for ATSF, BN, CSX, NS, SP, and UP. For 1996, the industry averages are calculated using data for BNSF, CSX, NS, SP, and UP. For 1997-2006, the industry averages are calculated using data for BNSF, CSX, NS, and UP.

network-size elasticity gradually increases over time until 1995, after which it has been decreasing.

Finally, the derivative of the variable cost function with respect to time provides evidence of strong technological progress in the late 1980s, a resurgence of technological progress in the late 1990s, but a near disappearance of the technological change component of productivity in recent years. This impact is analyzed below in the discussion on technological change.

Economies of Density

Economies of density indicate how variable cost changes as output increases. The capital stock and network size are held constant when measuring economies of density, and thus the measure is essentially a short-run concept. A railroad is said to experience: (a) *economies of density* if an increase in revenue ton-miles results in a less than proportional increase in variable cost, (b) *constant returns to density* if an increase in revenue ton-miles results in an increase in variable cost of equal proportion, or (c) *diseconomies of density* if an increase in revenue ton-miles results in a more than proportional increase in variable cost.

The measure of density economies depends upon whether the increase in revenue ton-miles results primarily from an increase in revenue tons or an increase in the average length of haul of shipments. Thus we report two density measures:[25]

(9.7) $$DENSITY\_1 = 1/\left(\partial \ln C^V / \partial \ln Y\right)$$

(9.8) $$DENSITY\_2 = 1/\left[\left(\partial \ln C^V / \partial \ln Y\right) + \left(\partial \ln C^V / \partial \ln ALOH\right)\right].$$

DENSITY_1 would be the relevant measure if the increase in revenue ton-miles results from an increase in revenue tons, holding the average length of haul constant. In contrast, DENSITY_2 would be relevant if the increase in revenue ton-miles results entirely from an increase in the average length of haul. The true density measure depends on the variability of average length of haul, and lies between DENSITY_1 and DENSITY_2. The density measures given by equations (9.7) and (9.8) indicate economies of density for values greater than 1.0, constant returns to density for a value of 1.0, and diseconomies of density for values less than 1.0.

[25] One can calculate "long-run density" measures by multiplying the short-run measures given by equations (9.7) and (9.8) by $(1 - \partial \ln C^V / \partial \ln K)$. However, in the long-run analysis we believe that scale is the more relevant concept.

The density measure has implications for revenue recovery. A railroad with economies of density cannot fully recover its variable cost by pricing ton-miles at short-run marginal cost, while a railroad experiencing diseconomies of density more than recovers its variable cost by pricing ton-miles at short-run marginal cost. The density measure indicates the average mark-up factor over short-run marginal cost mark-up factor (if any) needed to recover variable cost. Recovery of capital costs and other network and fixed costs may require additional markups. Marginal cost pricing and cost recovery is discussed at greater length in the pricing analysis chapters of this report.

Table 9-4 reports industry averages for the estimated density measures for selected years. Density estimates for each railroad by year are presented in the appendix to this chapter. The density estimates indicate that the Class I railroad industry still experiences economies of density although they have diminished over the years in our sample frame. However, the stronger density economies now appear to result from adding more shipments rather than from increasing the average length of a shipment.

TABLE 9-4
INDUSTRY AVERAGE ECONOMIES OF DENSITY*
(90 PERCENT CONFIDENCE INTERVALS IN BRAKETS)

	1987	1995	2000	2006
DENSITY_1	1.405	1.595	1.275	1.263
(Average length of haul constant)	[1.05 – 2.14]	[1.14 – 2.71]	[0.95 – 1.98]	[0.93 – 1.98]
DENSITY_2	1.823	1.776	1.259	1.160
(Revenue tons constant)	[1.25 – 3.78]	[1.26 – 3.20]	[0.94 – 1.95]	[0.86 – 1.83]

* Firm variable cost shares are used as weights in averaging.

Table 9-5 presents some railroad-specific estimates of density economies. Examination of these estimates shows that the BN-ATSF merger in 1996 and the UP-SP merger in 1997 apparently resulted in the full extraction of economies of density resulting from increasing the average length of haul. BNSF and UP, the two largest railroad systems, currently appear to have mild economies of density from increasing the number of shipments, but virtually no economies of density from increasing the average length of haul. In contrast, CSX and NS still appear to experience greater economies of density from increasing the average length of haul than from increasing the number of shipments, although their density differentials have been shrinking over the twenty-year time frame. In fact, the economies of density from additional shipments appear to be almost exhausted for NS by 2006.

TABLE 9-5
ECONOMICS OF DENSITY
SELECTED YEARS BY RAILROAD
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

Railroads	DENSITY_1 (Average length of haul constant)	DENSITY_2 (Revenue tons constant)
ATSF-BN-BNSF		
ATSF 1987	1.521	1.333
	[1.16 – 2.24]	[0.97 – 2.10]
BN 1987	1.456	1.255
	[1.03 – 2.49]	[0.90 – 2.08]
ATSF 1995	2.202	1.851
	[1.53 – 3.92]	[1.23 – 3.69]
BN 1995	1.586	1.264
	[1.09 – 2.98]	[0.89 – 2.17]
BNSF 1996	1.253	1.012
	[0.91 – 1.99]	[0.75 – 1.56]
BNSF 2006	1.394	1.021
	[0.96 – 2.51]	[0.73 – 1.72]
SP-UP		
SP 1987	1.720	1.507
	[1.28 – 2.67]	[1.07 – 2.51]
UP1987	1.427	1.404
	[1.04 – 2.26]	[1.02 – 2.32]
SP 1996	1.652	1.603
	[1.21 – 2.60]	[1.14 – 2.66]
UP 1996	1.755	1.393
	[1.15 – 3.64]	[0.95 – 2.57]
UP 1997	1.326	1.056
	[0.94 – 2.22]	[0.77 – 1.68]
UP 2006	1.281	0.995
	[0.92 – 2.05]	[0.72 – 1.60]
CSX		
CSX 1987	1.281	2.617
	[0.97 – 1.88]	[1.54 – 7.61]
CSX 1996	1.315	2.172
	[1.02 – 1.86]	[1.48 – 3.99]
CSX 2006	1.210	1.402
	[0.94 – 1.74]	[1.04 – 2.18]
NS		
NS 1987	1.247	2.229
	[0.96 – 1.76]	[1.49 – 4.59]
NS 1996	1.489	2.271
	[1.14 – 2.15]	[1.56 – 4.09]
NS 2006	1.080	1.428
	[0.85 – 1.49]	[1.06 – 2.18]

Economies of Scale

Economies of scale indicate how total cost changes as output increases. The scale measure is a "long-run" concept in that all factors of production (i.e., including capital stock), as well as network size, are allowed to adjust. A railroad is said to experience (a) *economies of scale* if an increase in revenue ton-miles results in a less than proportional increase in total cost, (b) *constant returns to scale* if an increase in revenue ton-miles results in an increase in total cost of equal proportion, or (c) *diseconomies of scale* if an increase in revenue ton-miles results in a more than proportional increase in total cost.

As was the case with the density measures, the measurement of scale economies depends upon whether the increase in revenue ton-miles is achieved from an increase in revenue tons or an increase in the average length of haul of shipments. Thus we also report two scale measures:[26]

$$(9.9)\quad SCALE\_1=\left[1-\left(\partial\ln C^V/\partial\ln K\right)\right]/\left[\left(\partial\ln C^V/\partial\ln Y\right)+\left(\partial\ln C^V/\partial\ln N\right)\right]$$

$$(9.10)\quad SCALE\_2=\left[1-\left(\partial\ln C^V/\partial\ln K\right)\right]/\left[\left(\partial\ln C^V/\partial\ln Y\right)+\left(\partial\ln C^V/\partial\ln ALOH\right)+\left(\partial\ln C^V/\partial\ln N\right)\right].$$

SCALE_1 would be the relevant measure if the increase in revenue ton-miles results from an increase in revenue tons, holding the average length of haul constant. In contrast, SCALE_2 would be relevant if the increase in revenue ton-miles results entirely from an increase in the average length of haul. The true scale measure depends on how average length of haul changes, and lies between SCALE_1 and SCALE_2. The scale measures given by equations (9.9) and (9.10) indicate economies of scale for values greater than 1.0, constant returns to scale for a value of 1.0, and diseconomies of scale for values less than 1.0.

Table 9-6 reports industry averages for the estimated scale measures for selected years. Scale estimates for each railroad by year are presented in the appendix to this chapter. The scale estimates indicate that in recent years the Class I railroad industry has been experiencing approximately constant returns to scale, regardless of which scale measure is used. The similarity of the industry averages for the two scale measures in recent years reflects the exhaustion of scale economies from changing the average length of haul. It is interesting to note that approximately constant returns to scale are implied when the number of shipments is changed while holding the average length of

[26] "Short-run scale" measures can be calculated by replacing the numerators in equations (9.9) and (9.10) with 1. However, we find the restriction of holding capital stock constant while adjusting network size in the short run to be somewhat inconsistent. Thus, we believe the economies of density measure is the more meaningful short-run concept.

haul constant. This result does not vary substantially over the sample time frame.

TABLE 9-6
INDUSTRY AVERAGE ECONOMIES OF SCALE*
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

	1987	1995	2000	2006
SCALE_1	1.033	1.027	1.064	1.086
(Average length of haul constant)	[0.84 – 1.24]	[0.89 – 1.23]	[0.89 – 1.23]	[0.92 – 1.36]
SCALE_2	1.247	1.119	1.098	1.070
(Revenue tons constant)	[1.02 – 1.68]	[0.91 – 1.47]	[0.88 – 1.50]	[0.85 – 1.45]

* Firm variable cost shares are used as weights in averaging.

Table 9-7 presents some railroad-specific estimates of scale. Examination of these estimates shows that the BN-ATSF merger in 1996 and the UP-SP merger in 1997 apparently did not substantially impact either of the scale measures. This is in contrast to the apparent impact of these mergers on the density measures, as discussed above. CSX and NS appear to have approximately constant returns to scale from increasing the number of shipments, but significant economies of scale from increasing the average length of haul.

Technological Change and Productivity Growth

Technological change is a fundamental component of productivity growth. This source of productivity can be viewed from two related perspectives. One view of technological change focuses on output growth. This view observes how the maximum possible output (the production possibilities curve) increases over time, holding the available inputs constant. We refer to this perspective as PGY (for productivity growth in output). Alternatively, the focus of technological change can be on input requirements. This view we refer to as PGX (for productivity growth of inputs). PGX shows how the resource requirements—for a given level of output—decrease over time.

TABLE 9-7
ECONOMIES OF SCALE
SELECTED YEARS BY RAILROAD
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

Railroads	SCALE_1 (Average length of haul constant)	SCALE_2 (Revenue tons constant)
ATSF-BN-BNF		
ATSF 1987	1.060	0.975
	[0.94 – 1.22]	[0.78 – 1.33]
BN 1987	0.975	0.890
	[0.83 – 1.21]	[0.70 – 1.23]
ATSF 1995	1.024	0.949
	[0.92 – 1.17]	[0.76 – 1.25]
BN 1995	0.980	0.860
	[0.83 – 1.21]	[0.67 – 1.18]
BNSF 1996	1.014	0.866
	[0.84 – 1.30]	[0.67 – 1.23]
BNSF 2006	1.014	0.820
	[0.84 – 1.30]	[0.64 – 1.17]
SP-UP		
SP 1987	1.042	0.969
	[0.93 – 1.19]	[0.78 – 1.31]
UP1987	1.008	0.998
	[0.86 – 1.23]	[0.79 – 1.36]
SP 1996	1.038	1.020
	[0.90 – 1.24]	[0.82 – 1.35]
UP 1996	0.968	0.859
	[0.82 – 1.19]	[0.68 – 1.16]
UP 1997	1.004	0.857
	[0.83 – 1.29]	[0.66 – 1.21]
UP 2006	1.044	0.865
	[0.87 – 1.33]	[0.67 – 1.23]
CSX		
CSX 1987	1.039	1.640
	[0.89 – 1.26]	[1.28 – 2.31]
CSX 1996	1.096	1.548
	[0.95 – 1.31]	[1.24 – 2.06]
CSX 2006	1.148	1.297
	[0.99 – 1.39]	[1.04 – 1.72]
NS		
NS 1987	1.085	1.644
	[0.94 – 1.28]	[1.31 – 2.21]
NS 1996	1.082	1.392
	[0.95 – 1.27]	[1.15 – 1.80]
NS 2006	1.210	1.597
	[1.04 – 1.46]	[1.28 – 2.14]

As shown by Caves, Christensen, and Swanson, the PGY and PGX perspectives are linked by the concept of economies of scale, with PGY and PGX being equivalent only in the case of constant returns to scale.[27]

We calculate three technological change-based productivity measures:

$$(9.11)\quad PGY\_1 = -\left(\partial \ln C^V / \partial Time\right) \times SCALE\_1 / \left(1 - \partial \ln C^V / \partial \ln K\right)$$

$$(9.12)\quad PGY\_2 = -\left(\partial \ln C^V / \partial Time\right) \times SCALE\_2 / \left(1 - \partial \ln C^V / \partial \ln K\right)$$

$$(9.13)\quad PGX = -\left(\partial \ln C^V / \partial Time\right) / \left(1 - \partial \ln C^V / \partial \ln K\right).$$

PGY_1 would be the appropriate output-focused productivity measure if output growth results from increasing revenue tons while keeping the average length of haul constant. PGY_2 would be the output-focused measure if output growth results entirely from an increase in the average length of haul. The true value for PGY depends on how average length of haul changes, and lies between PGY_1 and PGY_2.[28]

The industry average productivity measures implied by the variable cost function are presented in Table 9-8. The implied rate of annual productivity gain due to technological progress was in the 5 to 7 percent range in the late 1980s, but down to about 2 percent by the mid-nineties. The switching parameter model indicates that there was a resurgence of productivity in the last half of the 1990s. However, productivity gains seem to have vanished in the first half of the next decade. These findings are consistent with the productivity trends reported in Chapter 8. As was shown in Table 9-6, the scale measures do not change much between 2000 and 2006. Thus the decline in productivity since 2000 is attributable almost entirely to the reversal of the time derivative, $\partial \ln C^V / \partial Time$.[29]

We note the puzzling result of apparently negative technical change. The estimated $\partial C^V / \partial Time$ becomes positive in 2003. The theoretical interpretation of this phenomenon is technical regress rather than technical progress. We believe that interpretation is fairly implausible, but the statistical significance of the effect, along with corroborating evidence from the

[27] D. Caves, L. Christensen, and J. Swanson, "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955-1974," *American Economic Review*, 1981, pp. 994-1002.

[28] We note that SCALE_1 = PGY_1 / PGX and SCALE_2 = PGY_2 / PGX.

[29] Estimating the model without the switching regressions' parameters results in a less dramatic productivity reversal, but the productivity gains still disappear in the same time frame of 2002-2004 and become negative by 2005-2006.

productivity analyses, suggest that something happened around 2003 to cause the variable cost curve to shift up rather dramatically. We speculate about several possible causes for the upward shift in costs starting around 2003. These possible causes include major rail construction projects, extreme weather-related events, and changes in service mix to higher-valued express priority service.

TABLE 9-8
INDUSTRY AVERAGE PRODUCTIVITY GAINS*
(STANDARD ERRORS IN PARENTHESES)

	1987	1995	2000	2006
PGY_1	0.056	0.021	0.047	-0.066
	[0.04 – 0.07]	[0.01 – 0.03]	[0.03 – 0.07]	-0.10 – -0.04]
PGY_2	0.068	0.024	0.049	-0.065
	[0.05 – 0.09]	[0.02 – 0.03]	[0.03 – 0.07]	[-0.10 – -0.04]
PGX	0.054	0.021	0.044	-0.061
	[0.04 – 0.06]	[0.01 – 0.03]	[0.03 – 0.06]	[-0.08 – -0.04]

* Firm variable cost shares are used as weights in averaging.

Several major rail enhancement projects were initiated in the 2003-2007 period. For UP, these projects include: going from double- to triple-tracking between Gibbon Junction and North Platte, NE; going from double- to quadruple-tracking between North Platte and O'Fallons, NE; extending centralized traffic control between Nelson, IL and Missouri Valley, IA; and enhancements along the Sunset Route. During the same period, BNSF began several major enhancements including: improved signaling along the Transcontinental Route between Chicago and Kansas City; double-tracking of Abo Canyon, NM; and construction of a double-tracked bridge over the UP tracks at Grand Island, NE. In addition, improvements were inaugurated for the BNSF-UP shared track to the Powder River Basin and the BNSF-owned, UP-shared track at Cajon Pass, CA. These construction projects could have impacted operations, explaining the observed shift up in cost starting around 2003. To the extent that construction projects help explain the shift up in cost, these enhancements should yield productivity gains once they are completed and fully operational.

We also note that in 2005, heavy rainfall caused numerous cases of track and bridge outages, particularly for UP. To the extent that these weather-related problems contributed to the increased cost, repair and return to normal service should result in a return to normal productivity changes.

Finally, the growth of express priority service (e.g., BNSF's Z-train service) may have also contributed to the shift up in cost. However, it would be inaccurate to consider this effect a decline in productivity. In this case, the traditional productivity measure would be flawed because of its failure to adjust the output measure for changes in quality. To the extent that the shift up in cost is due to higher-valued service, the cost increase may actually reflect a quality-adjusted productivity gain.

Table 9-9 presents some railroad-specific estimates of the productivity measures.

TABLE 9-9
PRODUCTIVITY GAINS
SELECTED YEARS BY RAILROAD
(STANDARD ERRORS IN PARENTHESES)

Railroads	PGY_1	PGY_2*	PGX
ATSF-BN-BNSF			
ATSF 1987	0.053	0.048	0.050
	[0.04 – 0.06]	[0.03 – 0.07]	[0.04 – 0.06]
BN 1987	0.053	0.048	0.054
	[0.04 – 0.07]	[0.03 – 0.07]	[0.04 – 0.07]
ATSF 1995	0.012	0.011	0.012
	[0.00 – 0.02]	[0.00 – 0.02]	[0.00 – 0.02]
BN 1995	0.022	0.019	0.022
	[0.01 – 0.03]	[0.01 – 0.03]	[0.01 – 0.03]
BNSF 1996	0.025	0.021	0.025
	[0.02 – 0.03]	[0.01 – 0.03]	[0.01 – 0.03]
BNSF 2006	-0.062	-0.050	-0.061
	[-0.10 – -0.04]	[-0.08 – -0.03]	[-0.09 – -0.04]
SP-UP			
SP 1987	0.049	0.045	0.047
	[0.04 – 0.06]	[0.03 – 0.06]	[0.04 – 0.06]
UP1987	0.054	0.053	0.053
	[0.04 – 0.07]	[0.04 – 0.08]	[0.04 – 0.06]
SP 1996	0.015	0.015	0.015
	[0.01 – 0.02]	[0.01 – 0.02]	[0.01 – 0.02]
UP 1996	0.014	0.013	0.012
	[0.00 – 0.02]	[0.00 – 0.02]	[0.00 – 0.02]
UP 1997	0.019	0.016	0.019
	[0.01 – 0.03]	[0.01 – 0.02]	[0.01 – 0.03]
UP 2006	-0.064	-0.053	-0.061
	[-0.10 – -0.04]	[-0.09 – -0.03]	[-0.08 – -0.04]
CSX			
CSX 1987	0.059	0.093	0.057
	[0.05 – 0.07]	[0.07 – 0.13]	[0.05 – 0.07]
CSX 1996	0.022	0.032	0.020
	[0.02 – 0.03]	[0.02 – 0.04]	[0.01 – 0.03]
CSX 2006	-0.070	-0.080	-0.061
	[-0.11 – -0.04]	[-0.13 – -0.05]	[-0.08 – -0.04]
NS			
NS 1987	0.061	0.092	0.056
	[0.05 – 0.07]	[0.07 – 0.12]	[0.05 – 0.06]
NS 1996	0.017	0.022	0.021
	[0.01 – 0.02]	[0.01 – 0.03]	[0.01 – 0.02]
NS 2006	-0.073	-0.096	-0.060
	[-0.11 – -0.04]	[-0.15 – -0.06]	[-0.08 – -0.04]

The appendix to this chapter provides productivity estimates for each railroad by year. Examination of these estimates shows that the BN-ATSF merger in 1996 and the UP-SP merger in 1997 did not appear to immediately result in higher productivity gains. There is some evidence of a productivity resurgence in the late 1990s which disappears in the first half of the next decade. However, it is not possible to say whether the mergers contributed to the productivity resurgence or subsequent decline.[30] The apparently negative productivity effects for the last few years of the study time frame are translated into marginal cost increases, as discussed below. In the pricing analysis chapters of this report, we examine the extent to which the apparent productivity decline is reflected in recent pricing behavior.

Input Demand and Substitution Elasticities

The variable cost function also reveals information about the input side of technology. We report below both the own-price elasticities of demand and the Allen-Uzawa partial elasticities of substitution.[31] The partial elasticities of substitution show the degree to which any pair of inputs substitute or complement one another in the production process.

The own-price elasticities of demand for the variable inputs are reported in Table 9-10. As required by theory, all the own-price elasticities are negative. These estimates are stable over time and indicate that the demands for equipment and fuel are relatively more price sensitive than the demands for labor and materials.

TABLE 9-10
INDUSTRY AVERAGE OWN-PRICE ELASTICITIES OF INPUT DEMAND*
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

Inputs	1987	1995	2000	2006
Labor	-0.432	-0.480	-0.493	-0.498
	[-0.51 – -0.34]	[-0.58 – -0.38]	[-0.59 – -0.39]	[-0.60 – -0.39]
Equipment	-0.825	-0.820	-0.815	-0.813
	[-0.88 – -0.77]	[-0.87 – -0.77]	[-0.87 – -0.77]	[-0.86 – -0.77]
Materials	-0.422	-0.412	-0.415	-0.422
	[-0.52 – -0.32]	[-0.51 – -0.31]	[-0.51 – -0.32]	[-0.52 – -0.32]
Fuel	-0.931	-0.900	-0.883	-0.859
	[-0.94 – -0.92]	[-0.91 – -0.89]	[-0.89 – -0.88]	[-0.87 – -0.85]

* Firm variable cost shares are used as weights in averaging.

[30] When the model is estimated with the common time trend structure, the apparent productivity reversal is less dramatic, but approximates negative 1 percent in 2006. Regardless of the time trend specification, the variable cost function estimates clearly indicate some significant productivity decline in the last few years of the study time frame.

[31] R. G. D. Allen, *Mathematical Analysis for Economists*, (London: McMillan), 1938; and H. Uzawa, "Production Functions with Constant Elasticities of Substitution," *Review of Economic Studies*, 29(4) October 1962, pp. 291-99.

The industry average Allen-Uzawa elasticities of substitution are reported in Table 9-11. Elasticity of substitution estimates for each railroad by year are presented in the appendix to this chapter. These estimates indicate strong substitution possibilities between labor and fuel, and between equipment and materials. In recent years, all input pairs appear as substitutes in production. Interestingly, in the earlier years of the sample time period, material and fuels, and to a lesser extent equipment and materials, appear as complements in production.

TABLE 9-11
INDUSTRY AVERAGE ALLEN-UZAWA ELASTICITIES OF SUBSTITUTION*
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

	1987	1995	2000	2006
Labor-Equipment	0.501	0.473	0.482	0.480
	[0.31 – 0.68]	[0.27 – 0.66]	[0.28 – 0.66]	[0.28 – 0.66]
Labor-Materials	0.583	0.545	0.514	0.477
	[0.37 – 0.77]	[0.32 – 0.75]	[0.27 – 0.74]	[0.22 – 0.72]
Labor-Fuel	2.452	2.167	2.047	1.902
	[2.01 – 2.93]	[1.79 – 2.57]	[1.72 – 2.39]	[1.63 – 2.19]
Equipment-Materials	1.695	1.592	1.565	1.588
	[1.44 – 1.98]	[1.38 – 1.82]	[1.36 – 1.79]	[1.37 – 1.83]
Equipment-Fuel	-0.153	0.278	0.419	0.524
	[-0.96 – 0.66]	[-0.20 – 0.78]	[0.02 – 0.83]	[0.19 – 0.86]
Materials-Fuel	-0.533	0.007	0.131	0.236
	[-1.20 – 0.08]	[-0.41 – 0.39]	[-0.23 – 0.48]	[-0.12 – 0.54]

* Firm variable cost shares are used as weights in averaging.

Input Biases in Technical Change

The analysis of bias in technical change can be traced to Hicks in the context of general economic growth, with a focus on the distribution of income between capital and labor.[32] The concept of bias in technical change has been generalized to the case of multiple factors of production, and applied at a microeconomic level to describe how specific production technologies change over time.

As shown by Binswanger, input bias in technical change estimates can be retrieved directly from a dual cost function, and in fact are simply the time derivatives of the input share expressions.[33] That is,

[32] J. Hicks, *The Theory of Wages*, London: Macmillan & Co., Ltd., 1932.

[33] H. P. Binswanger, "The Measurement of Technical Change Biases with Many Factors of Production," *American Economic Review*, 64(6), 1974, pp. 964-976.

(9.14) $\text{Input Bias} = \left(\partial^2 \ln C^V / \partial \ln W_i \partial Time\right) = \partial M_i / \partial Time$.

Technical change is said to be (relatively) input-saving, input-neutral, or input-using as the bias measure is negative, zero or positive, respectively. With our specification of the variable cost function, the measures of input biases are the parameters τ_L, τ_E, τ_M, and τ_F.[34] The estimates of input biases in technical change are reported in Table 9-12. The magnitudes of the bias measures indicate the average annual rates of change in the input cost shares. For example, on average the labor share of variable cost has been decreasing by about 6/10 of a percentage point per year. The estimates indicate technical change in the freight railroad industry since 1987 has been labor-saving, material-neutral, and equipment- and fuel-using.

TABLE 9-12
INPUT BIASES IN TECHNICAL CHANGE
(STANDARD ERRORS IN PARENTHESES)

Labor	-0.006 (0.0007)	Labor-Saving
Equipment	0.003 (0.0004)	Equipment-Using
Materials	0.001 (0.0010)	Materials-Neutral
Fuel	0.002 (0.0004)	Fuel-Using

Capacity and the Employment of Capital

Our estimated variable cost function allows us to investigate the issue of capacity investment by the railroads. Our approach is similar to that of Friedlaender and her co-authors, who used a variable cost function to evaluate trends in excess capacity prior to and after railroad regulatory reform.[35] We start by noting the relationship between total cost (C^T) and variable cost (C^V) when there is one quasi-fixed input. That is,

(9.15) $C^T = C^V + W_K K$

where K is way and structures capital input (the quasi-fixed input) and W_K is the market price of K. When capital is employed at its cost-minimizing level, K*, the following condition holds:

[34] Estimates of τ_L are retrieved via the homogeneity restrictions.

[35] A. Friedlaender, E. Berndt, J. Chiang, M. Showalter, and C. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-regulated Environment," *Journal of Transport Economics and Policy* 27, 1993, pp. 131-152.

$\partial C^T/\partial K = 0 \rightarrow \partial C^V/\partial K = -W_K$, or in logarithmic form, $\partial \ln C^V/\partial \ln K = -W_K K/C^V$. However, way and structures capital may not be optimally employed.

To investigate capital employment, we first imputed the price for way and structures capital. We tried two methods to impute this price. One approach calculates the way and structures capital cost as freight operating revenue minus variable cost. This is the approach used by Friedlaender et al. The alternative method follows Bitzan and Wilson and calculates way and structures capital cost as operating expenses attributed to road.[36] With both methods, dividing the way and structures capital cost by the way and structures capital stock gives the imputed price of capital. [37] We chose to use the latter approach, because the former resulted in several instances where revenue was less than variable cost or very close to variable cost.[38]

After imputing a price for way and structures capital, we compare that price to the marginal impact of capital on variable cost. Specifically,

$$(9.16) \quad -\partial \ln C^V / \partial \ln K >=< W_K K / C^V \leftrightarrow -\partial C^V / \partial K >=< W_K \leftrightarrow K <=> K^*.$$

K < K* indicates underemployment of capital, also called constrained capacity. K > K* indicates overemployment of capital, also called excess capacity. The comparison can be expressed in terms of a "Q Ratio."[39]

$$(9.17) \quad Q\,Ratio = -\left[\partial \ln C^V / \partial \ln K\right] / \left[W_K K / C^V\right]$$

where a Q ratio equal to one implies cost-minimizing employment of capital, while values greater than one imply underemployment of capital and values less than one imply overemployment of capital.

Table 9-13 presents industry average information on way and structures capital employment for selected years. At the industry level, the variable cost function does not provide evidence of constrained capacity. In fact, the

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36 J. Bitzan and W. Wilson, "A Hedonic Cost Function Approach to Estimating Railroad Costs," in Scott Dennis and Wayne K. Talley eds., *Research in Transport Economics: Railroad Economics*, 2007, pp. 119-152.

37 The two capital cost variables are included in Table 9-2 as CAPCOST1 and CAPCOST2.

38 Overall, the two methods gave similar results. However, 15 observations had variable cost exceeding revenue, yielding a negative capital price. There were several other observations with only a small difference between revenue and variable cost, resulting in an unreasonably large magnitude of the Q ratio, which is defined in equation (9.17).

39 This terminology is from A. Friedlaender, E. Berndt, J. Chiang, M. Showalter, and C. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-regulated Environment," *Journal of Transport Economics and Policy* 27, 1993, pp. 131-152.

evidence from the variable cost function is in the other direction, indicating overcapitalization continues to characterize the railroad industry. The variable cost savings from adding a dollar of capital has been increasing over time, most rapidly in recent years, but still remains modest. At the industry level in 2006, an additional dollar of way and structures capital put in place appears to reduce variable cost by about 7 cents. In contrast, the imputed market price of capital has risen much more rapidly such that the 2006 real price of capital is about 16 cents.[40]

TABLE 9-13
INDUSTRY AVERAGE WAY AND STRUCTURES CAPITAL EMPLOYMENT*
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

	1987	1995	2000	2006
Shadow Price of Capital $-(\partial C^V/\partial K)$	0.039 [0.01 – 0.07]	0.044 [0.01 – 0.08]	0.047 [0.01 – 0.09]	0.067 [0.01 – 0.13]
Imputed Price of Capital	0.062	0.098	0.116	0.163
– Capital Stock Elasticity $-(\partial \ln C^V/\partial \ln K)$	0.127 [0.03 – 0.23]	0.126 [0.03 – 0.22]	0.129 [0.03 – 0.24]	0.129 [0.03 – 0.24]
Capital Cost to Variable Cost Ratio $(W_K K/C^V)$	0.207	0.283	0.307	0.302
Q Ratio $-(\partial \ln C^V/\partial \ln K) / (W_K K/C^V.)$	0.630 [0.16 – 1.13]	0.461 [0.13 – 0.81]	0.469 [0.10 – 0.87]	0.410 [0.08 – 0.76]

* Firm variable cost shares are used as weights in averaging.

Table 9-14 presents the way and structures capital employment information for selected railroads for selected years. The appendix to this chapter presents way and structures capital employment estimates for all railroads and all years. In 2006, CSX and NS appear to have lower shadow prices and imputed prices of capital than do the BNSF and UP systems, but the Q Ratios for all four systems have similar magnitudes and indicate excess capacity overall.

[40] All monetary figures are in real dollars with 2000 being the base year.

TABLE 9-14
WAY AND STRUCTURES CAPITAL EMPLOYMENT
SELECTED YEARS BY RAILROAD
(90 PERCENT CONFIDENCE INTERVALS IN BRACKETS)

Railroads	Shadow P_K	Imputed P_K	Q Ratio
ATSF-BN-BNSF			
ATSF 1987	0.039	0.065	0.603
	[0.01 – 0.07]		[0.18 – 1.04]
BN 1987	0.033	0.057	0.588
	[0.01 – 0.06]		[0.12 – 1.09]
ATSF 1995	0.030	0.127	0.238
	[0.01 – 0.06]		[0.07 – 0.41]
BN 1995	0.042	0.077	0.547
	[0.01 – 0.08]		[0.14 -0.97]
BNSF 1996	0.039	0.117	0.348
	[0.01 – 0.07]		[0.06 – 0.66]
BNSF 2006	0.081	0.191	0.425
	[0.01 – 0.15]		[0.09-0.79]
SP-UP			
SP 1987	0.041	0.071	0.572
	[0.01 – 0.07]		[0.18-0.99]
UP1987	0.043	0.066	0.655
	[0.01 – 0.08]		[0.16-1.18]
SP 1996	0.069	0.131	0.526
	[0.02 – 0.12]		[0.17 – 0.90]
UP 1996	0.041	0.109	0.379
	[0.01 – 0.08]		[0.07 – 0.71]
UP 1997	0.051	0.145	0.353
	[0.01 -0.10]		[0.06 – 0.67]
UP 2006	0.078	0.191	0.409
	[0.01 – 0.15]		[0.07 – 0.77]
CSX			
CSX 1987	0.038	0.056	0.678
	[0.01 – 0.07]		[0.12 – 1.27]
CSX 1996	0.046	0.093	0.490
	[0.01 – 0.08]		[0.12 – 0.87]
CSX 2006	0.051	0.131	0.392
	[0.01 – 0.09]		[0.08 – 0.72]
NS			
NS 1987	0.039	0.062	0.631
	[0.01 – 0.07]		[0.16 – 1.13]
NS 1996	0.049	0.125	0.387
	[0.02 – 0.08]		[0.12 – 0.67]
NS 2006	0.042	0.103	0.406
	[0.01 – 0.08]		[0.09 – 0.74]

Marginal Cost Analysis

From the variable cost function, we are able to retrieve and analyze estimates of the short-run marginal cost of transporting rail freight.[41] Marginal cost is a key variable in analyzing several aspects of the performance of an industry. First, in competitive industries the marginal cost curve constitutes the price-taking firm's supply curve. In imperfectly competitive situations, the firm compares marginal cost to marginal revenue in making output decisions. Second, marginal cost provides the basis for assessing the exercise of market power. The deviation between the price a firm charges and the marginal cost it faces reflects the extent of market power. And third, marginal cost is central to social welfare analysis. The competitive result equating price and marginal cost implies an efficient allocation of resources, in that the marginal social benefit of production just equals the marginal social opportunity cost. In comparison to a competitive market, a situation where price exceeds marginal cost results in some economic value being taken from consumers, with some of that value being transferred to producers while other value is simply lost. The divergence between price and marginal cost is an important determinant of the magnitude of lost value. Thus, understanding marginal cost is fundamental to analyses of pricing, market power, and public policy.

We can manipulate the estimated variable cost function to obtain marginal cost estimates. That is,

(9.18) $MC = (\partial \ln C^V / \partial \ln Y) \times (C^V / Y)$.

Figure 9-1 presents the industry average estimates for the marginal cost of a revenue ton-mile over the period 1987 to 2006.[42] This figure shows that, in constant dollars, the marginal cost of a ton-mile steadily decreased from 2.4 cents in 1987 to 1.4 cents in 1994. Between 1994 and 2004, marginal cost appears fairly stable at around 1.4 cents, except for spiking to 1.6 cents in 1999. Marginal cost jumped to 1.6 cents in 2005, and further jumped to 1.75 cents in 2006. Interestingly, the pattern of marginal cost changes shown in Figure 9-1 very closely mirrors the pattern of industry-wide railroad rate changes presented in Figure 8-1.[43]

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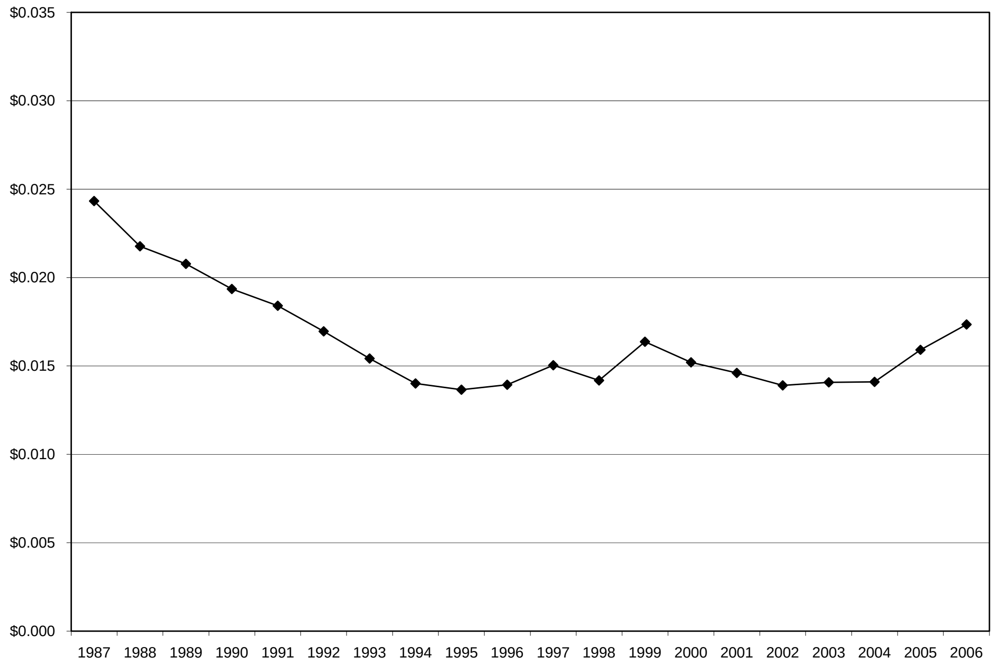
[41] Our use of the term marginal cost refers to short-run marginal cost. The measure of short-run marginal cost is the change in variable cost as ton-miles increase, holding average length of haul constant.

[42] Railroad-specific estimates of marginal costs are presented in the appendix to this chapter.

[43] The values in Figure 9-1 are in constant dollars, while the indexes presented in Figure 8-1 are based on nominal values. Nevertheless, the patterns should remain similar if both figures were based on constant-dollar values.

FIGURE 9-1
INDUSTRY AVERAGE MARGINAL COST OF A REVENUE TON-MILE*
1987-2006
(YEAR 2000 DOLLARS)



*Firm variable cost shares are used as weights in averaging.

Figures 9-2 to 9-5 display the marginal cost of a revenue ton-mile for the period 1987-2006 for BNSF, UP, CSX, and NS. Marginal cost estimates by railroad and by year are presented in the appendix to this chapter. ATSF and BN, BNSF's predecessor firms, show declining marginal cost (and rapidly declining marginal cost in the case of ATSF) up to the time of their merger in 1995. BNSF's marginal cost initially increases after the merger, and then shows modest decline through 2004. In 2005 and 2006, BNSF's marginal cost increases. UP's marginal cost follows a somewhat similar pattern. Both UP and SP have rapidly declining marginal cost up until their merger in 1996, UP's marginal cost increases after the merger and then shows modest decreases until about 2002. From 2003 to 2006, UP's marginal cost increases substantially. Likewise, CSX and NS have marginal cost patterns very similar to each other, even sharing a spike in 1999, most likely related to the operational difficulties experienced when Conrail assets were absorbed into the CSX and NS systems.[44] Both of these railroads have seen substantial increases in marginal cost starting about 2005.

[44] In 1997, CSX and NS proposed an agreement to jointly acquire Conrail and to split the assets. The STB approved the agreement in August 1998, with CSX getting 42 percent of Conrail's assets and NS getting 58 percent. Operations under CSX and NS began in June 1999.

FIGURE 9-2
BNSF MARGINAL COST OF A REVENUE TON-MILE
1987-2006
(YEAR 2000 DOLLARS)

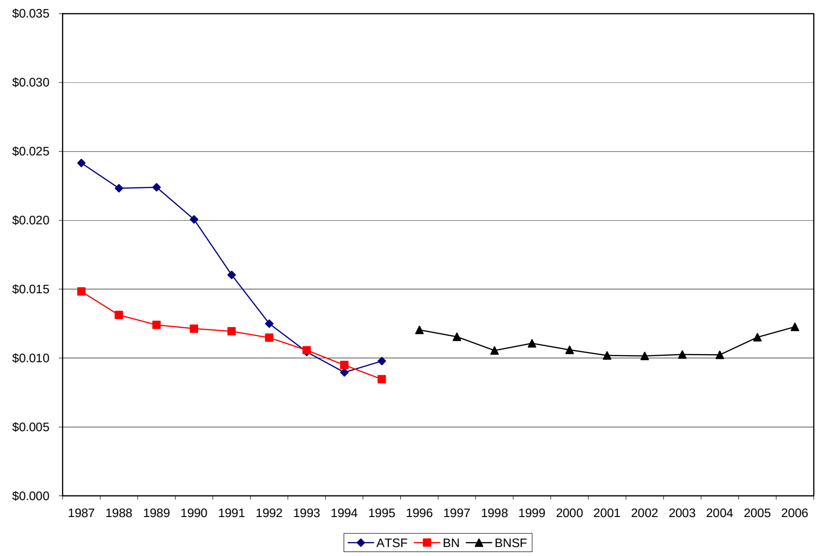


FIGURE 9-3
UNION PACIFIC MARGINAL COST OF A REVENUE TON-MILE
1987-2006
(YEAR 2000 DOLLARS)

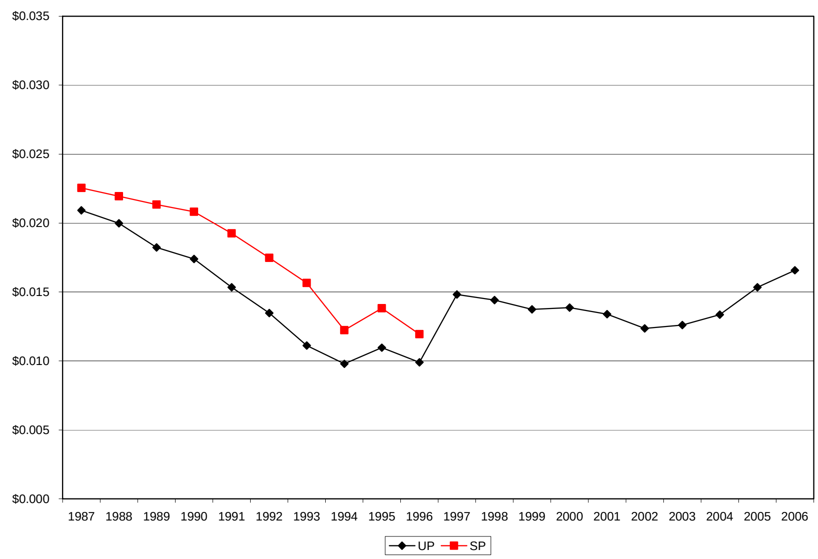


FIGURE 9-4
CSX MARGINAL COST OF A REVENUE TON-MILE
1987-2006
(YEAR 2000 DOLLARS)

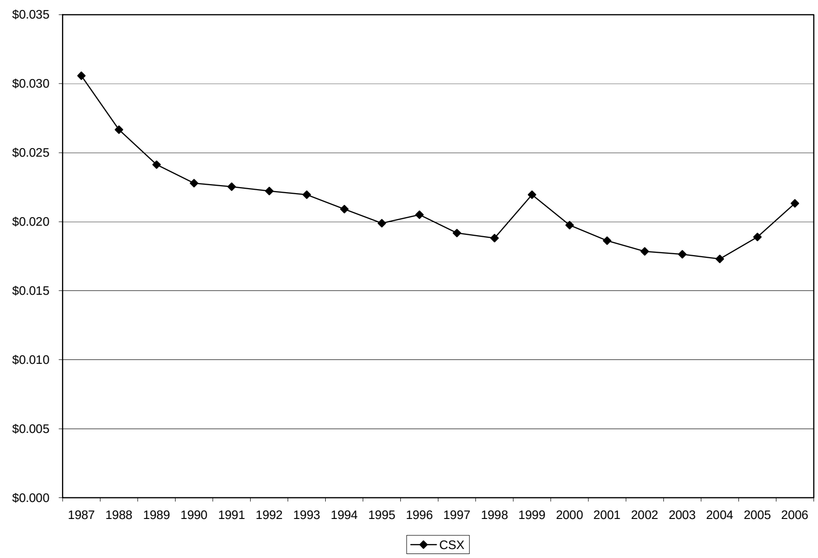
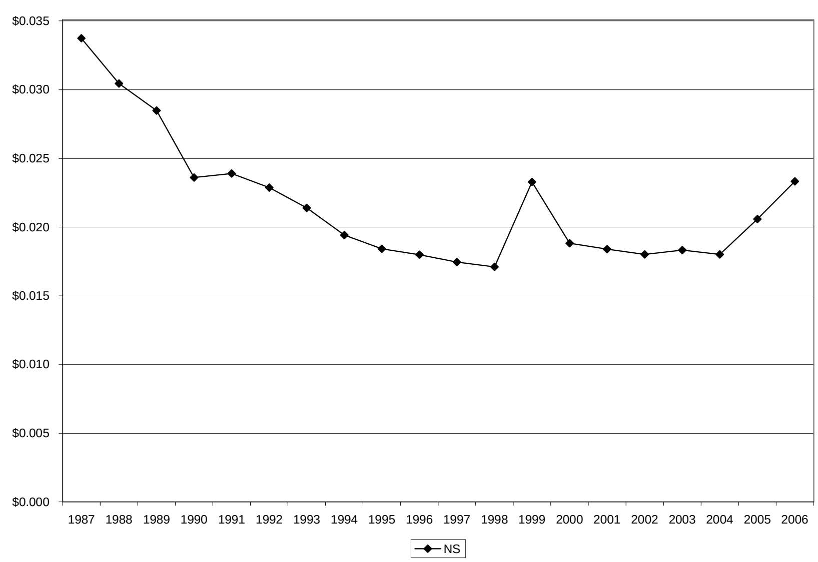


FIGURE 9-5
NORFOLK SOUTHERN MARGINAL COST OF A REVENUE TON-MILE
1987-2006
(YEAR 2000 DOLLARS)



These figures reinforce what already has been revealed in the cost analysis. Namely, the western railroads (BNSF and UP) have similar cost structures to each other, the eastern railroads (CSX and NS) have similar cost structures to each other, but the cost structures differ somewhat between the western and eastern railroads.

The similarity of cost structures can have implications for the competitive behavior of the railroad industry. BNSF and UP are about equal-sized railroads and dominate the industry in the western U.S. Likewise, CSX and NS are about the same size and dominate the eastern corridor freight traffic. In fact, many of the shippers we interviewed suggested that the U.S. railroad industry functions like two duopolies. Theories of oligopoly suggest that parallel behavior (whether coordinated or not) is more likely in situations where the industry has only a few firms, each offering a fairly standard product and facing a similar cost structure. Our cost analysis indicates that BNSF and UP face similar cost structures, and the same is true for CSX and NS. In particular, the similarities in marginal cost, because of its fundamental relationship to price, suggest conditions favorable for parallelism.[45]

We summarize the percentage changes in marginal cost over different time periods in Table 9-15. Between 1987 and 2006, marginal cost decreased on average by 1.5 percent per year. The most rapid decline occurred between 1987 and 1994, when marginal cost decreased at an average annual rate of 6 percent. Between 1994 and 2004, marginal cost was essentially constant. Since 2004, marginal cost has been increasing at an average annual rate of over 11 percent.

TABLE 9-15
CHANGES IN INDUSTRY AVERAGE MARGINAL COST OF A REVENUE TON-MILE OVER DIFFERENT TIME PERIODS

Time Period	Cumulative Change	Average Annual Change
1987-1994	-42.2%	-6.0%
1994-2004	0.6%	0.1%
2004-2006	22.9%	11.5%
1987-2006	-28.6%	-1.5%

We can further examine marginal cost changes over time by breaking down the changes into causal components. We do this by stating a first-order approximation to the percentage change in marginal cost. That is,

$$\text{(9.19)} \quad \textit{Percent Change in Marginal Cost} \approx \sum_i \left[\partial \ln MC_t / \partial \ln X_{i,t}\right] \times \left[\ln X_{i,t} - \ln X_{i,t-1}\right]$$

[45] We are deliberate in the choice of the term "parallel behavior." It should not be interpreted as "collusion." In fact, theory suggests that with very few firms facing very similar conditions, "conscious parallelism" makes collusion unnecessary.

where the X_i variables are the exogenous arguments of the variable cost function, and t and t-1 indicate current year and one-year lagged values, respectively. From this expression, we can isolate the impact of each exogenous variable as

$$(9.20) \quad X_{i,t,}Impact = \left[\partial \ln MC_t / \partial \ln X_{i,t}\right] \times \left[\ln X_{i,t} - \ln X_{i,t-1}\right].$$

Table 9-16 shows the industry-wide year-to-year changes in the exogenous variables and their estimated impacts on marginal cost for the years 2000-2006. Difference and impact estimates by railroad and by year are presented in the appendix to this chapter. The last row of this table shows the sum of the variable impacts and the estimated year-to-year percentage change in marginal cost. Overall, the first-order approximation does a fairly good job of accounting for year-to-year marginal cost changes, especially in years when marginal cost changes are relatively large. This comparison for all railroads and all years appears in the appendix to this chapter.

The data in Table 9-16 provide an explanation for marginal cost changes in the railroad industry. Year 2000 saw a big jump in the fuel price paid by railroads, putting substantial upward pressure on marginal cost. However, overall marginal cost in 2000 declined by about seven percent, due mainly to revenue ton-mile growth, capital increase, labor price decline, and technical change. Technical change and output growth in 2001 decreased marginal cost by more than three percent. The decline in marginal cost continued at about the same pace in 2002, driven by decreases in fuel prices and road abandonment. It is noteworthy that at about this time the marginal cost savings from technical change vanish. Year 2003 marks the beginning of the current upturn in marginal cost (consistent with upturn in RCAF-A noted in Chapter 8). Increasing fuel prices and apparently negative technical change were the primary factors pushing up marginal cost, but this upward pressure was mitigated in part by renewed revenue ton-mile growth. In 2004, revenue ton-mile growth and road abandonment continued to put downward pressure on marginal cost, but this was offset by the fuel price increase and the negative technical change impact. These are the same factors that explain the marginal cost change in 2005 and 2006. Year 2006 also saw a substantial decrease in the price of equipment.

We make three observations about how the marginal cost of freight rail has been changing in recent years. First, since 2003 steadily increasing fuel prices have been driving up marginal cost. Between 2002 and 2006, fuel prices increased on average by about 20 percent per year, resulting in a three percent average increase in marginal cost per year. This effect alone would cause rail rates to increase by three percent per year in a competitive scenario.

TABLE 9-16
SOURCES OF INDUSTRY MARGINAL COST CHANGES*
2000-2006
(STANDARD ERRORS IN PARENTHESES)

Variable		2000	2001	2002	2003	2004	2005	2006
Revenue Ton-Mile	Impact	-4.88%	-1.53%	-0.05%	-2.08%	-5.27%	-1.39%	-3.00%
	Difference	7.25%	1.69%	-0.08%	2.78%	6.81%	1.75%	3.67%
Road	Impact	-0.31%	0.15%	-1.21%	-0.93%	-1.15%	-1.02%	-0.63%
	Difference	-0.26%	0.05%	-1.00%	-0.84%	-1.10%	-1.02%	-0.56%
Time	Impact	-3.10%	-1.21%	0.64%	2.63%	4.75%	6.79%	8.76%
	Difference	1	1	1	1	1	1	1
Capital	Impact	-2.44%	0.41%	0.34%	0.32%	-1.12%	0.26%	0.09%
	Difference	19.10%	-3.21%	-2.69%	-2.48%	8.67%	-1.99%	-0.70%
Labor Price	Impact	-1.76%	0.05%	1.52%	0.35%	0.76%	0.11%	0.04%
	Difference	-4.88%	0.08%	4.43%	1.03%	2.17%	0.30%	0.11%
Equipment Price	Impact	0.22%	-0.26%	-0.50%	-0.37%	0.17%	0.74%	-1.80%
	Difference	2.33%	-2.79%	-5.47%	-4.19%	0.60%	7.31%	-19.46%
Materials Price	Impact	-0.95%	0.18%	-0.94%	-0.79%	1.43%	1.95%	2.55%
	Difference	-2.43%	0.47%	-2.38%	-2.04%	3.72%	5.14%	6.85%
Fuel Price	Impact	6.92%	-0.72%	-2.93%	2.97%	2.54%	5.61%	3.91%
	Difference	44.65%	-4.78%	-17.67%	16.91%	14.01%	31.78%	21.85%
Average Haul Length	Impact	-0.35%	0.01%	-0.05%	-0.02%	-0.08%	0.11%	0.06%
	Difference	1.48%	1.85%	-0.45%	1.12%	1.21%	-0.46%	0.28%
	Total Impact	-6.64%	-2.91%	-3.17%	2.08%	2.03%	13.15%	9.97%
	Marginal Cost Change	-7.06%	-3.79%	-3.89%	1.02%	1.22%	12.90%	9.43%

* Firm variable cost shares are used as weights in averaging.

Second, there is a puzzling "negative technical change" impact that has also put substantial pressure on marginal cost since 2003. This effect alone would account for railroad rates increasing by five percent per year. Further investigation into what is truly behind this effect is warranted. However, for our immediate objective of distinguishing competitive response from the exercise of market power, merely knowing the magnitude of this unexplained effect is sufficient.

Third, over the period 2000 to 2006, revenue ton-miles grew by more than three percent per year on average. This strong output growth actually put downward pressure on marginal cost. This impact provides evidence against the hypothesis that the freight railroad industry overall is experiencing significant congestion on a system-wide basis. The strong growth in revenue ton-miles has opposing implications for rail rates. The competitive effect from this output growth would be downward pressure on rates as marginal cost decreases. However, the increasing demand that is reflected in ton-mile growth strengthens the railroads' ability to price above marginal cost and possibly select more high-margin traffic.

Similar decomposition of the marginal cost changes for BNSF, UP, CSX, and NS are presented in the appendix to this chapter.

CONCLUSIONS

In this chapter we have presented estimates of a variable cost function for U.S. freight railroads. From this variable cost function we have been able to infer important characteristics about freight railroad technology and the corresponding implications about industry structure, and how that structure has changed over time. We have also used the variable cost function to obtain marginal cost estimates. Our analysis of those estimates provides some understanding of the causes of changes in marginal cost over time for the freight railroad industry.

The cost analysis undertaken in this chapter provides a foundation for some of the analyses of pricing, reported in the subsequent chapters of this volume, and the evaluation of likely impacts from the policy alternatives discussed in Volume 3 of this report.

CHAPTER 9 Appendix

Exhibit 1: Variable Cost Function Definitions and Sources

	Definition/Source
Variable Cost	
Real Variable Cost	VARIABLE COST ⁄ GDPPI
VARIABLE COST	OPERCOST – CAPEXP + ROIROAD + ROILOCO + ROICARS – ROADCOST
GDPPI	Price Index for the Gross Domestic Product (Year 2000 = 1.0): Bureau of Economic Analysis
OPERCOST	Operating cost: R-1, Sched. 410, Line 620, Col. F
CAPEXP	Capital expenditures classified as operating expense: R-1, Sched. 410, Lines 12-30, 101-109, Col. F
ROIROAD	Return on investment in road: (ROADINV – ACCDEPR) × COSTKAP
ROADINV	Road investment: R-1, Sched. 352B, Line 31 + CAPEXP from all previous years
ACCDEPR	Accumulated depreciation on road: R-1, Sched. 335, Line 30, Col. G
COSTKAP	Cost of capital: Association of American Railroads, *Railroad Facts*
ROILOCO	Return on investment in locomotives: [(IBOLOCO + LOCOINVL) – (ACDOLOCO + ACDLLOCO)] × COSTKAP
IBOLOCO	Investment base in owned locomotives: R-1, Sched. 415, Line 5, Col. G
LOCOINVL	Investment base in leased locomotives: R-1, Sched. 415, Line 5, Col. H
ACDOLOCO	Accumulated depreciation on owned locomotives: R-1, Sched. 415, Line 5, Col. I
ACDLLOCO	Accumulated depreciation on leased locomotives: R-1, Sched. 415, Line 5, Col. J
ROICARS	Return on investment in cars: [(IBOCARS + CARSINVL) – (ACDOCARS + ACDLCARS)] × COSTKAP
IBOCARS	Investment base in owned cars: R-1, Sched. 415, Line 24, Col. G
CARSINVL	Investment base in leased cars: R-1, Sched. 415, Line 24, Col. H
ACDOCARS	Accumulated depreciation on owned cars: R-1, Sched. 415, Line 24, Col. I
ACDLCARS	Accumulated depreciation on leased cars: R-1, Sched. 415, Line 24, Col. J
ROADCOST	(ROADINV – ACCDEPR) × COSTKAP + ANNDEPRD
ANNDEPRD	Annual depreciation in road: R-1, Sched. 335, Line 30, Col. C
Input Shares of Variable Cost	
Labor Share of Variable Cost	LABORCOST ⁄ VARIABLE COST
LABORCOST	SWGE + FRINGE – CAPLAB
SWGE	Total salary and wages: R-1, Sched. 410, Line 620, Col. B

FRINGE	Fringe benefits: R-1, Sched. 410, Lines 112-114, 205, 224, 309, 414, 430, 505, 512, 522, 611, Col. E
CAPLAB	Labor portion of capital expenditures classified as operating expense: R-1, Sched. 410, Lines 12-30, 101-109, Col. B
Equipment Share of Variable Cost	(LOCOCOST + CARSCOST) / VARIABLE COST
LOCOCOST	ROILOCO + ANNDEPLOC + RENTLOCO
ANNDEPLOC	Annual depreciation on locomotives: R-1, Sched. 410, Line 213, Col. F
RENTLOCO	Net leases and rentals, locomotives: R-1, Sched. 415, Line 5, Col. F
CARSCOST	ROICARS + ANNDEPRCAR + RENTCARS
ANNDEPCAR	Annual depreciation on cars: R-1, Sched. 410, Line 232, Col. F
RENTCARS	Net leases and rentals, cars: R-1, Sched. 415, Line 24, Col. F
Fuel Share of Variable Cost	FUELCOST / VARIABLE COST
FUELCOST	Cost of diesel fuel: R-1, Sched. 755, Line 105, Col. B
Materials Share of Variable Cost	MATCOST / VARIABLE COST
MATCOST	Materials Cost: VARIABLE COST – LABORCOST – LOCOCOST – CARSCOST – FUELCOST
Output and Network	
Revenue Ton-Miles	R-1, Sched. 755, Line 110, Col. B
Miles of Road	R-1, Sched. 700, Line 57, Col. C
Capital Stock	
MOT	Miles of track: R-1, Sched. 720, Line 6, Col. B
Way and Structures Capital per Mile of Track	[(ROADINV – ACCDEPR) / MOT] / GDPPI
Input Prices	
Real Price of Labor	(LABORCOST / LABHOURS) / GDPPI
LABHOURS	Labor hours: Wage Form A, Line 700, Col. 4 and Col. 6
Real Price of Equipment	[(LOCOCOST + CARSCOST) / EQQUANT] / GDPPI
EQQUANT	Weighted average equipment price: Return on investment plus annual depreciation per car and locomotive weighted by that type of equipment's share in total equipment cost, all divided by GDPPI.
Real Price of Materials	
Real Price of Fuel	(FUELCOST / FUELGAL) / GDPPI
FUELGAL	Gallons of diesel fuel: R-1, Sched. 750, Line 4, Col. B
Other Variables	
Average Length of Haul	RTM / REVTONS
RTM	Revenue ton-miles: R-1, Sched. 755, Line 110, Col. B

REVTONS	Revenue tons of freight: R-1, Sched. 755, Line 105, Col. B
Time Trend	Year minus 2000
CAPCOST1	REVENUE-VARCOST
REVENUE	Freight-related revenue: R-1, Sched. 210, Line 13, Col. D
Capital Employment Variables	
CAPCOST2	ROADCOST
CAPCOST_RATIO1	CAPCOST1 / VARCOST
CAPCOST_RATIO2	CAPCOST2 / VARCOST
IMPUTED_PK1	CAPCOST1 / (Way and Structures Capital per Mile of Track)
IMPUTED_PK2	CAPCOST2 / (Way and Structures Capital per Mile of Track)

Exhibit 2: Iterated Seemingly Unrelated Estimation of Variable Cost Function*

Equation	R-Square	R-Square
ln Variable Cost	0.9858	0.9819
Labor Share	0.3906	0.3735
Equipment Share	0.2211	0.2162
Fuel Share	0.4049	0.4021

Parameter (Variable)	Estimate	Std. Error	t Value	Pr > |t|
α_0 (Intercept)	-0.05623	0.1548	-0.36	0.7169
α_Y (Ton-Miles)	0.653867	0.1131	5.78	<.0001
α_N (Miles of Road)	0.36294	0.0860	4.22	<.0001
η_K (Capital Stock)	-0.12375	0.0524	-2.36	0.0194
η_H (Avg. Length of Haul)	-0.16623	0.1039	-1.60	0.1116
β_L (Equipment)	0.132442	0.00253	52.30	<.0001
β_M (Materials)	0.368223	0.00622	59.18	<.0001
β_F (Fuel)	0.112773	0.00281	40.10	<.0001
α_{YY} (Tons-Mile Squared)	-0.42654	0.1779	-2.40	0.0177
α_{YN} (T-M x Road)	0.66594	0.1767	3.77	0.0002
α_{NN} (Road Squared)	-0.88687	0.1742	-5.09	<.0001
η_{KK} (Capital Squared)	-0.00694	0.0372	-0.19	0.8524
η_{HH} (ALOH Squared)	0.627543	0.2095	3.00	0.0032
β_{EE} (Equip. Squared)	0.007064	0.00348	2.03	0.0438
β_{EM} (Equip. x Materials)	0.027233	0.00637	4.28	<.0001
β_{EF} (Equip. x Fuel)	-0.00877	0.00349	-2.51	0.0128
β_{MM}(Materials Squared)	0.079063	0.0215	3.68	0.0003
β_{MF} (Materials x Fuel)	-0.03746	0.00938	-3.99	<.0001
α_{YE} (Ton-Miles x Equip.)	-0.02926	0.00749	-3.91	0.0001
α_{YM} (Ton-Miles x Mat.)	0.014858	0.0185	0.80	0.4229
α_{YF} (Ton-Miles x Fuel)	0.031757	0.00836	3.80	0.0002
α_{NE} (Road x Equip)	0.029795	0.00892	3.34	0.0010
α_{NM} (Road x Mat.)	-0.0165	0.0219	-0.75	0.4522
α_{NF} (Road x Fuel)	-0.02818	0.00997	-2.83	0.0052
$\tau_{T1} = \tau_{T2}$ (Time)	0.042347	0.0114	3.72	0.0003
τ_{T3} (Time)	-0.0425	0.00957	-4.44	<.0001
$\tau_{TT1} = \tau_{TT2}$ (Time Squared)	-0.01526	0.00337	-4.53	<.0001
τ_{TT3} (Time Squared)	0.019095	0.00332	5.75	<.0001
τ_Y (Ton-Miles x Time)	0.014931	0.00891	1.68	0.0959
τ_N (Road x Time)	-0.02805	0.0101	-2.78	0.0061
τ_E (Equip x Time)	0.002722	0.000403	6.75	<.0001
τ_M(Material x Time)	0.000831	0.000992	0.84	0.4037
τ_F (Fuel x Time)	0.002369	0.000440	5.38	<.0001
d_1 (ATSF)	0.074802	0.1524	0.49	0.6243
d_2 (BN)	-0.29292	0.0615	-4.76	<.0001

d_3 (BNSF)	-0.25306	0.0296	-8.56	<.0001
d_4 (CNGT)	-0.41734	0.2119	-1.97	0.0507
d_5 (CNW)	-0.04733	0.2148	-0.22	0.8259
d_6 (CR)	0.270526	0.1729	1.56	0.1196
d_7 (CSX)	0.100702	0.1226	0.82	0.4129
d_8 (DRGW)	-0.31982	0.2332	-1.37	0.1721
d_9 (GTW)	0.197026	0.2453	0.80	0.4230
d_{10} (IC)	-0.26344	0.2250	-1.17	0.2434
d_{11} (KCS)	-0.50773	0.2346	-2.16	0.0320
d_{12} (MKT)	-0.69712	0.2741	-2.54	0.0119
d_{13} (NS)	0.121931	0.1402	0.87	0.3859
d_{14} (SOO)	-0.47099	0.2427	-1.94	0.0541
d_{15} (SSW)	-0.42821	0.2350	-1.82	0.0703
d_{16} (SP 1987-89)	0.201137	0.1657	1.21	0.2265
d_{17} (SP 1990-93)	0.028367	0.1453	0.20	0.8454
d_{18} (SP 1994-96)	-0.14406	0.1200	-1.20	0.2316
d_{19} (UP 1987-89)	-0.123	0.0858	-1.43	0.1539
d_{20} (UP 1990-94)	-0.06135	0.0801	-0.77	0.4449
d_{21} (UP 1995-96)	-0.01732	0.0680	-0.25	0.7992

* UP 1997-2006 is the omitted binary variable. Labor price parameters are retrieved via homogeneity restrictions.

Exhibit 3: Iterated Three-Stage Leaast Squares Estimation of Variable Cost Function*

Equation	R-Square	R-Square
ln Variable Cost		
Labor Share		
Equipment Share		
Fuel Share		

Parameter (Variable)	Estimate	Std. Error	t Value	Pr > |t|

Exhibit 4: Railroad-Specific Elasticity Estimates

ATSF, BN, BNSF

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	ATSF	0.65732	0.09263	-0.12373	0.40271	-0.055815
1988	ATSF	0.63241	0.06813	-0.12340	0.43183	-0.051467
1989	ATSF	0.59267	0.13648	-0.12305	0.48205	-0.046695
1990	ATSF	0.60644	0.09991	-0.12266	0.45439	-0.040597
1991	ATSF	0.53821	0.11325	-0.12223	0.53996	-0.033327
1992	ATSF	0.46363	0.11698	-0.12186	0.63616	-0.026350
1993	ATSF	0.42971	0.12884	-0.12162	0.68272	-0.020185
1994	ATSF	0.39457	0.14255	-0.12160	0.72642	-0.014650
1995	ATSF	0.45419	0.08620	-0.12452	0.64435	-0.013369
1987	BN	0.68661	0.11018	-0.12871	0.47132	-0.061384
1988	BN	0.66023	0.10232	-0.12832	0.50408	-0.056620
1989	BN	0.66568	0.12076	-0.12799	0.49547	-0.052408
1990	BN	0.68220	0.10695	-0.12763	0.46968	-0.048001
1991	BN	0.70020	0.11025	-0.12722	0.43726	-0.044942
1992	BN	0.70496	0.10577	-0.12692	0.42234	-0.040763
1993	BN	0.70272	0.11651	-0.12664	0.42050	-0.036523
1994	BN	0.67048	0.12865	-0.12639	0.46302	-0.031101
1995	BN	0.63054	0.16067	-0.12616	0.51814	-0.025235
1996	BNSF	0.79791	0.19023	-0.13009	0.31712	-0.027852
1997	BNSF	0.76954	0.23204	-0.13000	0.34923	-0.022732
1998	BNSF	0.72724	0.25505	-0.12995	0.40458	-0.017076
1999	BNSF	0.71832	0.26346	-0.12967	0.40993	-0.070760
2000	BNSF	0.74140	0.25888	-0.12950	0.37627	-0.050259
2001	BNSF	0.74278	0.26893	-0.12930	0.36868	-0.030704
2002	BNSF	0.75383	0.26274	-0.12912	0.34088	-0.012802
2003	BNSF	0.75489	0.26274	-0.12902	0.33762	0.007109
2004	BNSF	0.71923	0.26257	-0.12880	0.38891	0.027875
2005	BNSF	0.72251	0.26257	-0.12876	0.38413	0.048610
2006	BNSF	0.71731	0.26257	-0.12882	0.39616	0.068912

CNGT, GTW, IC

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
2002	CNGT	0.65192	-0.47015	-0.11526	0.25747	-0.000537
2003	CNGT	0.66758	-0.45266	-0.11521	0.23248	0.018059
2004	CNGT	0.69058	-0.55837	-0.11613	0.20007	0.036609
2005	CNGT	0.70856	-0.57028	-0.11614	0.16939	0.056959
2006	CNGT	0.72556	-0.53422	-0.11610	0.14554	0.077431
1987	GTW	0.14218	-0.81943	-0.10719	0.82971	-0.027384
1988	GTW	0.12748	-0.79612	-0.10681	0.84460	-0.023179
1989	GTW	0.15663	-0.76267	-0.10648	0.80149	-0.019695
1990	GTW	0.17562	-0.77073	-0.10618	0.76751	-0.015556
1991	GTW	0.20656	-0.71657	-0.10586	0.71821	-0.012725
1992	GTW	0.19008	-0.65894	-0.10557	0.73695	-0.010045
1993	GTW	0.14973	-0.62178	-0.10524	0.80309	-0.002273
1994	GTW	0.15054	-0.67848	-0.10498	0.80029	0.002545
1995	GTW	0.15279	-0.62994	-0.10465	0.78690	0.005734
1996	GTW	0.02169	-0.52318	-0.10440	0.99599	0.014242
1997	GTW	-0.20924	-0.56157	-0.10389	1.29351	0.027789
1998	GTW	-0.21435	-0.57014	-0.10382	1.28229	0.032205
1987	IC	0.43198	-0.56846	-0.11922	0.56801	-0.043070
1988	IC	0.37984	-0.60140	-0.11879	0.62870	-0.037834
1989	IC	0.40955	-0.60650	-0.11725	0.59057	-0.036300
1990	IC	0.40896	-0.56105	-0.11692	0.59015	-0.031416
1991	IC	0.38337	-0.52570	-0.11653	0.62695	-0.025964
1992	IC	0.39826	-0.53962	-0.11621	0.59346	-0.022425
1993	IC	0.37237	-0.47541	-0.11587	0.62708	-0.016808
1994	IC	0.34265	-0.48734	-0.11555	0.65764	-0.010661
1995	IC	0.27484	-0.38698	-0.11526	0.75070	-0.003378
1996	IC	0.33310	-0.41625	-0.11499	0.65575	-0.000470
1997	IC	0.33990	-0.42593	-0.11474	0.63814	0.003753
1998	IC	0.32574	-0.43978	-0.11447	0.65133	0.007579

CR

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	CR	0.70723	-0.28762	-0.13076	0.35232	-0.058461
1988	CR	0.68376	-0.27947	-0.13045	0.37842	-0.053758
1989	CR	0.71461	-0.29222	-0.13011	0.32606	-0.050214
1990	CR	0.71046	-0.29168	-0.12975	0.32732	-0.045243
1991	CR	0.71842	-0.28001	-0.12939	0.30854	-0.040317
1992	CR	0.69284	-0.27803	-0.12902	0.33572	-0.035085
1993	CR	0.68986	-0.28304	-0.12865	0.33423	-0.030415
1994	CR	0.63757	-0.25802	-0.12827	0.40215	-0.024089
1995	CR	0.61576	-0.24438	-0.12789	0.41911	-0.019133
1996	CR	0.61518	-0.23928	-0.12754	0.41563	-0.014084
1997	CR	0.62388	-0.23289	-0.12719	0.39466	-0.013045
1998	CR	0.61933	-0.23267	-0.12685	0.39520	-0.007242

CSX

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	CSX	0.78040	-0.39831	-0.12936	0.30635	-0.063948
1988	CSX	0.75021	-0.36226	-0.12903	0.33792	-0.058813
1989	CSX	0.73252	-0.34826	-0.12869	0.35788	-0.053548
1990	CSX	0.72373	-0.34248	-0.12836	0.36511	-0.048324
1991	CSX	0.74933	-0.32517	-0.12802	0.32022	-0.044624
1992	CSX	0.75757	-0.31516	-0.12764	0.30175	-0.040666
1993	CSX	0.77144	-0.28980	-0.12719	0.27254	-0.036813
1994	CSX	0.75583	-0.29089	-0.12679	0.28881	-0.032107
1995	CSX	0.74805	-0.28679	-0.12638	0.29396	-0.027323
1996	CSX	0.76040	-0.29989	-0.12606	0.26704	-0.023060
1997	CSX	0.74202	-0.28454	-0.12575	0.28755	-0.018219
1998	CSX	0.74652	-0.29658	-0.12552	0.26972	-0.015267
1999	CSX	0.87876	-0.24826	-0.12532	0.10077	-0.074042
2000	CSX	0.86203	-0.21978	-0.12827	0.13383	-0.051433
2001	CSX	0.84143	-0.15743	-0.12798	0.15841	-0.031981
2002	CSX	0.84637	-0.14109	-0.12772	0.14174	-0.013219
2003	CSX	0.84992	-0.12690	-0.12750	0.13452	0.006987
2004	CSX	0.81880	-0.11017	-0.12890	0.17418	0.028121
2005	CSX	0.81464	-0.12323	-0.12855	0.17292	0.049033
2006	CSX	0.82637	-0.11292	-0.12838	0.15687	0.069315

KCS

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	KCS	0.14246	-0.42246	-0.10870	0.90944	-0.030560
1988	KCS	0.16656	-0.41789	-0.10829	0.86933	-0.027456
1989	KCS	0.18413	-0.41462	-0.10841	0.84012	-0.023537
1990	KCS	0.19027	-0.43731	-0.10820	0.83012	-0.018810
1991	KCS	0.19403	-0.43995	-0.10789	0.81619	-0.014393
1992	KCS	0.17005	-0.43840	-0.10770	0.84596	-0.009580
1993	KCS	0.18504	-0.47122	-0.10759	0.82203	-0.006312
1994	KCS	0.49200	-0.56842	-0.10970	0.41745	-0.015237
1995	KCS	0.43655	-0.47639	-0.10990	0.50290	-0.009060
1996	KCS	0.48413	-0.48608	-0.10963	0.43092	-0.006681
1997	KCS	0.45303	-0.43436	-0.10933	0.47109	-0.002607
1998	KCS	0.39902	-0.43617	-0.10901	0.54619	0.004629
1999	KCS	0.40385	-0.40056	-0.10882	0.53451	-0.049319
2000	KCS	0.46556	-0.44219	-0.10845	0.44011	-0.030074
2001	KCS	0.56470	-0.46477	-0.10890	0.29875	-0.015574
2002	KCS	0.57104	-0.47371	-0.10916	0.28041	0.003581
2003	KCS	0.58474	-0.46869	-0.10901	0.25864	0.023367
2004	KCS	0.59215	-0.45362	-0.10892	0.24793	0.043807
2005	KCS	0.56944	-0.39321	-0.10925	0.29080	0.065492
2006	KCS	0.51137	-0.33156	-0.10894	0.38337	0.087310

NS

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	NS	0.80212	-0.35345	-0.12665	0.23649	-0.063171
1988	NS	0.77467	-0.35091	-0.12637	0.26944	-0.058442
1989	NS	0.75342	-0.35500	-0.12607	0.29040	-0.052785
1990	NS	0.68958	-0.30906	-0.12575	0.37740	-0.045009
1991	NS	0.71641	-0.29197	-0.12544	0.32865	-0.041654
1992	NS	0.71509	-0.28422	-0.12522	0.32365	-0.037574
1993	NS	0.70518	-0.26204	-0.12492	0.33167	-0.033083
1994	NS	0.68170	-0.23819	-0.12467	0.36271	-0.027899
1995	NS	0.66645	-0.22286	-0.12442	0.37768	-0.023168
1996	NS	0.67151	-0.23118	-0.12412	0.36723	-0.018012
1997	NS	0.66960	-0.22118	-0.12387	0.36481	-0.013801
1998	NS	0.68503	-0.24561	-0.12377	0.33066	-0.010959
1999	NS	0.89493	-0.21245	-0.12360	0.06850	-0.073489
2000	NS	0.85029	-0.19639	-0.12722	0.14450	-0.050091
2001	NS	0.89404	-0.22702	-0.12694	0.07023	-0.031587
2002	NS	0.91009	-0.23208	-0.12668	0.03623	-0.013401
2003	NS	0.91532	-0.22562	-0.12638	0.02396	0.006204
2004	NS	0.88880	-0.21281	-0.12862	0.05864	0.027314
2005	NS	0.90075	-0.21840	-0.12832	0.04202	0.048454
2006	NS	0.92579	-0.22552	-0.12809	0.00619	0.067791

SOO

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	SOO	0.71361	-0.30710	-0.11152	0.21613	-0.056100
1988	SOO	0.75528	-0.31201	-0.11122	0.14600	-0.053898
1989	SOO	0.77416	-0.30627	-0.11030	0.11429	-0.049999
1990	SOO	0.68927	-0.27649	-0.11063	0.23268	-0.041424
1991	SOO	0.67144	-0.29157	-0.11033	0.24687	-0.036461
1992	SOO	0.68565	-0.34403	-0.11016	0.22015	-0.032735
1993	SOO	0.69873	-0.31450	-0.10997	0.19327	-0.028585
1994	SOO	0.76176	-0.31230	-0.10982	0.08702	-0.026535
1995	SOO	0.68875	-0.27825	-0.10693	0.19318	-0.019079
1996	SOO	0.68804	-0.28321	-0.10689	0.18593	-0.014089
1997	SOO	0.50228	-0.35983	-0.10703	0.41198	-0.001177
1998	SOO	0.52274	-0.35135	-0.10718	0.36546	0.001370
1999	SOO	0.51740	-0.33372	-0.10703	0.36675	-0.050794
2000	SOO	0.51786	-0.27202	-0.10681	0.37270	-0.030551
2001	SOO	0.52061	-0.30220	-0.10665	0.36490	-0.011470
2002	SOO	0.53723	-0.30406	-0.10655	0.33268	0.007444
2003	SOO	0.55147	-0.29139	-0.10647	0.31119	0.026227
2004	SOO	0.55371	-0.27226	-0.10647	0.30933	0.046544
2005	SOO	0.64488	-0.23820	-0.10625	0.18007	0.064153
2006	SOO	0.61683	-0.21398	-0.10628	0.21498	0.085210

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	$\partial \ln C^V / \partial \ln Y$	$\partial \ln C^V / \partial \ln ALOH$	$\partial \ln C^V / \partial \ln K$	$\partial \ln C^V / \partial \ln Road$	$\partial \ln C^V / \partial Time$
1987	CNW	0.69096	-0.46943	-0.11774	0.27792	-0.055353
1988	CNW	0.60940	-0.46416	-0.11739	0.38564	-0.049069
1989	CNW	0.64787	-0.48855	-0.11666	0.31580	-0.045078
1990	CNW	0.65881	-0.49233	-0.11634	0.30186	-0.040528
1991	CNW	0.66250	-0.49309	-0.11663	0.29385	-0.036778
1992	CNW	0.64775	-0.49571	-0.11634	0.30746	-0.031934
1993	CNW	0.61811	-0.46781	-0.11605	0.34749	-0.026399
1994	CNW	0.56633	-0.44616	-0.11582	0.42161	-0.020178
1987	DRGW	0.37136	-0.20387	-0.11092	0.60000	-0.039203
1988	DRGW	0.34886	-0.21027	-0.11058	0.62950	-0.034533
1989	DRGW	0.32161	-0.21719	-0.11028	0.67036	-0.029043
1990	DRGW	0.32873	-0.18563	-0.11001	0.65929	-0.024521
1991	DRGW	0.33618	-0.16530	-0.10969	0.64435	-0.020079
1992	DRGW	0.30262	-0.17234	-0.10941	0.69617	-0.015157
1993	DRGW	0.26634	-0.19988	-0.10877	0.74562	-0.009148
1987	MKT	0.63392	-0.40246	-0.10817	0.23784	-0.048913
1987	SP	0.58151	0.08210	-0.12324	0.49614	-0.052419
1988	SP	0.59315	0.06697	-0.12317	0.47060	-0.048967
1989	SP	0.59411	0.07164	-0.12298	0.46791	-0.044850
1990	SP	0.68530	0.02083	-0.12268	0.36173	-0.045046
1991	SP	0.67273	0.01195	-0.12230	0.37055	-0.039729
1992	SP	0.65175	0.00007	-0.12207	0.39835	-0.034896
1993	SP	0.62565	0.01653	-0.12182	0.43246	-0.029181
1994	SP	0.61193	-0.00687	-0.12130	0.46715	-0.025486
1995	SP	0.66455	0.00299	-0.12106	0.39541	-0.023708
1996	SP	0.60534	0.01851	-0.12067	0.47466	-0.016681
1987	SSW	0.42661	-0.10966	-0.11027	0.55066	-0.041524
1988	SSW	0.39833	-0.09035	-0.11013	0.58344	-0.037219
1989	SSW	0.36455	-0.12057	-0.10986	0.63183	-0.031554
1987	UP	0.70065	0.01152	-0.12725	0.41771	-0.060270
1988	UP	0.71647	0.02619	-0.12709	0.39890	-0.057296
1989	UP	0.69550	0.04041	-0.12719	0.42327	-0.051610
1990	UP	0.67891	0.03187	-0.12751	0.44363	-0.045697
1991	UP	0.64015	0.05419	-0.12725	0.49183	-0.040154
1992	UP	0.59403	0.06567	-0.12704	0.54805	-0.034239
1993	UP	0.54277	0.07713	-0.12681	0.61322	-0.027750
1994	UP	0.51389	0.08138	-0.12710	0.64862	-0.022687
1995	UP	0.60154	-0.03323	-0.12939	0.55317	-0.022674
1996	UP	0.56990	0.14819	-0.12912	0.59615	-0.016747
1997	UP	0.75443	0.19269	-0.13066	0.37214	-0.021050
1998	UP	0.75914	0.18500	-0.13047	0.35084	-0.017563
1999	UP	0.72210	0.19263	-0.13035	0.39859	-0.069659
2000	UP	0.73363	0.19523	-0.13020	0.38380	-0.048969
2001	UP	0.74315	0.19843	-0.13003	0.36614	-0.029992
2002	UP	0.73134	0.20443	-0.12994	0.37400	-0.010933
2003	UP	0.73603	0.21252	-0.12983	0.36544	0.009103
2004	UP	0.74870	0.21812	-0.12972	0.34790	0.029167
2005	UP	0.76924	0.22015	-0.12971	0.31769	0.049228
2006	UP	0.78077	0.22379	-0.12974	0.30093	0.068694

Exhibit 5: Railroad-Specific Estimates of Scale and Density

ATSF, BN, BNSF

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	ATSF	1.52133	1.33341	1.06010	0.97490
1988	ATSF	1.58124	1.42746	1.05559	0.99208
1989	ATSF	1.68728	1.37147	1.04498	0.92723
1990	ATSF	1.64897	1.41574	1.05828	0.96719
1991	ATSF	1.85800	1.53500	1.04086	0.94192
1992	ATSF	2.15691	1.72233	1.02007	0.92199
1993	ATSF	2.32713	1.79033	1.00826	0.90361
1994	ATSF	2.53442	1.86179	1.00055	0.88767
1995	ATSF	2.20171	1.85052	1.02365	0.94917
1987	BN	1.45643	1.25503	0.97477	0.89007
1988	BN	1.51463	1.31139	0.96909	0.89080
1989	BN	1.50222	1.27154	0.97144	0.87992
1990	BN	1.46584	1.26718	0.97895	0.89578
1991	BN	1.42817	1.23388	0.99101	0.90344
1992	BN	1.41852	1.23346	0.99966	0.91392
1993	BN	1.42304	1.22065	1.00304	0.90877
1994	BN	1.49147	1.25137	0.99373	0.89244
1995	BN	1.58593	1.26388	0.98039	0.86009
1996	BNSF	1.25328	1.01201	1.01351	0.86580
1997	BNSF	1.29948	0.99842	1.01004	0.83654
1998	BNSF	1.37507	1.01803	0.99835	0.81475
1999	BNSF	1.39214	1.01856	1.00126	0.81171
2000	BNSF	1.34879	0.99972	1.01057	0.82052
2001	BNSF	1.34630	0.98842	1.01606	0.81810
2002	BNSF	1.32656	0.98370	1.03143	0.83179
2003	BNSF	1.32470	0.98268	1.03342	0.83307
2004	BNSF	1.39037	1.01854	1.01864	0.82351
2005	BNSF	1.38406	1.01514	1.01999	0.82439
2006	BNSF	1.39409	1.02053	1.01378	0.82034

CNGT, GTW, IC

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
2002	CNGT	1.5339	5.5016	1.22639	2.53910
2003	CNGT	1.4979	4.6528	1.23904	2.49263
2004	CNGT	1.4481	7.5637	1.25317	3.35902
2005	CNGT	1.4113	7.2318	1.27130	3.62778
2006	CNGT	1.3782	5.2263	1.28126	3.31311
1987	GTW	7.0331	-1.4766	1.13920	7.26166
1988	GTW	7.8443	-1.4956	1.13859	6.29001
1989	GTW	6.3846	-1.6500	1.15485	5.66119
1990	GTW	5.6941	-1.6804	1.17287	6.41631
1991	GTW	4.8413	-1.9608	1.19582	5.31142
1992	GTW	5.2609	-2.1328	1.19259	4.12386
1993	GTW	6.6786	-2.1184	1.15997	3.33867
1994	GTW	6.6430	-1.8941	1.16212	4.05726
1995	GTW	6.5451	-2.0957	1.17555	3.56631
1996	GTW	46.1115	-1.9941	1.08522	2.23339
1997	GTW	-4.7792	-1.2973	1.01810	2.11191
1998	GTW	-4.6654	-1.2747	1.03359	2.21738
1987	IC	2.3149	-7.3269	1.11923	2.59361
1988	IC	2.6327	-4.5136	1.10931	2.74789
1989	IC	2.4417	-5.0772	1.11712	2.83844
1990	IC	2.4452	-6.5751	1.11792	2.54970
1991	IC	2.6085	-7.0256	1.10513	2.30395
1992	IC	2.5110	-7.0740	1.12553	2.46893
1993	IC	2.6855	-9.7056	1.11648	2.12933
1994	IC	2.9184	-6.9115	1.11522	2.17474
1995	IC	3.6385	-8.9172	1.08749	1.74654
1996	IC	3.0021	-12.0264	1.12755	1.94723
1997	IC	2.9420	-11.6241	1.13977	2.01904
1998	IC	3.0699	-8.7689	1.14062	2.07423

CR

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	CR	1.41397	2.38317	1.06722	1.46486
1988	CR	1.46251	2.47348	1.06427	1.44428
1989	CR	1.39936	2.36747	1.08594	1.50993
1990	CR	1.40754	2.38791	1.08862	1.51421
1991	CR	1.39195	2.28097	1.09975	1.51201
1992	CR	1.44333	2.41072	1.09767	1.50430
1993	CR	1.44958	2.45809	1.10210	1.52304
1994	CR	1.56846	2.63470	1.08516	1.44335
1995	CR	1.62402	2.69265	1.08990	1.42683
1996	CR	1.62553	2.66023	1.09383	1.42449
1997	CR	1.60287	2.55759	1.10667	1.43471
1998	CR	1.61465	2.58628	1.11071	1.44124

CSX

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	CSX	1.28139	2.61714	1.03921	1.64044
1988	CSX	1.33296	2.57767	1.03759	1.55543
1989	CSX	1.36515	2.60240	1.03512	1.52086
1990	CSX	1.38172	2.62293	1.03629	1.51181
1991	CSX	1.33452	2.35757	1.05466	1.51536
1992	CSX	1.32001	2.26035	1.06449	1.51532
1993	CSX	1.29628	2.07623	1.07971	1.49459
1994	CSX	1.32305	2.15082	1.07864	1.49492
1995	CSX	1.33680	2.16796	1.08097	1.49146
1996	CSX	1.31510	2.17154	1.09600	1.54777
1997	CSX	1.34767	2.18589	1.09342	1.51102
1998	CSX	1.33955	2.22252	1.10754	1.56397
1999	CSX	1.13797	1.58606	1.14884	1.53887
2000	CSX	1.16005	1.55703	1.13295	1.45379
2001	CSX	1.18845	1.46199	1.12815	1.33898
2002	CSX	1.18152	1.41789	1.14129	1.33140
2003	CSX	1.17658	1.38308	1.14532	1.31480
2004	CSX	1.22131	1.41118	1.13689	1.27876
2005	CSX	1.22754	1.44632	1.14276	1.30569
2006	CSX	1.21012	1.40164	1.14761	1.29651

KCS

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	KCS	7.01963	-3.571	1.05400	1.76141
1988	KCS	6.00371	-3.979	1.06989	1.79333
1989	KCS	5.43105	-4.338	1.08217	1.81818
1990	KCS	5.25576	-4.048	1.08606	1.90061
1991	KCS	5.15384	-4.066	1.09668	1.94272
1992	KCS	5.88069	-3.726	1.09025	1.91775
1993	KCS	5.40418	-3.494	1.09982	2.06699
1994	KCS	2.03252	-13.086	1.22019	3.25396
1995	KCS	2.29070	-25.096	1.18144	2.39690
1996	KCS	2.06555	-514.427	1.21263	2.58668
1997	KCS	2.20737	53.578	1.20043	2.26509
1998	KCS	2.50613	-26.917	1.17328	2.17861
1999	KCS	2.47615	304.108	1.18166	2.06177
2000	KCS	2.14796	42.794	1.22390	2.39159
2001	KCS	1.77085	10.007	1.28427	2.78144
2002	KCS	1.75119	10.274	1.30268	2.93635
2003	KCS	1.71015	8.616	1.31496	2.95978
2004	KCS	1.68875	7.219	1.32002	2.86943
2005	KCS	1.75611	5.674	1.28946	2.37509
2006	KCS	1.95552	5.561	1.23940	1.96907

NS

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	NS	1.24670	2.22882	1.08477	1.64437
1988	NS	1.29088	2.35982	1.07879	1.62489
1989	NS	1.32728	2.50991	1.07880	1.63478
1990	NS	1.45015	2.62794	1.05508	1.48531
1991	NS	1.39584	2.35601	1.07691	1.49441
1992	NS	1.39843	2.32087	1.08326	1.49130
1993	NS	1.41808	2.25662	1.08495	1.45187
1994	NS	1.46693	2.25476	1.07686	1.39500
1995	NS	1.50050	2.25438	1.07691	1.36915
1996	NS	1.48918	2.27103	1.08220	1.39200
1997	NS	1.49343	2.23007	1.08648	1.38199
1998	NS	1.45979	2.27573	1.10641	1.45930
1999	NS	1.11740	1.46523	1.16625	1.49617
2000	NS	1.17607	1.52929	1.13313	1.41186
2001	NS	1.11852	1.49920	1.16870	1.52857
2002	NS	1.09879	1.47491	1.19059	1.57745
2003	NS	1.09251	1.44990	1.19919	1.57830
2004	NS	1.12511	1.47932	1.19124	1.53632
2005	NS	1.11019	1.46552	1.19681	1.55765
2006	NS	1.08016	1.42802	1.21042	1.59680

SOO

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	SOO	1.40132	2.45997	1.19551	1.78517
1988	SOO	1.32401	2.25592	1.23293	1.88573
1989	SOO	1.29172	2.13727	1.24971	1.90717
1990	SOO	1.45080	2.42256	1.20464	1.72065
1991	SOO	1.48934	2.63252	1.20911	1.77162
1992	SOO	1.45847	2.92720	1.22561	1.97616
1993	SOO	1.43116	2.60261	1.24436	1.92203
1994	SOO	1.31275	2.22489	1.30754	2.06869
1995	SOO	1.45190	2.43605	1.25512	1.83363
1996	SOO	1.45340	2.47018	1.26651	1.87368
1997	SOO	1.99093	7.01987	1.21085	1.99668
1998	SOO	1.91300	5.83457	1.24654	2.06235
1999	SOO	1.93273	5.44408	1.25208	2.01119
2000	SOO	1.93101	4.06767	1.24283	1.78940
2001	SOO	1.92084	4.57867	1.24973	1.89719
2002	SOO	1.86140	4.28862	1.27202	1.95552
2003	SOO	1.81335	3.84497	1.28263	1.93687
2004	SOO	1.80599	3.55295	1.28206	1.87289
2005	SOO	1.55067	2.45893	1.34099	1.88539
2006	SOO	1.62120	2.48235	1.32998	1.79062

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	DENSITY_1	DENSITY_2	SCALE_1	SCALE_2
1987	CNW	1.44727	4.5141	1.15364	2.23794
1988	CNW	1.64096	6.8854	1.12296	2.10482
1989	CNW	1.54352	6.2767	1.15875	2.35026
1990	CNW	1.51788	6.0067	1.16203	2.38357
1991	CNW	1.50944	5.9029	1.16760	2.41041
1992	CNW	1.54380	6.5773	1.16868	2.42946
1993	CNW	1.61784	6.6536	1.15581	2.24203
1994	CNW	1.76577	8.3220	1.12944	2.05956
1987	DRGW	2.69284	5.9705	1.14368	1.44747
1988	DRGW	2.86647	7.2153	1.13514	1.44589
1989	DRGW	3.10936	9.5766	1.11927	1.43302
1990	DRGW	3.04197	6.9878	1.12347	1.38337
1991	DRGW	2.97461	5.8522	1.13173	1.36121
1992	DRGW	3.30443	7.6754	1.11074	1.34236
1993	DRGW	3.75457	15.0457	1.09566	1.36533
1987	MKT	1.57749	4.3204	1.27120	2.36135
1987	SP	1.71967	1.5069	1.04231	0.96853
1988	SP	1.68592	1.5149	1.05587	0.99333
1989	SP	1.68319	1.5021	1.05740	0.99058
1990	SP	1.45922	1.4162	1.07226	1.05134
1991	SP	1.48648	1.4605	1.07574	1.06356
1992	SP	1.53433	1.5342	1.06854	1.06847
1993	SP	1.59834	1.5572	1.06021	1.04391
1994	SP	1.63417	1.6527	1.03912	1.04577
1995	SP	1.50479	1.4980	1.05765	1.05467
1996	SP	1.65198	1.6030	1.03767	1.02018
1987	SSW	2.34408	3.1551	1.13609	1.27968
1988	SSW	2.51050	3.2470	1.13075	1.24536
1989	SSW	2.74309	4.0986	1.11389	1.26723
1987	UP	1.42725	1.4042	1.00795	0.99767
1988	UP	1.39573	1.3465	1.01051	0.98732
1989	UP	1.43782	1.3589	1.00753	0.97241
1990	UP	1.47296	1.4069	1.00443	0.97670
1991	UP	1.56213	1.4402	0.99582	0.95032
1992	UP	1.68340	1.5158	0.98682	0.93317
1993	UP	1.84240	1.6132	0.97476	0.91379
1994	UP	1.94594	1.6799	0.96954	0.90611
1995	UP	1.66241	1.7596	0.97807	1.00706
1996	UP	1.75469	1.3926	0.96833	0.85914
1997	UP	1.32551	1.0558	1.00363	0.85704
1998	UP	1.31728	1.0592	1.01846	0.87296
1999	UP	1.38484	1.0932	1.00862	0.86068
2000	UP	1.36308	1.0766	1.01143	0.86100
2001	UP	1.34563	1.0620	1.01870	0.86412
2002	UP	1.36736	1.0686	1.02227	0.86271
2003	UP	1.35864	1.0542	1.02575	0.85985
2004	UP	1.33564	1.0343	1.03020	0.85928
2005	UP	1.29999	1.0107	1.03937	0.86431
2006	UP	1.28079	0.9955	1.04441	0.86538

Exhibit 6: Railroad-Specific Estimates of Productivity Measures

ATSF, BN, BNSF

Year	Railroad	PGY1	PGY2	PGX
1987	ATSF	0.052654	0.048423	0.049669
1988	ATSF	0.048361	0.045451	0.045814
1989	ATSF	0.043449	0.038553	0.041579
1990	ATSF	0.038269	0.034975	0.036161
1991	ATSF	0.030910	0.027972	0.029697
1992	ATSF	0.023959	0.021656	0.023488
1993	ATSF	0.018145	0.016261	0.017996
1994	ATSF	0.013069	0.011594	0.013061
1995	ATSF	0.012170	0.011285	0.011889
1987	BN	0.053012	0.048406	0.054385
1988	BN	0.048630	0.044701	0.050181
1989	BN	0.045135	0.040883	0.046462
1990	BN	0.041672	0.038132	0.042568
1991	BN	0.039511	0.036020	0.039870
1992	BN	0.036160	0.033059	0.036172
1993	BN	0.032516	0.029460	0.032417
1994	BN	0.027438	0.024642	0.027612
1995	BN	0.021968	0.019273	0.022408
1996	BNSF	0.024979	0.021338	0.024646
1997	BNSF	0.020318	0.016828	0.020117
1998	BNSF	0.015087	0.012313	0.015112
1999	BNSF	0.062717	0.050844	0.062638
2000	BNSF	0.044967	0.036511	0.044497
2001	BNSF	0.027625	0.022243	0.027189
2002	BNSF	0.011694	0.009431	0.011338
2003	BNSF	-0.006507	-0.005246	-0.006297
2004	BNSF	-0.025154	-0.020336	-0.024694
2005	BNSF	-0.043926	-0.035502	-0.043065
2006	BNSF	-0.061889	-0.050080	-0.061048

CNGT, GTW, IC

Year	Railroad	PGY1	PGY2	PGX
2002	CNGT	0.000591	0.00122	0.000482
2003	CNGT	-0.020064	-0.04036	-0.016194
2004	CNGT	-0.041104	-0.11018	-0.032800
2005	CNGT	-0.064877	-0.18513	-0.051032
2006	CNGT	-0.088889	-0.22985	-0.069376
1987	GTW	0.028176	0.17960	0.024733
1988	GTW	0.023845	0.13173	0.020942
1989	GTW	0.020556	0.10077	0.017800
1990	GTW	0.016494	0.09023	0.014063
1991	GTW	0.013761	0.06112	0.011507
1992	GTW	0.010835	0.03747	0.009086
1993	GTW	0.002386	0.00687	0.002057
1994	GTW	-0.002676	-0.00934	-0.002303
1995	GTW	-0.006102	-0.01851	-0.005191
1996	GTW	-0.013995	-0.02880	-0.012896
1997	GTW	-0.025630	-0.05317	-0.025174
1998	GTW	-0.030156	-0.06469	-0.029176
1987	IC	0.043071	0.09981	0.038482
1988	IC	0.037514	0.09293	0.033817
1989	IC	0.036296	0.09222	0.032491
1990	IC	0.031444	0.07172	0.028127
1991	IC	0.025699	0.05358	0.023254
1992	IC	0.022613	0.04960	0.020091
1993	IC	0.016817	0.03207	0.015063
1994	IC	0.010657	0.02078	0.009556
1995	IC	0.003293	0.00529	0.003028
1996	IC	0.000476	0.00082	0.000422
1997	IC	-0.003837	-0.00680	-0.003367
1998	IC	-0.007757	-0.01411	-0.006800

CR

Year	Railroad	PGY1	PGY2	PGX
1987	CR	0.055176	0.075734	0.051700
1988	CR	0.050611	0.068682	0.047555
1989	CR	0.048251	0.067090	0.044433
1990	CR	0.043596	0.060640	0.040047
1991	CR	0.039258	0.053975	0.035698
1992	CR	0.034111	0.046746	0.031075
1993	CR	0.029699	0.041043	0.026948
1994	CR	0.023169	0.030816	0.021351
1995	CR	0.018489	0.024204	0.016964
1996	CR	0.013663	0.017793	0.012491
1997	CR	0.012807	0.016604	0.011573
1998	CR	0.007139	0.009263	0.006427

CSX

Year	Railroad	PGY1	PGY2	PGX
1987	CSX	0.058843	0.09289	0.056623
1988	CSX	0.054050	0.08103	0.052092
1989	CSX	0.049109	0.07215	0.047442
1990	CSX	0.044381	0.06475	0.042827
1991	CSX	0.041722	0.05995	0.039560
1992	CSX	0.038389	0.05465	0.036063
1993	CSX	0.035262	0.04881	0.032659
1994	CSX	0.030735	0.04260	0.028494
1995	CSX	0.026221	0.03618	0.024257
1996	CSX	0.022444	0.03170	0.020478
1997	CSX	0.017696	0.02445	0.016184
1998	CSX	0.015023	0.02121	0.013564
1999	CSX	0.075589	0.10125	0.065796
2000	CSX	0.051646	0.06627	0.045585
2001	CSX	0.031986	0.03796	0.028353
2002	CSX	0.013378	0.01561	0.011722
2003	CSX	-0.007098	-0.00815	-0.006197
2004	CSX	-0.028320	-0.03185	-0.024910
2005	CSX	-0.049651	-0.05673	-0.043448
2006	CSX	-0.070496	-0.07964	-0.061429

KCS

Year	Railroad	PGY1	PGY2	PGX
1987	KCS	0.029053	0.04855	0.027564
1988	KCS	0.026504	0.04443	0.024773
1989	KCS	0.022980	0.03861	0.021235
1990	KCS	0.018434	0.03226	0.016974
1991	KCS	0.014247	0.02524	0.012991
1992	KCS	0.009429	0.01658	0.008648
1993	KCS	0.006267	0.01178	0.005698
1994	KCS	0.016755	0.04468	0.013731
1995	KCS	0.009644	0.01957	0.008163
1996	KCS	0.007301	0.01557	0.006021
1997	KCS	0.002821	0.00532	0.002350
1998	KCS	-0.004898	-0.00909	-0.004174
1999	KCS	0.052559	0.09171	0.044479
2000	KCS	0.033207	0.06489	0.027132
2001	KCS	0.018037	0.03906	0.014044
2002	KCS	-0.004206	-0.00948	-0.003229
2003	KCS	-0.027706	-0.06236	-0.021070
2004	KCS	-0.052146	-0.11335	-0.039504
2005	KCS	-0.076131	-0.14023	-0.059041
2006	KCS	-0.097582	-0.15503	-0.078733

NS

Year	Railroad	PGY1	PGY2	PGX
1987	NS	0.060823	0.092200	0.056070
1988	NS	0.055973	0.084308	0.051885
1989	NS	0.050569	0.076630	0.046875
1990	NS	0.042183	0.059384	0.039981
1991	NS	0.039858	0.055311	0.037012
1992	NS	0.036172	0.049798	0.033392
1993	NS	0.031908	0.042699	0.029409
1994	NS	0.026713	0.034605	0.024807
1995	NS	0.022189	0.028210	0.020604
1996	NS	0.017341	0.022305	0.016024
1997	NS	0.013342	0.016971	0.012280
1998	NS	0.010790	0.014231	0.009752
1999	NS	0.076278	0.097856	0.065404
2000	NS	0.050354	0.062740	0.044438
2001	NS	0.032757	0.042844	0.028029
2002	NS	0.014161	0.018762	0.011894
2003	NS	-0.006605	-0.008693	-0.005508
2004	NS	-0.028829	-0.037181	-0.024201
2005	NS	-0.051395	-0.066891	-0.042943
2006	NS	-0.072738	-0.095957	-0.060093

SOO

Year	Railroad	PGY1	PGY2	PGX
1987	SOO	0.06034	0.09010	0.050472
1988	SOO	0.05980	0.09147	0.048504
1989	SOO	0.05628	0.08588	0.045032
1990	SOO	0.04493	0.06418	0.037298
1991	SOO	0.03970	0.05818	0.032838
1992	SOO	0.03614	0.05827	0.029486
1993	SOO	0.03205	0.04950	0.025753
1994	SOO	0.03126	0.04946	0.023909
1995	SOO	0.02163	0.03160	0.017236
1996	SOO	0.01612	0.02385	0.012729
1997	SOO	0.00129	0.00212	0.001064
1998	SOO	-0.00154	-0.00255	-0.001237
1999	SOO	0.05745	0.09228	0.045884
2000	SOO	0.03431	0.04939	0.027603
2001	SOO	0.01295	0.01966	0.010364
2002	SOO	-0.00856	-0.01315	-0.006727
2003	SOO	-0.03040	-0.04591	-0.023703
2004	SOO	-0.05393	-0.07878	-0.042065
2005	SOO	-0.07777	-0.10934	-0.057991
2006	SOO	-0.10244	-0.13792	-0.077024

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	PGY1	PGY2	PGX
1987	CNW	0.057131	0.11083	0.049523
1988	CNW	0.049314	0.09243	0.043914
1989	CNW	0.046777	0.09488	0.040368
1990	CNW	0.042187	0.08653	0.036305
1991	CNW	0.038456	0.07939	0.032936
1992	CNW	0.033431	0.06950	0.028606
1993	CNW	0.027340	0.05303	0.023654
1994	CNW	0.020425	0.03724	0.018084
1987	DRGW	0.040359	0.05108	0.035288
1988	DRGW	0.035297	0.04496	0.031095
1989	DRGW	0.029278	0.03749	0.026158
1990	DRGW	0.024819	0.03056	0.022091
1991	DRGW	0.020477	0.02463	0.018094
1992	DRGW	0.015176	0.01834	0.013663
1993	DRGW	0.009040	0.01127	0.008251
1987	MKT	0.056108	0.10423	0.044138
1987	SP	0.048642	0.04520	0.046667
1988	SP	0.046033	0.04331	0.043597
1989	SP	0.042231	0.03956	0.039938
1990	SP	0.043023	0.04218	0.040123
1991	SP	0.038081	0.03765	0.035400
1992	SP	0.033231	0.03323	0.031100
1993	SP	0.027579	0.02715	0.026012
1994	SP	0.023618	0.02377	0.022729
1995	SP	0.022367	0.02230	0.021148
1996	SP	0.015445	0.01519	0.014885
1987	SSW	0.042490	0.04786	0.037400
1988	SSW	0.037910	0.04175	0.033527
1989	SSW	0.031669	0.03603	0.028431
1987	UP	0.053892	0.05334	0.053467
1988	UP	0.051369	0.05019	0.050835
1989	UP	0.046131	0.04452	0.045787
1990	UP	0.040709	0.03959	0.040530
1991	UP	0.035472	0.03385	0.035622
1992	UP	0.029980	0.02835	0.030380
1993	UP	0.024005	0.02250	0.024627
1994	UP	0.019515	0.01824	0.020128
1995	UP	0.019636	0.02022	0.020076
1996	UP	0.014362	0.01274	0.014832
1997	UP	0.018685	0.01596	0.018617
1998	UP	0.015823	0.01356	0.015536
1999	UP	0.062157	0.05304	0.061626
2000	UP	0.043823	0.03731	0.043328
2001	UP	0.027037	0.02293	0.026541
2002	UP	0.009891	0.00835	0.009675
2003	UP	-0.008265	-0.00693	-0.008057
2004	UP	-0.026598	-0.02219	-0.025818
2005	UP	-0.045291	-0.03766	-0.043576
2006	UP	-0.063505	-0.05262	-0.060805

Exhibit 7: Railroad-Specific Estimates of Input Own-Elasticity of Demands

ATSF, BN, BNSF

Year	Railroad	Labor	Equipment	Material	Fuel
1987	ATSF	-0.43305	-0.82351	-0.42025	-0.93843
1988	ATSF	-0.44120	-0.82352	-0.41921	-0.93046
1989	ATSF	-0.43573	-0.82653	-0.42531	-0.91421
1990	ATSF	-0.44064	-0.82382	-0.42265	-0.92160
1991	ATSF	-0.45492	-0.82269	-0.41688	-0.91973
1992	ATSF	-0.46471	-0.82300	-0.41366	-0.91329
1993	ATSF	-0.47097	-0.82263	-0.41138	-0.91046
1994	ATSF	-0.48106	-0.82185	-0.40741	-0.90626
1995	ATSF	-0.47997	-0.82104	-0.41121	-0.90130
1987	BN	-0.42631	-0.82940	-0.42551	-0.91742
1988	BN	-0.43695	-0.82899	-0.42303	-0.91212
1989	BN	-0.43599	-0.82904	-0.42509	-0.90739
1990	BN	-0.43244	-0.82896	-0.42769	-0.90432
1991	BN	-0.43914	-0.82780	-0.42683	-0.90181
1992	BN	-0.44942	-0.82600	-0.42386	-0.90170
1993	BN	-0.45323	-0.82545	-0.42390	-0.89782
1994	BN	-0.46301	-0.82491	-0.42108	-0.89347
1995	BN	-0.47121	-0.82492	-0.41879	-0.88794
1996	BNSF	-0.47835	-0.82104	-0.41686	-0.89071
1997	BNSF	-0.48167	-0.82151	-0.41758	-0.88333
1998	BNSF	-0.49181	-0.82109	-0.41391	-0.87790
1999	BNSF	-0.49519	-0.82133	-0.41509	-0.86965
2000	BNSF	-0.49396	-0.81993	-0.41612	-0.87178
2001	BNSF	-0.49724	-0.81916	-0.41621	-0.86806
2002	BNSF	-0.49942	-0.81903	-0.41853	-0.85936
2003	BNSF	-0.49555	-0.82001	-0.42258	-0.85299
2004	BNSF	-0.49768	-0.82125	-0.42352	-0.84480
2005	BNSF	-0.49633	-0.82100	-0.42498	-0.84320
2006	BNSF	-0.49201	-0.82202	-0.42808	-0.83820

CNGT, GTW, IC

Year	Railroad	Labor	Equipment	Material	Fuel
2002	CNGT	-0.49266	-0.80551	-0.41769	-0.89383
2003	CNGT	-0.48792	-0.80707	-0.42303	-0.88480
2004	CNGT	-0.48858	-0.80663	-0.42470	-0.87981
2005	CNGT	-0.48841	-0.80489	-0.42541	-0.88061
2006	CNGT	-0.48843	-0.80304	-0.42566	-0.88255
1987	GTW	-0.41194	-0.82453	-0.42696	-0.94421
1988	GTW	-0.41811	-0.82437	-0.42671	-0.93759
1989	GTW	-0.42447	-0.82225	-0.42529	-0.93833
1990	GTW	-0.41816	-0.82248	-0.42913	-0.93377
1991	GTW	-0.41901	-0.82138	-0.43034	-0.93065
1992	GTW	-0.41797	-0.82368	-0.43344	-0.91466
1993	GTW	-0.43476	-0.82070	-0.42719	-0.92245
1994	GTW	-0.43765	-0.81993	-0.42715	-0.92029
1995	GTW	-0.44631	-0.81863	-0.42604	-0.91478
1996	GTW	-0.43996	-0.82557	-0.43053	-0.89406
1997	GTW	-0.45164	-0.82878	-0.42815	-0.87826
1998	GTW	-0.47968	-0.82411	-0.41594	-0.88467
1987	IC	-0.41752	-0.82347	-0.42574	-0.94322
1988	IC	-0.41920	-0.82509	-0.42782	-0.93112
1989	IC	-0.40021	-0.82791	-0.43544	-0.91598
1990	IC	-0.39784	-0.82787	-0.43628	-0.91328
1991	IC	-0.40901	-0.82694	-0.43472	-0.91184
1992	IC	-0.41814	-0.82518	-0.43367	-0.91001
1993	IC	-0.42856	-0.82419	-0.43162	-0.90783
1994	IC	-0.44356	-0.82219	-0.42743	-0.90727
1995	IC	-0.45915	-0.82155	-0.42199	-0.90346
1996	IC	-0.45863	-0.81905	-0.42357	-0.90466
1997	IC	-0.46595	-0.81702	-0.42166	-0.90350
1998	IC	-0.47678	-0.81570	-0.41875	-0.89813

CR

Year	Railroad	Labor	Equipment	Material	Fuel
1987	CR	-0.42708	-0.82394	-0.42309	-0.93766
1988	CR	-0.43681	-0.82326	-0.42090	-0.93241
1989	CR	-0.43903	-0.82163	-0.42148	-0.93136
1990	CR	-0.43925	-0.82160	-0.42297	-0.92714
1991	CR	-0.44510	-0.81940	-0.42110	-0.92872
1992	CR	-0.45821	-0.81717	-0.41602	-0.92783
1993	CR	-0.46617	-0.81532	-0.41329	-0.92648
1994	CR	-0.47552	-0.81517	-0.40990	-0.92113
1995	CR	-0.48086	-0.81471	-0.40945	-0.91528
1996	CR	-0.48160	-0.81424	-0.41066	-0.91241
1997	CR	-0.47343	-0.81864	-0.42158	-0.89038
1998	CR	-0.49584	-0.81186	-0.40790	-0.90121

CSX

Year	Railroad	Labor	Equipment	Material	Fuel
1987	CSX	-0.42862	-0.82562	-0.42409	-0.92909
1988	CSX	-0.43817	-0.82493	-0.42191	-0.92431
1989	CSX	-0.43927	-0.82511	-0.42306	-0.91936
1990	CSX	-0.43822	-0.82535	-0.42501	-0.91470
1991	CSX	-0.44767	-0.82250	-0.42193	-0.91707
1992	CSX	-0.45682	-0.82042	-0.41919	-0.91605
1993	CSX	-0.46358	-0.81842	-0.41761	-0.91447
1994	CSX	-0.47297	-0.81715	-0.41463	-0.91079
1995	CSX	-0.47922	-0.81600	-0.41296	-0.90774
1996	CSX	-0.48325	-0.81437	-0.41255	-0.90566
1997	CSX	-0.49037	-0.81349	-0.41043	-0.90133
1998	CSX	-0.49986	-0.81144	-0.40761	-0.89633
1999	CSX	-0.50036	-0.80751	-0.40940	-0.89791
2000	CSX	-0.48798	-0.81096	-0.41745	-0.89296
2001	CSX	-0.49206	-0.81171	-0.41821	-0.88385
2002	CSX	-0.49894	-0.81003	-0.41682	-0.87948
2003	CSX	-0.49667	-0.81020	-0.41959	-0.87591
2004	CSX	-0.50111	-0.81011	-0.41867	-0.87151
2005	CSX	-0.50454	-0.80830	-0.41747	-0.87189
2006	CSX	-0.50078	-0.80822	-0.42057	-0.87019

KCS

Year	Railroad	Labor	Equipment	Material	Fuel
1987	KCS	-0.42197	-0.82774	-0.42447	-0.93105
1988	KCS	-0.42783	-0.82640	-0.42378	-0.92907
1989	KCS	-0.42921	-0.82564	-0.42470	-0.92656
1990	KCS	-0.42597	-0.82592	-0.42733	-0.92210
1991	KCS	-0.44102	-0.82303	-0.42215	-0.92411
1992	KCS	-0.45211	-0.82206	-0.41887	-0.91994
1993	KCS	-0.45817	-0.82066	-0.41788	-0.91698
1994	KCS	-0.46308	-0.81110	-0.41757	-0.92770
1995	KCS	-0.46507	-0.81390	-0.41889	-0.91714
1996	KCS	-0.46067	-0.81316	-0.42314	-0.91331
1997	KCS	-0.45531	-0.81688	-0.42860	-0.89786
1998	KCS	-0.47463	-0.81351	-0.42003	-0.90163
1999	KCS	-0.47517	-0.81376	-0.42226	-0.89463
2000	KCS	-0.46250	-0.81312	-0.42844	-0.89504
2001	KCS	-0.46567	-0.80989	-0.42956	-0.89210
2002	KCS	-0.47350	-0.80768	-0.42809	-0.88958
2003	KCS	-0.47034	-0.80774	-0.43042	-0.88591
2004	KCS	-0.46978	-0.80690	-0.43116	-0.88518
2005	KCS	-0.46803	-0.80841	-0.43225	-0.88097
2006	KCS	-0.46778	-0.81142	-0.43330	-0.87206

NS

Year	Railroad	Labor	Equipment	Material	Fuel
1987	NS	-0.43093	-0.82215	-0.42214	-0.93904
1988	NS	-0.44045	-0.82170	-0.42008	-0.93301
1989	NS	-0.44120	-0.82186	-0.42138	-0.92832
1990	NS	-0.44279	-0.82316	-0.42180	-0.92248
1991	NS	-0.45251	-0.82008	-0.41863	-0.92385
1992	NS	-0.46393	-0.81776	-0.41452	-0.92249
1993	NS	-0.47130	-0.81665	-0.41258	-0.91865
1994	NS	-0.48001	-0.81572	-0.40934	-0.91501
1995	NS	-0.48406	-0.81562	-0.40949	-0.90903
1996	NS	-0.48493	-0.81468	-0.41016	-0.90792
1997	NS	-0.49229	-0.81315	-0.40776	-0.90473
1998	NS	-0.50522	-0.80918	-0.40153	-0.90382
1999	NS	-0.49740	-0.80609	-0.41024	-0.90280
2000	NS	-0.49124	-0.80911	-0.41425	-0.89856
2001	NS	-0.50035	-0.80351	-0.40950	-0.90370
2002	NS	-0.50754	-0.80104	-0.40766	-0.89986
2003	NS	-0.50788	-0.80084	-0.40980	-0.89508
2004	NS	-0.51403	-0.79989	-0.40700	-0.89230
2005	NS	-0.51051	-0.79926	-0.40984	-0.89299
2006	NS	-0.50681	-0.79886	-0.41381	-0.89076

SOO

Year	Railroad	Labor	Equipment	Material	Fuel
1987	SOO	-0.41058	-0.81960	-0.42955	-0.94750
1988	SOO	-0.41416	-0.81755	-0.43012	-0.94474
1989	SOO	-0.41450	-0.81662	-0.43116	-0.94209
1990	SOO	-0.41765	-0.81854	-0.43090	-0.93569
1991	SOO	-0.43123	-0.81593	-0.42732	-0.93527
1992	SOO	-0.43969	-0.81334	-0.42530	-0.93481
1993	SOO	-0.44978	-0.81016	-0.42219	-0.93536
1994	SOO	-0.45923	-0.80468	-0.41942	-0.93821
1995	SOO	-0.47105	-0.80507	-0.41455	-0.93305
1996	SOO	-0.47107	-0.80477	-0.41641	-0.92917
1997	SOO	-0.47770	-0.80779	-0.41390	-0.92107
1998	SOO	-0.49252	-0.80312	-0.40780	-0.91977
1999	SOO	-0.49374	-0.80238	-0.40851	-0.91751
2000	SOO	-0.47544	-0.80789	-0.42145	-0.90575
2001	SOO	-0.47968	-0.80697	-0.42138	-0.90132
2002	SOO	-0.48836	-0.80363	-0.41844	-0.90117
2003	SOO	-0.48358	-0.80504	-0.42340	-0.89316
2004	SOO	-0.47932	-0.80592	-0.42655	-0.88884
2005	SOO	-0.47566	-0.80219	-0.42855	-0.89318
2006	SOO	-0.47592	-0.80270	-0.42951	-0.88881

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	Labor	Equipment	Material	Fuel
1987	CNW	-0.40503	-0.82180	-0.43061	-0.94634
1988	CNW	-0.41375	-0.82355	-0.43002	-0.93397
1989	CNW	-0.41995	-0.82029	-0.42863	-0.93753
1990	CNW	-0.41466	-0.82071	-0.43133	-0.93374
1991	CNW	-0.42118	-0.81937	-0.43051	-0.93115
1992	CNW	-0.43243	-0.81738	-0.42775	-0.92984
1993	CNW	-0.43984	-0.81696	-0.42619	-0.92582
1994	CNW	-0.44504	-0.81806	-0.42566	-0.91863
1987	DRGW	-0.41800	-0.82261	-0.42554	-0.94502
1988	DRGW	-0.42274	-0.82302	-0.42576	-0.93753
1989	DRGW	-0.42722	-0.82325	-0.42532	-0.93265
1990	DRGW	-0.42492	-0.82339	-0.42757	-0.92842
1991	DRGW	-0.43847	-0.82011	-0.42268	-0.93185
1992	DRGW	-0.44516	-0.82043	-0.42151	-0.92561
1993	DRGW	-0.45342	-0.81977	-0.41875	-0.92293
1987	MKT	-0.42270	-0.81267	-0.42263	-0.96529
1987	SP	-0.43602	-0.82422	-0.41842	-0.93764
1988	SP	-0.44380	-0.82266	-0.41685	-0.93460
1989	SP	-0.44069	-0.82357	-0.42077	-0.92704
1990	SP	-0.43611	-0.82356	-0.42532	-0.92053
1991	SP	-0.44884	-0.82098	-0.42054	-0.92221
1992	SP	-0.45881	-0.81989	-0.41734	-0.91890
1993	SP	-0.46501	-0.81936	-0.41554	-0.91571
1994	SP	-0.47546	-0.81944	-0.41238	-0.90820
1995	SP	-0.48123	-0.81745	-0.41169	-0.90515
1996	SP	-0.47925	-0.81988	-0.41503	-0.89599
1987	SSW	-0.42315	-0.82143	-0.42302	-0.94806
1988	SSW	-0.43491	-0.82098	-0.42053	-0.94047
1989	SSW	-0.43614	-0.82233	-0.42204	-0.93223
1987	UP	-0.43998	-0.82597	-0.41846	-0.92835
1988	UP	-0.44825	-0.82495	-0.41664	-0.92430
1989	UP	-0.45132	-0.82480	-0.41663	-0.92056
1990	UP	-0.45125	-0.82489	-0.41787	-0.91745
1991	UP	-0.46242	-0.82405	-0.41385	-0.91374
1992	UP	-0.47119	-0.82374	-0.41102	-0.90860
1993	UP	-0.47922	-0.82353	-0.40798	-0.90420
1994	UP	-0.48706	-0.82313	-0.40551	-0.89882
1995	UP	-0.48713	-0.82228	-0.40804	-0.89525
1996	UP	-0.48962	-0.82277	-0.40839	-0.88985
1997	UP	-0.49078	-0.81966	-0.41083	-0.88902
1998	UP	-0.49849	-0.81775	-0.40877	-0.88534
1999	UP	-0.50736	-0.81720	-0.40502	-0.88021
2000	UP	-0.49587	-0.81924	-0.41421	-0.87465
2001	UP	-0.50121	-0.81789	-0.41310	-0.87145
2002	UP	-0.50844	-0.81708	-0.41149	-0.86504
2003	UP	-0.50438	-0.81788	-0.41604	-0.85974
2004	UP	-0.50114	-0.81777	-0.41908	-0.85762
2005	UP	-0.49655	-0.81757	-0.42255	-0.85604
2006	UP	-0.49730	-0.81673	-0.42342	-0.85402

Exhibit 8: Railroad-Specific Estimates of Allen-Uzawa Elasticities of Substitution

ATSF, BN, BNSF

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	ATSF	0.52103	0.58735	2.62156	1.65646	-0.23695	-0.68820
1988	ATSF	0.50975	0.58076	2.46945	1.65179	-0.09546	-0.48399
1989	ATSF	0.48630	0.56770	2.17254	1.72660	0.05500	-0.25979
1990	ATSF	0.50779	0.57085	2.30117	1.67205	0.02294	-0.34948
1991	ATSF	0.49685	0.56997	2.32627	1.63214	0.06517	-0.26571
1992	ATSF	0.47810	0.56522	2.26651	1.62298	0.12983	-0.14835
1993	ATSF	0.47063	0.56198	2.25223	1.61065	0.16292	-0.09725
1994	ATSF	0.45894	0.55616	2.23906	1.58938	0.21104	-0.02524
1995	ATSF	0.46828	0.54848	2.17228	1.59386	0.26068	0.00547
1987	BN	0.45786	0.57808	2.18690	1.78836	-0.06341	-0.31102
1988	BN	0.44918	0.57412	2.14866	1.76225	0.01420	-0.20744
1989	BN	0.44972	0.56818	2.08707	1.77633	0.06288	-0.16494
1990	BN	0.45654	0.56248	2.04178	1.79240	0.09528	-0.15383
1991	BN	0.46452	0.55766	2.03456	1.76010	0.14757	-0.11550
1992	BN	0.47178	0.55544	2.06498	1.70947	0.18504	-0.08653
1993	BN	0.47201	0.55011	2.03649	1.70122	0.22535	-0.04563
1994	BN	0.46157	0.54593	2.02521	1.67866	0.26526	0.01843
1995	BN	0.44672	0.54089	2.00147	1.66787	0.30144	0.08174
1996	BNSF	0.47133	0.53537	2.05254	1.61466	0.33234	0.07045
1997	BNSF	0.46088	0.52762	1.99776	1.62230	0.36973	0.12518
1998	BNSF	0.44383	0.52048	1.99043	1.60382	0.40198	0.18321
1999	BNSF	0.43409	0.51052	1.94022	1.61064	0.43758	0.22937
2000	BNSF	0.44928	0.50973	1.95121	1.60105	0.44083	0.21143
2001	BNSF	0.44852	0.50294	1.93662	1.59434	0.46300	0.23326
2002	BNSF	0.44466	0.49076	1.88664	1.60226	0.49720	0.26961
2003	BNSF	0.44509	0.48397	1.83488	1.62938	0.51173	0.28072
2004	BNSF	0.42909	0.47572	1.79768	1.64665	0.52823	0.31369
2005	BNSF	0.43453	0.47237	1.78524	1.65168	0.53496	0.31260
2006	BNSF	0.43466	0.46679	1.74799	1.68142	0.54164	0.31517

CNGT, GTW, IC

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
2002	CNGT	0.54151	0.50725	2.14286	1.50812	0.43490	0.03792
2003	CNGT	0.54244	0.49738	2.03415	1.53649	0.47070	0.07895
2004	CNGT	0.54342	0.48935	1.99373	1.54120	0.49499	0.10525
2005	CNGT	0.55178	0.48665	1.99973	1.53476	0.50063	0.09397
2006	CNGT	0.55993	0.48548	2.01637	1.52616	0.50162	0.07693
1987	GTW	0.53823	0.58849	2.69169	1.70632	-0.39230	-0.96555
1988	GTW	0.53233	0.58281	2.53672	1.70243	-0.24068	-0.75326
1989	GTW	0.54260	0.58096	2.58146	1.66720	-0.20741	-0.75229
1990	GTW	0.54833	0.57304	2.44811	1.69410	-0.12883	-0.69040
1991	GTW	0.55578	0.56655	2.38618	1.68997	-0.05805	-0.63547
1992	GTW	0.53862	0.55065	2.12328	1.74695	0.10465	-0.38138
1993	GTW	0.54146	0.56169	2.29375	1.66118	0.06421	-0.41702
1994	GTW	0.54328	0.55824	2.26900	1.65299	0.10057	-0.37819
1995	GTW	0.54075	0.55147	2.21705	1.63400	0.17511	-0.27624
1996	GTW	0.49110	0.53991	1.96109	1.74783	0.25094	-0.07280
1997	GTW	0.42862	0.53536	1.86577	1.79137	0.29293	0.08916
1998	GTW	0.43924	0.53592	2.00211	1.64506	0.33208	0.12435
1987	IC	0.54097	0.58699	2.68641	1.68467	-0.34052	-0.91068
1988	IC	0.52418	0.57733	2.39635	1.71995	-0.14049	-0.60486
1989	IC	0.51547	0.55565	2.09094	1.84859	0.00099	-0.45135
1990	IC	0.51880	0.54980	2.05090	1.86376	0.03319	-0.43289
1991	IC	0.51691	0.55186	2.06266	1.81679	0.07128	-0.36477
1992	IC	0.52457	0.54890	2.06572	1.77200	0.12546	-0.31450
1993	IC	0.52082	0.54872	2.06990	1.73626	0.16302	-0.24871
1994	IC	0.51799	0.54949	2.10950	1.67926	0.19786	-0.18766
1995	IC	0.50001	0.54848	2.11748	1.64233	0.23771	-0.09050
1996	IC	0.52013	0.54371	2.12966	1.62504	0.25800	-0.11767
1997	IC	0.52282	0.53959	2.14263	1.59828	0.28804	-0.08822
1998	IC	0.51377	0.53213	2.12301	1.57561	0.33752	-0.00984

CR

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	CR	0.52503	0.58543	2.57559	1.67582	-0.23160	-0.70291
1988	CR	0.51815	0.58101	2.49292	1.65652	-0.12171	-0.54513
1989	CR	0.52876	0.57656	2.47939	1.64073	-0.07340	-0.52793
1990	CR	0.52870	0.57151	2.39461	1.64767	-0.01078	-0.45576
1991	CR	0.53710	0.57026	2.44988	1.61667	0.00238	-0.46716
1992	CR	0.53361	0.56790	2.49038	1.57680	0.04605	-0.40008
1993	CR	0.53330	0.56410	2.50089	1.55319	0.08668	-0.35135
1994	CR	0.51921	0.55881	2.44414	1.54144	0.15019	-0.23536
1995	CR	0.51295	0.55152	2.37011	1.53686	0.21356	-0.14719
1996	CR	0.51456	0.54726	2.32860	1.53731	0.24393	-0.11704
1997	CR	0.49924	0.52814	2.03156	1.61190	0.35856	0.04251
1998	CR	0.50219	0.52922	2.24385	1.51394	0.34889	0.02455

CSX

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	CSX	0.50648	0.58039	2.39092	1.70481	-0.12026	-0.50888
1988	CSX	0.50042	0.57625	2.33838	1.68313	-0.03459	-0.39015
1989	CSX	0.49696	0.57118	2.26011	1.69172	0.02533	-0.31619
1990	CSX	0.49600	0.56572	2.18770	1.70610	0.07404	-0.26395
1991	CSX	0.50943	0.56431	2.25586	1.65253	0.09810	-0.26890
1992	CSX	0.51275	0.56068	2.27559	1.61805	0.13950	-0.22903
1993	CSX	0.51703	0.55586	2.27933	1.59323	0.18062	-0.19364
1994	CSX	0.51060	0.55040	2.26558	1.57162	0.22846	-0.12285
1995	CSX	0.50758	0.54506	2.25066	1.55711	0.26563	-0.07481
1996	CSX	0.51086	0.53953	2.24106	1.54405	0.29690	-0.04853
1997	CSX	0.50307	0.53276	2.21884	1.53159	0.33507	0.00959
1998	CSX	0.49639	0.52213	2.20494	1.51064	0.38261	0.07194
1999	CSX	0.51697	0.51644	2.22620	1.49355	0.39988	0.04828
2000	CSX	0.52229	0.51683	2.11325	1.53823	0.40536	0.04724
2001	CSX	0.51043	0.50669	2.04223	1.54573	0.44715	0.11752
2002	CSX	0.50636	0.49749	2.03255	1.53038	0.47743	0.15730
2003	CSX	0.51003	0.49281	1.99357	1.54131	0.49153	0.16621
2004	CSX	0.50146	0.48665	1.97735	1.53737	0.50942	0.19978
2005	CSX	0.50408	0.48323	1.99475	1.52254	0.51769	0.20384
2006	CSX	0.51245	0.48056	1.96604	1.53324	0.52448	0.19743

KCS

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	KCS	0.49017	0.58656	2.40510	1.74361	-0.21180	-0.55671
1988	KCS	0.49895	0.58232	2.38750	1.71536	-0.13948	-0.50476
1989	KCS	0.50551	0.57762	2.34519	1.70859	-0.08210	-0.46421
1990	KCS	0.50680	0.57159	2.25709	1.72958	-0.02653	-0.41253
1991	KCS	0.51432	0.57200	2.34574	1.65988	0.00511	-0.38888
1992	KCS	0.50665	0.56798	2.31834	1.63352	0.07302	-0.28593
1993	KCS	0.50879	0.56270	2.29536	1.61497	0.12651	-0.23187
1994	KCS	0.56135	0.55673	2.51086	1.53950	0.11827	-0.41149
1995	KCS	0.54334	0.54986	2.32699	1.56302	0.20415	-0.24276
1996	KCS	0.55387	0.54228	2.25042	1.57543	0.24623	-0.22511
1997	KCS	0.53966	0.52801	2.04354	1.63326	0.32864	-0.09043
1998	KCS	0.53069	0.53148	2.15428	1.56473	0.33286	-0.05508
1999	KCS	0.52839	0.52288	2.07959	1.57577	0.37530	-0.00117
2000	KCS	0.55149	0.51792	2.03880	1.60218	0.37779	-0.05945
2001	KCS	0.56372	0.50740	2.02103	1.58634	0.41724	-0.04233
2002	KCS	0.56280	0.50168	2.02424	1.56395	0.44419	-0.00359
2003	KCS	0.56722	0.49506	1.98075	1.57796	0.46172	0.00513
2004	KCS	0.57187	0.49171	1.97269	1.57770	0.46990	0.00301
2005	KCS	0.56744	0.48789	1.93276	1.59499	0.48035	0.02542
2006	KCS	0.55288	0.48106	1.86713	1.62427	0.49981	0.08035

NS

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	NS	0.53527	0.58405	2.62825	1.64961	-0.21933	-0.72886
1988	NS	0.52629	0.57913	2.52207	1.63500	-0.10115	-0.54980
1989	NS	0.52395	0.57423	2.42562	1.64278	-0.03200	-0.46217
1990	NS	0.51072	0.57095	2.32421	1.65961	0.02383	-0.35603
1991	NS	0.52173	0.56813	2.38774	1.61246	0.05633	-0.34987
1992	NS	0.52102	0.56405	2.41322	1.57621	0.10434	-0.29138
1993	NS	0.51670	0.55844	2.37992	1.56078	0.15968	-0.21622
1994	NS	0.50798	0.55315	2.36149	1.54367	0.20570	-0.14276
1995	NS	0.50135	0.54616	2.29087	1.54340	0.25887	-0.06854
1996	NS	0.50582	0.54298	2.27943	1.53881	0.27673	-0.05962
1997	NS	0.50146	0.53615	2.27173	1.52162	0.31426	-0.01072
1998	NS	0.49779	0.52604	2.32892	1.48244	0.35137	0.03028
1999	NS	0.52994	0.52005	2.27226	1.48849	0.37908	-0.00431
2000	NS	0.52628	0.52055	2.18951	1.51652	0.38552	0.01482
2001	NS	0.53636	0.51619	2.29985	1.47400	0.38935	-0.00943
2002	NS	0.53295	0.50589	2.28954	1.45824	0.42655	0.03893
2003	NS	0.53310	0.49932	2.23258	1.46279	0.45370	0.07197
2004	NS	0.52385	0.49264	2.23552	1.45177	0.47247	0.10955
2005	NS	0.53434	0.49318	2.22305	1.45619	0.47213	0.08987
2006	NS	0.54375	0.48998	2.17824	1.46511	0.48478	0.08764

SOO

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	SOO	0.57746	0.57949	2.79144	1.66503	-0.35852	-1.14170
1988	SOO	0.58617	0.57304	2.71784	1.64930	-0.25265	-1.04735
1989	SOO	0.59114	0.56760	2.64062	1.64854	-0.17993	-0.97680
1990	SOO	0.57646	0.56536	2.48931	1.66436	-0.09158	-0.77454
1991	SOO	0.57640	0.56544	2.53484	1.61759	-0.04593	-0.69977
1992	SOO	0.58038	0.56281	2.56065	1.58686	-0.00452	-0.65791
1993	SOO	0.58366	0.56069	2.62141	1.55138	0.02419	-0.63112
1994	SOO	0.59568	0.55663	2.74641	1.50980	0.03712	-0.67267
1995	SOO	0.57805	0.55353	2.67533	1.49585	0.10783	-0.49547
1996	SOO	0.57934	0.54829	2.58352	1.50009	0.15938	-0.42998
1997	SOO	0.55582	0.54496	2.45404	1.50810	0.22150	-0.26340
1998	SOO	0.55257	0.53563	2.51149	1.46782	0.26985	-0.20045
1999	SOO	0.55361	0.53158	2.47717	1.46629	0.29492	-0.17207
2000	SOO	0.55885	0.52533	2.20806	1.53480	0.34736	-0.11244
2001	SOO	0.55660	0.51843	2.17128	1.52928	0.38272	-0.06202
2002	SOO	0.55750	0.51294	2.20750	1.50111	0.40430	-0.03871
2003	SOO	0.55917	0.50402	2.09722	1.52686	0.44112	0.00389
2004	SOO	0.56200	0.49859	2.03839	1.54578	0.45803	0.01713
2005	SOO	0.58335	0.49567	2.06678	1.53586	0.45649	-0.04216
2006	SOO	0.58090	0.49027	2.02576	1.54376	0.47531	-0.01093

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	Lab-Equip	Lab-Mat	Lab-Fuel	Equip-Mat	Equip-Fuel	Mat-Fuel
1987	CNW	0.56835	0.58054	2.72866	1.69687	-0.37709	-1.11987
1988	CNW	0.54477	0.57394	2.43595	1.71428	-0.15433	-0.71145
1989	CNW	0.56242	0.57317	2.54251	1.66598	-0.15403	-0.78326
1990	CNW	0.56553	0.56658	2.43437	1.69023	-0.09531	-0.73095
1991	CNW	0.56721	0.56324	2.40410	1.66965	-0.03226	-0.65023
1992	CNW	0.56649	0.56226	2.42071	1.63243	0.01577	-0.57439
1993	CNW	0.55992	0.55928	2.37204	1.61991	0.07462	-0.46807
1994	CNW	0.54626	0.55462	2.26998	1.62665	0.14320	-0.33229
1987	DRGW	0.54753	0.58718	2.74389	1.67288	-0.36296	-0.96995
1988	DRGW	0.53842	0.58122	2.55414	1.67911	-0.20847	-0.73690
1989	DRGW	0.53094	0.57771	2.45887	1.67933	-0.12533	-0.60493
1990	DRGW	0.53260	0.57186	2.36425	1.69489	-0.06174	-0.54067
1991	DRGW	0.54093	0.57343	2.48777	1.63081	-0.05496	-0.55290
1992	DRGW	0.52960	0.56888	2.38961	1.62844	0.02871	-0.41018
1993	DRGW	0.52271	0.56658	2.37506	1.60998	0.07207	-0.33487
1987	MKT	0.60290	0.59174	3.79650	1.56971	-0.87120	-2.04754
1987	SP	0.51043	0.58914	2.61445	1.65704	-0.23800	-0.64585
1988	SP	0.51362	0.58417	2.57438	1.63176	-0.14694	-0.55335
1989	SP	0.51001	0.57674	2.39856	1.65961	-0.04510	-0.43011
1990	SP	0.51644	0.56718	2.26728	1.68329	0.04068	-0.36023
1991	SP	0.52020	0.56721	2.34351	1.62954	0.06292	-0.33904
1992	SP	0.51373	0.56338	2.32882	1.60537	0.11656	-0.25660
1993	SP	0.50793	0.55972	2.30418	1.59361	0.15685	-0.19508
1994	SP	0.48966	0.55259	2.24041	1.58305	0.22490	-0.07647
1995	SP	0.49406	0.54518	2.22539	1.56403	0.27132	-0.03770
1996	SP	0.47935	0.53929	2.10955	1.59642	0.31125	0.03452
1987	SSW	0.55051	0.59002	2.87123	1.64603	-0.41386	-1.04289
1988	SSW	0.53921	0.58437	2.68609	1.62951	-0.22452	-0.74970
1989	SSW	0.52701	0.57829	2.48611	1.65110	-0.10020	-0.55394
1987	UP	0.48660	0.58437	2.42104	1.68148	-0.11725	-0.43281
1988	UP	0.48536	0.57926	2.37806	1.65880	-0.03466	-0.34000
1989	UP	0.48207	0.57536	2.32539	1.65686	0.01691	-0.27684
1990	UP	0.48124	0.57198	2.27524	1.66346	0.05216	-0.23886
1991	UP	0.47174	0.56793	2.26374	1.63598	0.10804	-0.15568
1992	UP	0.45938	0.56257	2.22770	1.62187	0.16311	-0.07271
1993	UP	0.44623	0.55771	2.20449	1.60911	0.20461	-0.00636
1994	UP	0.43429	0.55073	2.17367	1.59678	0.25245	0.05953
1995	UP	0.44260	0.54456	2.13395	1.59576	0.28875	0.07938
1996	UP	0.43247	0.53936	2.08862	1.60202	0.31778	0.12282
1997	UP	0.45842	0.53095	2.08539	1.57975	0.35672	0.11743
1998	UP	0.45699	0.52185	2.08330	1.55723	0.39465	0.15559
1999	UP	0.44029	0.51309	2.07713	1.54201	0.42506	0.20768
2000	UP	0.45090	0.51184	1.98043	1.58767	0.43404	0.20295
2001	UP	0.44969	0.50429	1.97730	1.57229	0.45898	0.22799
2002	UP	0.43849	0.49320	1.96068	1.56051	0.49052	0.27155
2003	UP	0.44225	0.48835	1.90796	1.58266	0.50420	0.27951
2004	UP	0.45076	0.48515	1.88213	1.59359	0.51233	0.27582
2005	UP	0.46262	0.48199	1.85601	1.60693	0.51908	0.26562
2006	UP	0.46727	0.47692	1.84677	1.60389	0.53124	0.27086

Exhibit 9: Railroad-Specific Estimates of Capital Employment Statistics

ATSF, BN, BNSF

Year	Railroad	Shadow P_K	Imputed P_K	$[P_K K / C^V]$	Q RATIO
1987	ATSF	0.039113	0.06490	0.20532	0.60263
1988	ATSF	0.042187	0.06806	0.19907	0.61989
1989	ATSF	0.050685	0.06628	0.16093	0.76465
1990	ATSF	0.044138	0.07627	0.21194	0.57874
1991	ATSF	0.043711	0.07816	0.21857	0.55923
1992	ATSF	0.044184	0.06996	0.19294	0.63158
1993	ATSF	0.044799	0.07990	0.21692	0.56068
1994	ATSF	0.045128	0.08826	0.23783	0.51131
1995	ATSF	0.030045	0.12618	0.52293	0.23811
1987	BN	0.033494	0.05693	0.21876	0.58835
1988	BN	0.035280	0.05886	0.21407	0.59942
1989	BN	0.036025	0.05554	0.19733	0.64859
1990	BN	0.036336	0.05902	0.20732	0.61563
1991	BN	0.036562	0.05023	0.17477	0.72793
1992	BN	0.036431	0.05953	0.20739	0.61200
1993	BN	0.035681	0.06144	0.21806	0.58075
1994	BN	0.038195	0.06931	0.22935	0.55106
1995	BN	0.042096	0.07698	0.23071	0.54683
1996	BNSF	0.038714	0.11115	0.37350	0.34831
1997	BNSF	0.040258	0.11761	0.37977	0.34231
1998	BNSF	0.043279	0.12438	0.37347	0.34795
1999	BNSF	0.049666	0.15101	0.39425	0.32890
2000	BNSF	0.047630	0.14905	0.40524	0.31956
2001	BNSF	0.047905	0.14190	0.38301	0.33759
2002	BNSF	0.046855	0.14392	0.39662	0.32556
2003	BNSF	0.049728	0.14539	0.37722	0.34202
2004	BNSF	0.060314	0.16227	0.34653	0.37169
2005	BNSF	0.070855	0.21003	0.38168	0.33736
2006	BNSF	0.081140	0.19070	0.30275	0.42549

CNGT, GTW, IC

Year	Railroad	Shadow P_K	Imputed P_K	[$P_K K/C^V$]	Q RATIO
2002	CNGT	0.041715	0.22191	0.61317	0.18798
2003	CNGT	0.044726	0.24823	0.63940	0.18018
2004	CNGT	0.048971	0.29791	0.70649	0.16438
2005	CNGT	0.055222	0.39389	0.82839	0.14020
2006	CNGT	0.060658	0.38477	0.73646	0.15765
1987	GTW	0.065219	0.05945	0.09770	1.09711
1988	GTW	0.065831	0.05911	0.09591	1.11361
1989	GTW	0.063804	0.05644	0.09418	1.13055
1990	GTW	0.065103	0.06282	0.10246	1.03627
1991	GTW	0.063385	0.06287	0.10500	1.00821
1992	GTW	0.069457	0.06485	0.09857	1.07099
1993	GTW	0.059009	0.06277	0.11195	0.94003
1994	GTW	0.064753	0.07381	0.11966	0.87731
1995	GTW	0.063139	0.23500	0.38949	0.26868
1996	GTW	0.061582	0.03247	0.05505	1.89631
1997	GTW	0.052253	0.03611	0.07180	1.44699
1998	GTW	0.049357	0.03435	0.07225	1.43696
1987	IC	0.015415	0.04736	0.36632	0.32544
1988	IC	0.015918	0.04945	0.36905	0.32188
1989	IC	0.019222	0.04443	0.27101	0.43263
1990	IC	0.016884	0.04471	0.30963	0.37761
1991	IC	0.017060	0.04498	0.30727	0.37925
1992	IC	0.018319	0.05132	0.32556	0.35694
1993	IC	0.018263	0.05472	0.34718	0.33374
1994	IC	0.020461	0.06555	0.37018	0.31215
1995	IC	0.021057	0.06555	0.35881	0.32122
1996	IC	0.021677	0.07741	0.41059	0.28005
1997	IC	0.022226	0.08576	0.44276	0.25915
1998	IC	0.023219	0.07732	0.38119	0.30029

CR

Year	Railroad	Shadow P_K	Imputed P_K	[$P_K K/C^V$]	Q RATIO
1987	CR	0.017905	0.031645	0.23110	0.56581
1988	CR	0.018395	0.033750	0.23934	0.54503
1989	CR	0.018372	0.032699	0.23157	0.56184
1990	CR	0.019040	0.040005	0.27262	0.47595
1991	CR	0.018941	0.031304	0.21384	0.60507
1992	CR	0.018846	0.040219	0.27533	0.46860
1993	CR	0.019530	0.041570	0.27384	0.46980
1994	CR	0.021066	0.043270	0.26347	0.48684
1995	CR	0.021464	0.041544	0.24754	0.51666
1996	CR	0.022426	0.046889	0.26667	0.47827
1997	CR	0.028332	0.055023	0.24702	0.51491
1998	CR	0.026409	0.052465	0.25199	0.50337

CSX

Year	Railroad	Shadow P_K	Imputed P_K	$[P_K K/C^V]$	Q RATIO
1987	CSX	0.037955	0.05598	0.19081	0.67795
1988	CSX	0.036482	0.05151	0.18220	0.70819
1989	CSX	0.036371	0.06159	0.21794	0.59050
1990	CSX	0.037009	0.06654	0.23078	0.55620
1991	CSX	0.035914	0.05687	0.20273	0.63150
1992	CSX	0.037509	0.06144	0.20908	0.61048
1993	CSX	0.038098	0.07545	0.25190	0.50495
1994	CSX	0.041438	0.08560	0.26193	0.48407
1995	CSX	0.043765	0.08197	0.23670	0.53394
1996	CSX	0.045723	0.09328	0.25717	0.49019
1997	CSX	0.048268	0.10186	0.26535	0.47389
1998	CSX	0.048455	0.09580	0.24818	0.50578
1999	CSX	0.056257	0.09221	0.20541	0.61012
2000	CSX	0.038658	0.06249	0.20736	0.61858
2001	CSX	0.041771	0.06453	0.19772	0.64726
2002	CSX	0.041369	0.06841	0.21120	0.60470
2003	CSX	0.042985	0.07012	0.20796	0.61306
2004	CSX	0.038419	0.09546	0.32028	0.40246
2005	CSX	0.044031	0.13701	0.40001	0.32136
2006	CSX	0.051252	0.13081	0.32766	0.39180

KCS

Year	Railroad	Shadow P_K	Imputed P_K	$[P_K K/C^V]$	Q RATIO
1987	KCS	0.034145	0.06987	0.22244	0.48867
1988	KCS	0.034521	0.06643	0.20837	0.51969
1989	KCS	0.033004	0.07424	0.24387	0.44454
1990	KCS	0.034887	0.08156	0.25297	0.42773
1991	KCS	0.036668	0.08853	0.26050	0.41417
1992	KCS	0.038828	0.08789	0.24378	0.44179
1993	KCS	0.039297	0.10020	0.27433	0.39220
1994	KCS	0.042456	0.13798	0.35652	0.30769
1995	KCS	0.042375	0.13330	0.34572	0.31789
1996	KCS	0.041831	0.14235	0.37305	0.29386
1997	KCS	0.044085	0.12260	0.30406	0.35958
1998	KCS	0.041983	0.12631	0.32796	0.33237
1999	KCS	0.045142	0.13003	0.31348	0.34715
2000	KCS	0.046168	0.13769	0.32343	0.33531
2001	KCS	0.046437	0.13682	0.32088	0.33939
2002	KCS	0.043677	0.13160	0.32890	0.33190
2003	KCS	0.046124	0.13621	0.32190	0.33863
2004	KCS	0.049682	0.14295	0.31340	0.34755
2005	KCS	0.058018	0.14877	0.28014	0.38999
2006	KCS	0.071047	0.16605	0.25460	0.42787

NS

Year	Railroad	Shadow P_K	Imputed P_K	$[P_K K/C^V]$	Q RATIO
1987	NS	0.039225	0.06217	0.20073	0.63094
1988	NS	0.040683	0.08392	0.26067	0.48480
1989	NS	0.040483	0.08205	0.25551	0.49341
1990	NS	0.041609	0.08612	0.26025	0.48317
1991	NS	0.040503	0.07294	0.22589	0.55532
1992	NS	0.041197	0.09050	0.27507	0.45524
1993	NS	0.042400	0.09730	0.28666	0.43579
1994	NS	0.045103	0.11150	0.30821	0.40452
1995	NS	0.047078	0.11344	0.29981	0.41501
1996	NS	0.048544	0.12536	0.32053	0.38723
1997	NS	0.051222	0.13077	0.31622	0.39170
1998	NS	0.048761	0.11897	0.30198	0.40987
1999	NS	0.064509	0.11228	0.21513	0.57456
2000	NS	0.040001	0.05880	0.18701	0.68028
2001	NS	0.035618	0.05451	0.19429	0.65339
2002	NS	0.034901	0.05442	0.19752	0.64135
2003	NS	0.037630	0.05516	0.18524	0.68225
2004	NS	0.030393	0.08194	0.34676	0.37092
2005	NS	0.036509	0.11028	0.38761	0.33105
2006	NS	0.041760	0.10283	0.31541	0.40609

SOO

Year	Railroad	Shadow P_K	Imputed P_K	$[P_K K/C^V]$	Q RATIO
1987	SOO	0.053564	0.08290	0.17260	0.64612
1988	SOO	0.050890	0.08577	0.18745	0.59333
1989	SOO	0.054900	0.07283	0.14633	0.75383
1990	SOO	0.052158	0.08957	0.18999	0.58230
1991	SOO	0.051774	0.08440	0.17987	0.61343
1992	SOO	0.052384	0.07920	0.16656	0.66139
1993	SOO	0.051853	0.08937	0.18953	0.58021
1994	SOO	0.049567	0.08940	0.19806	0.55446
1995	SOO	0.084543	0.07219	0.09131	1.17108
1996	SOO	0.085567	0.12071	0.15079	0.70886
1997	SOO	0.070380	0.11639	0.17699	0.60471
1998	SOO	0.067370	0.11179	0.17785	0.60264
1999	SOO	0.071943	0.13033	0.19389	0.55201
2000	SOO	0.073048	0.14424	0.21090	0.50644
2001	SOO	0.073503	0.14453	0.20970	0.50857
2002	SOO	0.070191	0.14673	0.22273	0.47837
2003	SOO	0.073729	0.14288	0.20632	0.51603
2004	SOO	0.081643	0.14540	0.18962	0.56150
2005	SOO	0.094034	0.21940	0.24790	0.42859
2006	SOO	0.099441	0.20210	0.21600	0.49205

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	Shadow P_K	Imputed P_K	$[P_K K/C^V]$	Q RATIO
1987	CNW	0.033743	0.05235	0.18265	0.64461
1988	CNW	0.036671	0.05418	0.17346	0.67678
1989	CNW	0.038071	0.06741	0.20656	0.56480
1990	CNW	0.037850	0.07551	0.23207	0.50129
1991	CNW	0.034044	0.07480	0.25625	0.45515
1992	CNW	0.034351	0.08549	0.28952	0.40183
1993	CNW	0.035015	0.08929	0.29595	0.39215
1994	CNW	0.036941	0.09689	0.30377	0.38126
1987	DRGW	0.031745	0.07318	0.25572	0.43377
1988	DRGW	0.034135	0.07894	0.25572	0.43242
1989	DRGW	0.035286	0.07394	0.23109	0.47720
1990	DRGW	0.035845	0.08059	0.24733	0.44477
1991	DRGW	0.035051	0.07876	0.24648	0.44503
1992	DRGW	0.035930	0.07801	0.23754	0.46057
1993	DRGW	0.037437	0.07560	0.21966	0.49519
1987	MKT	0.038372	0.05788	0.16317	0.66294
1987	SP	0.040690	0.07109	0.21531	0.57240
1988	SP	0.039052	0.06723	0.21204	0.58089
1989	SP	0.040802	0.07359	0.22180	0.55447
1990	SP	0.044593	0.08632	0.23748	0.51660
1991	SP	0.044525	0.07690	0.21124	0.57897
1992	SP	0.046879	0.09177	0.23897	0.51080
1993	SP	0.048627	0.09582	0.24004	0.50749
1994	SP	0.054890	0.11162	0.24666	0.49177
1995	SP	0.064658	0.11818	0.22128	0.54711
1996	SP	0.068989	0.13104	0.22921	0.52647
1987	SSW	0.039634	0.08659	0.24090	0.45772
1988	SSW	0.041814	0.07830	0.20623	0.53405
1989	SSW	0.046970	0.08890	0.20792	0.52837
1987	UP	0.042993	0.06566	0.19433	0.65479
1988	UP	0.046102	0.07465	0.20579	0.61758
1989	UP	0.044311	0.07332	0.21046	0.60436
1990	UP	0.042991	0.07534	0.22345	0.57063
1991	UP	0.044165	0.06476	0.18660	0.68192
1992	UP	0.044807	0.08184	0.23204	0.54749
1993	UP	0.044143	0.08316	0.23889	0.53084
1994	UP	0.042203	0.08527	0.25679	0.49496
1995	UP	0.038468	0.09697	0.32616	0.39671
1996	UP	0.041231	0.10884	0.34086	0.37881
1997	UP	0.051147	0.14490	0.37015	0.35298
1998	UP	0.048534	0.12796	0.34399	0.37928
1999	UP	0.054117	0.15835	0.38142	0.34176
2000	UP	0.056321	0.16559	0.38280	0.34012
2001	UP	0.057008	0.16849	0.38432	0.33835
2002	UP	0.055733	0.16325	0.38062	0.34140
2003	UP	0.058952	0.16321	0.35943	0.36121
2004	UP	0.063902	0.16515	0.33525	0.38694
2005	UP	0.071739	0.20715	0.37454	0.34632
2006	UP	0.078289	0.19133	0.31708	0.40918

Exhibit 10: Railroad-Specific Estimates of Marginal Cost and Year-to-Year Changes in Marginal Cost

ATSF, BN, BNSF

Year	Railroad	MC	% Δ MC
1987	ATSF	0.024266	.
1988	ATSF	0.022429	-0.07571
1989	ATSF	0.022497	0.00306
1990	ATSF	0.020167	-0.10358
1991	ATSF	0.016135	-0.19991
1992	ATSF	0.012599	-0.21920
1993	ATSF	0.010546	-0.16295
1994	ATSF	0.009058	-0.14105
1995	ATSF	0.009877	0.09043
1987	BN	0.014926	0.51110
1988	BN	0.013226	-0.11384
1989	BN	0.012515	-0.05377
1990	BN	0.012234	-0.02244
1991	BN	0.012045	-0.01552
1992	BN	0.011575	-0.03898
1993	BN	0.010668	-0.07840
1994	BN	0.009590	-0.10105
1995	BN	0.008559	-0.10751
1996	BNSF	0.012154	.
1997	BNSF	0.011654	-0.04108
1998	BNSF	0.010644	-0.08671
1999	BNSF	0.011169	0.04936
2000	BNSF	0.010703	-0.04174
2001	BNSF	0.010298	-0.03781
2002	BNSF	0.010251	-0.00462
2003	BNSF	0.010356	0.01027
2004	BNSF	0.010340	-0.00157
2005	BNSF	0.011615	0.12331
2006	BNSF	0.012358	0.06398

CNGT, GTW, IC

Year	Railroad	MC	% Δ MC
2002	CNGT	0.011684	.
2003	CNGT	0.012353	0.05728
2004	CNGT	0.014934	0.20893
2005	CNGT	0.017535	0.17417
2006	CNGT	0.019197	0.09480
1987	GTW	0.013707	.
1988	GTW	0.011258	-0.17866
1989	GTW	0.012531	0.11305
1990	GTW	0.014347	0.14492
1991	GTW	0.016111	0.12294
1992	GTW	0.014573	-0.09549
1993	GTW	0.007954	-0.45416
1994	GTW	0.008096	0.01784
1995	GTW	0.007645	-0.05580
1996	GTW	0.000699	-0.90856
1997	GTW	-0.005193	-8.42921
1998	GTW	-0.005117	-0.01472
1987	IC	0.014420	.
1988	IC	0.012335	-0.14459
1989	IC	0.012809	0.03839
1990	IC	0.010618	-0.17099
1991	IC	0.008636	-0.18670
1992	IC	0.009526	0.10307
1993	IC	0.007813	-0.17980
1994	IC	0.007413	-0.05126
1995	IC	0.005052	-0.31846
1996	IC	0.006763	0.33866
1997	IC	0.006836	0.01083
1998	IC	0.006254	-0.08518

CR

Year	Railroad	MC	% Δ MC
1987	CR	0.027676	.
1988	CR	0.025019	-0.09602
1989	CR	0.025914	0.03578
1990	CR	0.024837	-0.04156
1991	CR	0.024237	-0.02415
1992	CR	0.021644	-0.10700
1993	CR	0.020587	-0.04883
1994	CR	0.017934	-0.12887
1995	CR	0.017088	-0.04714
1996	CR	0.016625	-0.02714
1997	CR	0.019698	0.18488
1998	CR	0.016746	-0.14988

CSX

Year	Railroad	MC	% Δ MC
1987	CSX	0.030680	.
1988	CSX	0.026766	-0.12759
1989	CSX	0.024235	-0.09457
1990	CSX	0.022891	-0.05546
1991	CSX	0.022631	-0.01132
1992	CSX	0.022329	-0.01337
1993	CSX	0.022064	-0.01185
1994	CSX	0.021010	-0.04777
1995	CSX	0.019988	-0.04868
1996	CSX	0.020612	0.03125
1997	CSX	0.019280	-0.06461
1998	CSX	0.018914	-0.01898
1999	CSX	0.022058	0.16619
2000	CSX	0.019856	-0.09980
2001	CSX	0.018722	-0.05715
2002	CSX	0.017947	-0.04139
2003	CSX	0.017746	-0.01120
2004	CSX	0.017401	-0.01941
2005	CSX	0.018992	0.09144
2006	CSX	0.021425	0.12808

KCS

Year	Railroad	MC	% Δ MC
1987	KCS	0.003729	.
1988	KCS	0.004179	0.12063
1989	KCS	0.004465	0.06860
1990	KCS	0.004577	0.02499
1991	KCS	0.004638	0.01333
1992	KCS	0.003874	-0.16477
1993	KCS	0.004053	0.04620
1994	KCS	0.013608	2.35774
1995	KCS	0.010183	-0.25171
1996	KCS	0.011185	0.09836
1997	KCS	0.009980	-0.10765
1998	KCS	0.007149	-0.28372
1999	KCS	0.007389	0.03361
2000	KCS	0.009222	0.24804
2001	KCS	0.011858	0.28587
2002	KCS	0.011675	-0.01545
2003	KCS	0.012139	0.03972
2004	KCS	0.012657	0.04266
2005	KCS	0.012528	-0.01013
2006	KCS	0.010902	-0.12977

NS

Year	Railroad	MC	% Δ MC
1987	NS	0.033751	.
1988	NS	0.030450	-0.09780
1989	NS	0.028487	-0.06449
1990	NS	0.023617	-0.17093
1991	NS	0.023907	0.01227
1992	NS	0.022884	-0.04281
1993	NS	0.021407	-0.06452
1994	NS	0.019434	-0.09218
1995	NS	0.018430	-0.05164
1996	NS	0.017999	-0.02338
1997	NS	0.017466	-0.02962
1998	NS	0.017110	-0.02037
1999	NS	0.023296	0.36149
2000	NS	0.018829	-0.19176
2001	NS	0.018401	-0.02272
2002	NS	0.018018	-0.02082
2003	NS	0.018342	0.01799
2004	NS	0.018024	-0.01732
2005	NS	0.020594	0.14261
2006	NS	0.023340	0.13330

SOO

Year	Railroad	MC	% Δ MC
1987	SOO	0.022588	.
1988	SOO	0.023218	0.02788
1989	SOO	0.022816	-0.01733
1990	SOO	0.018029	-0.20981
1991	SOO	0.016791	-0.06864
1992	SOO	0.016915	0.00735
1993	SOO	0.016588	-0.01932
1994	SOO	0.018922	0.14070
1995	SOO	0.016321	-0.13743
1996	SOO	0.016553	0.01421
1997	SOO	0.011639	-0.29687
1998	SOO	0.012455	0.07008
1999	SOO	0.012792	0.02707
2000	SOO	0.011818	-0.07616
2001	SOO	0.011297	-0.04410
2002	SOO	0.011081	-0.01906
2003	SOO	0.011440	0.03238
2004	SOO	0.012089	0.05675
2005	SOO	0.016356	0.35296
2006	SOO	0.016358	0.00013

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	MC	% Δ MC
1987	CNW	0.025556	.
1988	CNW	0.021081	-0.17510
1989	CNW	0.023324	0.10641
1990	CNW	0.021779	-0.06627
1991	CNW	0.019894	-0.08652
1992	CNW	0.018378	-0.07620
1993	CNW	0.015813	-0.13960
1994	CNW	0.013044	-0.17507
1987	DRGW	0.012983	.
1988	DRGW	0.011501	-0.11415
1989	DRGW	0.009418	-0.18113
1990	DRGW	0.009094	-0.03436
1991	DRGW	0.008503	-0.06508
1992	DRGW	0.006606	-0.22303
1993	DRGW	0.005126	-0.22410
1987	MKT	0.020649	.
1987	SP	0.022649	.
1988	SP	0.022045	-0.02665
1989	SP	0.021439	-0.02749
1990	SP	0.020923	-0.02406
1991	SP	0.019351	-0.07515
1992	SP	0.017570	-0.09204
1993	SP	0.015765	-0.10269
1994	SP	0.012333	-0.21770
1995	SP	0.013919	0.12854
1996	SP	0.012039	-0.13508
1987	SSW	0.013167	.
1988	SSW	0.011795	-0.10418
1989	SSW	0.010418	-0.11675
1987	UP	0.021023	.
1988	UP	0.020084	-0.04464
1989	UP	0.018334	-0.08716
1990	UP	0.017504	-0.04526
1991	UP	0.015440	-0.11794
1992	UP	0.013573	-0.12091
1993	UP	0.011226	-0.17292
1994	UP	0.009893	-0.11874
1995	UP	0.011066	0.11858
1996	UP	0.010001	-0.09624
1997	UP	0.014916	0.49148
1998	UP	0.014520	-0.02658
1999	UP	0.013841	-0.04675
2000	UP	0.013967	0.00914
2001	UP	0.013495	-0.03379
2002	UP	0.012456	-0.07701
2003	UP	0.012707	0.02014
2004	UP	0.013462	0.05939
2005	UP	0.015441	0.14704
2006	UP	0.016679	0.08019

Exhibit 11: Railroad-Specific Year-to-Year Differences in Cost Function Variables

ATSF, BN, BNSF

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	ATSF	.	.	.	.	.	.	.	.
1988	ATSF	0.07064	-0.00488	-0.04781	0.08404	0.03888	0.00882	-0.12572	-0.03905
1989	ATSF	0.06835	-0.03369	-0.05001	0.25997	0.08262	0.01402	0.11447	0.10891
1990	ATSF	-0.05992	-0.05623	-0.05715	-0.21226	-0.04169	-0.00009	0.18344	-0.05828
1991	ATSF	0.03662	-0.09974	-0.06079	-0.05177	-0.01083	0.05818	-0.10054	0.02127
1992	ATSF	0.05773	-0.09676	-0.05437	0.01613	-0.06445	0.04803	-0.08742	0.00595
1993	ATSF	0.08367	-0.02476	-0.03402	-0.06152	-0.03013	0.00833	0.03977	0.01889
1994	ATSF	0.07166	-0.02179	-0.00251	-0.00011	0.07973	0.00952	-0.08849	0.02184
1995	ATSF	0.04358	0.08863	0.41987	0.03440	-0.18047	-0.01400	-0.00665	-0.08980
1987	BN	0.68025	0.94485	0.60430	-0.01580	-0.41330	-0.13280	0.07598	0.03822
1988	BN	0.08031	-0.00363	-0.05637	0.01482	0.00876	0.00882	-0.13420	-0.01253
1989	BN	0.03938	-0.00150	-0.04759	0.00074	-0.17740	0.01402	0.09249	0.02939
1990	BN	0.00756	-0.00618	-0.05100	-0.01058	-0.08824	-0.00009	0.19414	-0.02201
1991	BN	-0.00793	-0.00536	-0.05901	0.01480	-0.19756	0.05818	-0.09878	0.00526
1992	BN	0.00149	-0.01317	-0.04386	-0.02213	-0.01691	0.04803	-0.07417	-0.00715
1993	BN	0.01936	-0.02084	-0.04053	-0.02323	-0.19307	0.00833	-0.03800	0.01713
1994	BN	0.09340	-0.00571	-0.03622	-0.00685	0.05370	0.00952	-0.07009	0.01933
1995	BN	0.11870	0.00050	-0.03268	-0.00103	0.12276	-0.01400	-0.02463	0.05103
1996	BNSF	.	.	.	.	.	.	.	.
1997	BNSF	0.03238	-0.04209	-0.01316	0.06235	0.00329	0.00157	-0.00963	0.06663
1998	BNSF	0.09958	-0.01204	-0.00733	0.01145	0.11189	-0.00035	-0.10274	0.03667
1999	BNSF	0.03912	-0.00267	-0.04017	0.09555	0.05343	-0.01641	-0.06049	0.01341
2000	BNSF	0.00858	0.00366	-0.02517	-0.11532	0.02869	-0.02425	0.26999	-0.00730
2001	BNSF	0.01987	-0.00972	-0.02779	0.00648	-0.03718	0.00465	0.01093	0.01602
2002	BNSF	-0.02727	-0.01681	-0.02590	0.10907	-0.08921	-0.02382	-0.14736	-0.00987
2003	BNSF	0.03625	-0.00760	-0.01526	0.02880	-0.06261	-0.02040	0.17691	-0.00000
2004	BNSF	0.11651	-0.00360	-0.03137	0.07693	0.01699	0.03718	0.08783	-0.00027
2005	BNSF	0.04427	0.00012	-0.00535	0.01533	0.10895	0.05142	0.30975	-0.00000
2006	BNSF	0.07376	-0.00762	0.00788	0.00789	-0.26026	0.06854	0.24904	-0.00000

CNGT, GTW, IC

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
2002	CNGT	.	.	.	.	.	.	.	.
2003	CNGT	0.02990	0.01599	-0.00832	0.10873	-0.04309	-0.02040	0.11874	0.02788
2004	CNGT	0.06046	0.04943	0.13367	0.08597	0.05641	0.03718	0.11110	-0.16845
2005	CNGT	-0.01418	-0.01269	0.00057	0.00360	0.14966	0.05142	0.28748	-0.01899
2006	CNGT	0.02190	0.00015	-0.00544	-0.05347	-0.00375	0.06854	0.29138	0.05747
1987	GTW	.	.	.	.	.	.	.	.
1988	GTW	0.04585	-0.01281	-0.05470	0.04636	-0.07020	0.00882	-0.09225	0.03714
1989	GTW	0.02355	0.02963	-0.04702	-0.07549	-0.11367	0.01402	-0.01000	0.05330
1990	GTW	-0.04148	-0.03394	-0.04359	0.03420	-0.11067	-0.00009	0.19927	-0.01285
1991	GTW	-0.02295	-0.00216	-0.04550	0.03426	-0.22878	0.05818	0.02184	0.08632
1992	GTW	0.06918	0.00000	-0.04230	0.25272	-0.17660	0.04803	-0.10686	0.09183
1993	GTW	0.15941	0.00000	-0.04752	-0.36444	-0.22000	0.00833	-0.00533	0.05922
1994	GTW	0.04494	0.00000	-0.03814	-0.03676	-0.04786	0.00952	0.09002	-0.09036
1995	GTW	0.00295	-0.00978	-0.04719	0.03088	-0.09423	-0.01400	-0.21797	0.07735
1996	GTW	0.38140	0.00218	-0.03572	0.05345	-0.37803	-0.01365	0.16598	0.17013
1997	GTW	0.02842	-0.33147	-0.07359	0.13042	0.31801	0.00157	-0.04564	-0.06118
1998	GTW	-0.02718	-0.01992	-0.00974	-0.13897	0.23481	-0.00035	-0.43765	-0.01366
1987	IC	.	.	.	.	.	.	.	.
1988	IC	0.00141	-0.10000	-0.06189	0.12193	-0.17772	0.00882	-0.09701	-0.05248
1989	IC	0.01722	-0.00449	-0.22207	0.11791	-0.81789	0.01402	0.09501	-0.00814
1990	IC	0.01187	-0.04029	-0.04731	-0.10108	-0.39770	-0.00009	0.09407	0.07243
1991	IC	0.09985	-0.00253	-0.05590	-0.06237	-0.10191	0.05818	-0.03723	0.05633
1992	IC	-0.03270	-0.01237	-0.04667	0.06493	0.11922	0.04803	-0.05835	-0.02217
1993	IC	0.08189	-0.00551	-0.04901	-0.04258	0.07600	0.00833	-0.02686	0.10232
1994	IC	0.03987	-0.01932	-0.04593	0.02122	0.48422	0.00952	-0.01200	-0.01901
1995	IC	0.15206	-0.00867	-0.04208	-0.02341	0.35139	-0.01400	-0.06408	0.15992
1996	IC	-0.10719	-0.00722	-0.03917	-0.00978	0.04835	-0.01365	0.12185	-0.04665
1997	IC	0.00117	-0.00958	-0.03538	-0.02916	0.01192	0.00157	-0.04524	-0.01542
1998	IC	0.05281	-0.00193	-0.03981	0.01115	-0.08350	-0.00035	-0.23692	-0.02207

CR

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	CR	.	.	.	.	.	.	.	.
1988	CR	0.05191	-0.01739	-0.04465	0.02603	0.01491	0.00882	-0.12344	0.01299
1989	CR	-0.03904	-0.00329	-0.04940	0.01368	0.03170	0.01402	0.07617	-0.02032
1990	CR	0.02383	-0.01854	-0.05127	0.01495	0.01431	-0.00009	0.12915	0.00086
1991	CR	-0.01923	-0.02959	-0.05241	-0.04186	0.00618	0.05818	0.09821	0.01860
1992	CR	0.02127	-0.04592	-0.05349	-0.04996	-0.07470	0.04803	-0.14534	0.00315
1993	CR	0.03126	-0.00539	-0.05296	-0.03505	0.02603	0.00833	-0.03025	-0.00798
1994	CR	0.08244	-0.04159	-0.05541	0.00758	0.09223	0.00952	-0.05245	0.03987
1995	CR	-0.01857	-0.05879	-0.05370	0.05693	0.08493	-0.01400	-0.05764	0.02174
1996	CR	0.02189	-0.01488	-0.05129	-0.02071	0.01810	-0.01365	0.12951	0.00813
1997	CR	0.03092	0.02418	-0.04997	0.42189	0.01048	0.00157	-0.04838	0.01018
1998	CR	0.03779	-0.00037	-0.04970	-0.30353	0.04445	-0.00035	-0.22292	0.00034

CSX

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	CSX	.	.	.	.	.	.	.	.
1988	CSX	0.01337	-0.05342	-0.04658	0.015898	-0.00787	0.00882	-0.12384	0.05743
1989	CSX	0.02599	-0.04062	-0.04912	0.006149	-0.09764	0.01402	0.08042	0.02231
1990	CSX	0.01643	-0.03231	-0.04855	0.016626	-0.00974	-0.00009	0.15153	0.00921
1991	CSX	-0.02964	-0.00471	-0.04837	-0.041492	-0.01843	0.05818	-0.03022	0.02759
1992	CSX	0.01560	0.00270	-0.05523	0.006320	0.02903	0.04803	-0.05015	0.01595
1993	CSX	-0.01491	-0.00669	-0.06404	0.007739	0.06312	0.00833	-0.03503	0.04042
1994	CSX	0.05780	-0.00107	-0.05792	0.011847	0.08547	0.00952	-0.08231	-0.00174
1995	CSX	0.03807	-0.00610	-0.05936	-0.014085	0.06460	-0.01400	-0.01742	0.00653
1996	CSX	-0.01406	-0.00759	-0.04597	0.017075	0.15507	-0.01365	0.04748	-0.02088
1997	CSX	0.05373	-0.01191	-0.04525	0.001699	0.01188	0.00157	-0.06642	0.02447
1998	CSX	-0.00169	-0.00570	-0.03256	0.044062	-0.05471	-0.00035	-0.25758	-0.01919
1999	CSX	0.13162	0.25052	-0.02861	-0.065467	-0.15246	-0.01641	0.03978	0.07700
2000	CSX	0.11186	-0.00159	0.42432	-0.026372	0.08025	-0.02425	0.60973	0.04539
2001	CSX	0.07266	-0.00099	-0.04169	0.098670	-0.00187	0.00465	-0.07221	0.09935
2002	CSX	0.00270	-0.00590	-0.03781	0.014233	-0.02305	-0.02382	-0.15714	0.02604
2003	CSX	0.02380	-0.01387	-0.03171	-0.029872	-0.07646	-0.02040	0.17504	0.02262
2004	CSX	0.06140	-0.03058	0.20237	0.027160	0.07392	0.03718	0.08137	0.02666
2005	CSX	-0.00426	-0.03659	-0.05075	-0.016575	0.10869	0.05142	0.17607	-0.02082
2006	CSX	0.02219	-0.01144	-0.02479	0.000321	-0.09815	0.06854	0.31476	0.01643

KCS

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	KCS	.	.	.	.	.	.	.	.
1988	KCS	-0.00186	0.00956	-0.05904	-0.02032	-0.13843	0.00882	-0.07941	0.00728
1989	KCS	0.00529	0.00000	0.01744	-0.00390	-0.07700	0.01402	0.07429	0.00520
1990	KCS	0.03581	0.00000	-0.02972	0.01888	-0.00855	-0.00009	0.20664	-0.03615
1991	KCS	0.01407	0.00059	-0.04493	-0.03076	0.13758	0.05818	-0.09250	-0.00420
1992	KCS	0.07983	-0.00119	-0.02731	0.03029	0.04225	0.04803	-0.09516	0.00246
1993	KCS	0.03663	0.01887	-0.01573	-0.03133	-0.19639	0.00833	-0.10368	-0.05230
1994	KCS	0.12815	0.52013	0.30359	-0.06147	-0.07992	0.00952	-0.10176	-0.15488
1995	KCS	0.19559	0.01755	0.02894	0.04206	0.00018	-0.01400	0.07233	0.14664
1996	KCS	-0.04028	0.00782	-0.03947	-0.00178	-0.28886	-0.01365	0.06271	-0.01543
1997	KCS	0.06032	-0.03760	-0.04236	0.17023	-0.26181	0.00157	0.00006	0.08241
1998	KCS	0.11398	-0.03178	-0.04687	-0.24623	-0.08110	-0.00035	-0.18250	-0.00288
1999	KCS	0.02692	0.00000	-0.02627	0.05072	-0.09334	-0.01641	-0.00701	0.05674
2000	KCS	-0.10759	-0.02016	-0.05414	-0.01652	0.00813	-0.02425	0.46029	-0.06633
2001	KCS	0.00879	0.13842	0.06554	0.09007	-0.02246	0.00465	-0.10652	-0.03598
2002	KCS	0.00056	-0.00582	0.03748	-0.01403	0.03062	-0.02382	-0.10925	-0.01425
2003	KCS	0.01806	0.00000	-0.02266	-0.00430	-0.01796	-0.02040	0.19454	0.00801
2004	KCS	0.03386	-0.00390	-0.01204	-0.03632	-0.02799	0.03718	0.23666	0.02401
2005	KCS	0.17063	0.03988	0.04746	0.01146	0.11987	0.05142	0.36264	0.09627
2006	KCS	0.19160	-0.00659	-0.04532	0.01416	-0.24797	0.06854	0.16017	0.09824

NS

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	NS	.	.	.	.	.	.	.	.
1988	NS	0.06677	-0.01448	-0.04001	0.02943	-0.01125	0.008821	-0.13264	0.004059
1989	NS	-0.00661	-0.06379	-0.04290	0.02701	-0.00062	0.014022	0.11743	-0.006524
1990	NS	0.08177	-0.07231	-0.04719	-0.01314	0.06312	-0.000095	0.18537	0.073206
1991	NS	-0.04294	-0.00819	-0.04443	-0.01061	-0.00678	0.058183	-0.06968	0.027236
1992	NS	0.02934	-0.00122	-0.03128	-0.00445	-0.00379	0.048029	-0.12055	0.012352
1993	NS	0.04083	-0.00778	-0.04308	0.00661	0.00494	0.008325	-0.06635	0.035344
1994	NS	0.09090	0.00431	-0.03571	-0.01579	0.04613	0.009523	-0.04958	0.038001
1995	NS	0.03898	-0.01631	-0.03630	0.03895	0.04719	-0.014004	-0.01354	0.024421
1996	NS	0.02069	-0.00927	-0.04365	-0.05380	0.02294	-0.013654	0.15975	-0.013254
1997	NS	0.04620	0.00927	-0.03676	0.00039	0.03930	0.001570	-0.06848	0.015934
1998	NS	-0.01843	0.00055	-0.01330	-0.02907	-0.05366	-0.000353	-0.30867	-0.038926
1999	NS	0.21543	0.41254	-0.02453	0.01221	-0.25723	-0.016415	0.15964	0.052848
2000	NS	0.17654	-0.00133	0.52155	-0.10527	-0.02138	-0.024248	0.45737	0.025581
2001	NS	-0.08045	-0.00877	-0.03972	-0.11645	-0.04055	0.004651	-0.09227	-0.048807
2002	NS	-0.01769	-0.00051	-0.03828	0.01959	-0.02474	-0.023825	-0.19259	-0.008065
2003	NS	0.02255	-0.00176	-0.04298	0.02505	0.03097	-0.020400	0.08615	0.010301
2004	NS	0.07981	-0.00859	0.32288	0.00808	0.15412	0.037176	0.07572	0.020405
2005	NS	0.02217	-0.00715	-0.04358	-0.02116	0.12052	0.051419	0.42922	-0.008900
2006	NS	0.00511	-0.00203	-0.03335	0.01613	-0.16636	0.068540	0.25303	-0.011342

SOO

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	SOO	.	.	.	.	.	.	.	.
1988	SOO	-0.06250	-0.00034	-0.04324	0.03633	-0.11525	0.00882	-0.08061	-0.00781
1989	SOO	-0.00572	-0.00639	-0.13199	-0.00033	-0.09390	0.01402	0.08824	0.00914
1990	SOO	0.11235	-0.08629	0.04720	-0.04127	0.00665	-0.00009	0.15894	0.04746
1991	SOO	-0.00258	-0.04799	-0.04276	-0.02878	-0.03207	0.05818	-0.13258	-0.02404
1992	SOO	0.00158	-0.00238	-0.02536	-0.02019	-0.08095	0.04803	-0.05965	-0.08358
1993	SOO	0.00258	0.00575	-0.02736	-0.03007	0.13016	0.00833	-0.04441	0.04704
1994	SOO	-0.11080	0.01510	-0.02183	0.02196	0.22060	0.00952	-0.07948	0.00351
1995	SOO	0.19097	-0.00175	-0.41671	-0.04905	0.17993	-0.01400	-0.02180	0.05426
1996	SOO	-0.00798	-0.02968	-0.00522	0.02903	0.10503	-0.01365	0.14171	-0.00791
1997	SOO	-0.13940	-0.39230	0.01976	-0.01892	-0.00371	0.00157	0.01986	-0.12208
1998	SOO	-0.05089	-0.00179	0.02205	0.03800	0.14533	-0.00035	-0.31718	0.01351
1999	SOO	0.00821	-0.02931	-0.02191	-0.02665	0.06596	-0.01641	0.14068	0.02809
2000	SOO	0.06571	-0.01110	-0.03169	0.07956	-0.27451	-0.02425	0.46166	0.09831
2001	SOO	0.03498	0.00000	-0.02313	-0.00537	-0.15569	0.00465	-0.06249	-0.04809
2002	SOO	-0.00910	0.00000	-0.01462	-0.06914	-0.04277	-0.02382	-0.13488	-0.00295
2003	SOO	0.03303	0.01018	-0.01116	0.06033	-0.15078	-0.02040	0.11188	0.02019
2004	SOO	0.05089	-0.00215	0.00007	0.02669	-0.04998	0.03718	0.28041	0.03048
2005	SOO	-0.03856	0.07694	-0.03207	-0.00739	0.12026	0.05142	0.35207	0.05427
2006	SOO	0.01617	-0.07203	0.00522	-0.00151	-0.23945	0.06854	0.12060	0.03859

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	LNQ_DIFF	LNROAD_ DIFF	LNK_DIFF	LNPL_ DIFF	LNPE_ DIFF	LNPM_ DIFF	LNPF_ DIFF	LNALH_ DIFF
1987	CNW	.	.	.	.	.	.	.	.
1988	CNW	0.10304	-0.06998	-0.05002	0.10546	-0.02499	0.00882	-0.15633	0.00839
1989	CNW	-0.10144	-0.02517	-0.10524	-0.02029	0.22292	0.01402	0.09426	-0.03886
1990	CNW	0.03520	-0.00461	-0.04710	-0.04245	-0.24299	-0.00009	0.19687	-0.00602
1991	CNW	0.03032	-0.00911	0.04278	-0.03280	-0.30783	0.05818	-0.08460	-0.00121
1992	CNW	0.02579	-0.02802	-0.04246	-0.03016	-0.05924	0.04803	-0.09400	-0.00418
1993	CNW	0.08430	-0.01525	-0.04081	-0.03486	-0.05378	0.00833	-0.02401	0.04446
1994	CNW	0.12612	-0.02389	-0.03445	-0.00546	-0.08493	0.00952	0.00858	0.03450
1987	DRGW	.	.	.	.	.	.	.	.
1988	DRGW	0.08474	-0.00045	-0.04966	0.05493	-0.02370	0.00882	-0.02688	-0.01020
1989	DRGW	0.11108	0.00000	-0.04329	-0.03121	-0.10909	0.01402	0.03960	-0.01103
1990	DRGW	0.03614	0.00000	-0.03891	-0.00141	-0.08774	-0.00009	0.15806	0.05029
1991	DRGW	0.02428	0.00000	-0.04589	-0.11364	-0.09822	0.05818	-0.08948	0.03239
1992	DRGW	0.13367	0.00045	-0.04089	-0.03281	-0.33705	0.04803	-0.09160	-0.01121
1993	DRGW	0.08145	-0.03073	-0.09149	-0.08417	-0.12075	0.00833	-0.03541	-0.04389
1987	MKT	.	.	.	.	.	.	.	.
1987	SP	.	.	.	.	.	.	.	.
1988	SP	-0.00339	-0.00222	-0.00969	0.02015	-0.01235	0.00882	-0.10686	-0.02411
1989	SP	0.04687	0.00000	-0.02804	0.07057	-0.11005	0.01402	0.12034	0.00744
1990	SP	0.21580	0.24329	-0.04259	0.06674	-0.12068	-0.00009	0.12340	-0.08097
1991	SP	0.00558	-0.03694	-0.05566	-0.06191	0.02599	0.05818	-0.05339	-0.01415
1992	SP	0.08480	-0.00008	-0.03349	-0.01220	-0.06931	0.04803	-0.08309	-0.01894
1993	SP	0.07049	-0.01845	-0.03564	-0.03284	0.01184	0.00833	0.03069	0.02623
1994	SP	0.27384	0.14027	-0.07493	0.02455	0.04327	0.00952	-0.11666	-0.03728
1995	SP	0.09304	0.12756	-0.03428	0.05342	0.19119	-0.01400	-0.02682	0.01571
1996	SP	0.06407	-0.07855	-0.05577	0.03531	-0.04511	-0.01365	0.15710	0.02473
1987	SSW	.	.	.	.	.	.	.	.
1988	SSW	0.07720	0.00000	-0.01897	0.08560	0.09781	0.00882	-0.19103	0.03076
1989	SSW	0.11460	0.00000	-0.03972	0.07776	0.09504	0.01402	0.12906	-0.04814
1987	UP	.	.	.	.	.	.	.	.
1988	UP	0.11652	0.07844	-0.02254	0.00060	-0.05611	0.00882	-0.10712	0.02338
1989	UP	0.03556	-0.03463	0.01450	0.00279	0.03851	0.01402	0.10347	0.02265
1990	UP	0.03520	-0.03507	0.04577	-0.03358	-0.02045	-0.00009	0.17829	-0.01360
1991	UP	0.05769	-0.04190	-0.03804	0.00268	-0.04389	0.05818	-0.10322	0.03556
1992	UP	0.04026	-0.06321	-0.02993	0.03270	0.00005	0.04803	-0.06073	0.01829
1993	UP	0.05393	-0.06433	-0.03251	-0.02796	-0.01214	0.00833	-0.04135	0.01827
1994	UP	0.06607	-0.01902	0.04155	0.01599	0.00063	0.00952	-0.08850	0.00677
1995	UP	0.26537	0.26396	0.33049	-0.06196	-0.29135	-0.01400	0.02323	-0.18263
1996	UP	0.07949	-0.02304	-0.03913	-0.01492	-0.00360	-0.01365	0.07947	0.28910

1997	UP	0.30564	0.45074	0.22120	0.03779	0.02662	0.00157	0.03795	0.07091
1998	UP	-0.04478	-0.03613	-0.02693	0.03064	-0.03312	-0.00035	-0.17919	-0.01225
1999	UP	0.09073	-0.01089	-0.01693	-0.00606	0.08693	-0.01641	-0.10504	0.01215
2000	UP	0.02577	-0.00922	-0.02206	0.02784	0.00997	-0.02425	0.46810	0.00414
2001	UP	0.03695	0.01654	-0.02369	0.00064	-0.03091	0.00465	-0.05149	0.00511
2002	UP	0.02930	-0.01334	-0.01289	0.02719	-0.06702	-0.02382	-0.20449	0.00955
2003	UP	0.02697	-0.00940	-0.01653	0.01360	-0.04684	-0.02040	0.21071	0.01289
2004	UP	0.02491	-0.00657	-0.01595	-0.02051	-0.12702	0.03718	0.25572	0.00893
2005	UP	0.00446	-0.00584	-0.00116	0.01734	-0.00415	0.05142	0.34036	0.00323
2006	UP	0.02957	-0.00269	0.00471	-0.01318	-0.20582	0.06854	0.11764	0.00581

Exhibit 12: Railroad-Specific Estimates of Year-to-Year Impacts on Marginal Cost

ATSF, BN, BNSF

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	ATSF	.	.	-0.033100	.	.	.	.	.	.
1988	ATSF	-0.07361	-0.00725	-0.027859	0.005899	0.03571	0.002677	0.003409	-0.015055	-0.002660
1989	ATSF	-0.07704	-0.05409	-0.021503	0.006154	0.11184	0.004857	0.005211	0.015955	0.014864
1990	ATSF	0.06573	-0.08730	-0.015976	0.007010	-0.09010	-0.002761	-0.000036	0.023988	-0.005822
1991	ATSF	-0.04594	-0.17727	-0.005585	0.007431	-0.02081	-0.000677	0.023056	-0.014003	0.002409
1992	ATSF	-0.08407	-0.20055	0.005854	0.006625	0.00619	-0.003423	0.019606	-0.013569	0.000696
1993	ATSF	-0.13077	-0.05528	0.014561	0.004137	-0.02288	-0.001474	0.003462	0.006500	0.002434
1994	ATSF	-0.12084	-0.05261	0.023191	0.000305	-0.00004	0.003541	0.004070	-0.015418	0.003114
1995	ATSF	-0.06472	0.18705	0.019504	-0.052281	0.01243	-0.010063	-0.005802	-0.001122	-0.007740
1987	BN	-0.63578	1.36173	-0.039639	-0.077778	-0.00705	-0.023657	-0.048819	0.009789	0.004212
1988	BN	-0.07917	-0.00549	-0.034005	0.007233	0.00640	0.000499	0.003312	-0.018248	-0.001282
1989	BN	-0.03840	-0.00224	-0.029979	0.006091	0.00032	-0.010127	0.005181	0.012978	0.003549
1990	BN	-0.00713	-0.00894	-0.026115	0.006509	-0.00464	-0.005154	-0.000034	0.027613	-0.002354
1991	BN	0.00720	-0.00744	-0.023619	0.007508	0.00637	-0.012443	0.021132	-0.014179	0.000580
1992	BN	-0.00134	-0.01800	-0.019584	0.005567	-0.00923	-0.001149	0.017856	-0.010632	-0.000756
1993	BN	-0.01750	-0.02852	-0.015276	0.005132	-0.00956	-0.013350	0.003095	-0.005600	0.001995
1994	BN	-0.09019	-0.00831	-0.008833	0.004577	-0.00272	0.003672	0.003622	-0.010786	0.002487
1995	BN	-0.12415	0.00078	-0.001556	0.004123	-0.00040	0.008055	-0.005428	-0.004000	0.008198
1996	BNSF	.	.	-0.009140	.	.	.	.	.	.
1997	BNSF	-0.02541	-0.05112	-0.003330	0.001711	0.02335	0.000268	0.000607	-0.001520	0.015460
1998	BNSF	-0.08557	-0.01590	0.003455	0.000953	0.00410	0.008935	-0.000140	-0.017031	0.009353
1999	BNSF	-0.03425	-0.00357	-0.049975	0.005208	0.03373	0.004214	-0.006460	-0.010559	0.003532
2000	BNSF	-0.00715	0.00467	-0.030121	0.003259	-0.04101	0.002377	-0.009469	0.046182	-0.001891
2001	BNSF	-0.01652	-0.01230	-0.010603	0.003593	0.00227	-0.003137	0.001815	0.001910	0.004308
2002	BNSF	0.02214	-0.02057	0.007004	0.003344	0.03792	-0.007600	-0.009157	-0.026931	-0.002593
2003	BNSF	-0.02937	-0.00926	0.026888	0.001969	0.01018	-0.005221	-0.007627	0.033451	-0.000000
2004	BNSF	-0.10181	-0.00474	0.048634	0.004040	0.02687	0.001344	0.013841	0.017509	-0.000072
2005	BNSF	-0.03842	0.00016	0.069275	0.000689	0.00539	0.008690	0.018926	0.062184	-0.000000
2006	BNSF	-0.06471	-0.01009	0.089727	-0.001015	0.00282	-0.020156	0.024588	0.051322	-0.000000

CNGT, GTW, IC

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
2002	CNGT	.	.	0.02237	.	.	.	.	.	.
2003	CNGT	-0.02905	0.01967	0.04042	0.00096	0.03936	-0.00431	-0.007655	0.01933	-0.01262
2004	CNGT	-0.05605	0.05755	0.05823	-0.01552	0.03111	0.00576	0.013749	0.01846	0.09406
2005	CNGT	0.01267	-0.01407	0.07803	-0.00007	0.00131	0.01583	0.018883	0.04721	0.01083
2006	CNGT	-0.01888	0.00016	0.09801	0.00063	-0.01943	-0.00041	0.025084	0.04698	-0.03070
1987	GTW	.	.	0.07762	.	.	.	.	.	.
1988	GTW	-0.19340	-0.07772	0.09394	0.00584	0.01603	0.00816	0.004048	-0.02874	-0.02957
1989	GTW	-0.08400	0.14974	0.07563	0.00501	-0.02741	0.00785	0.006190	-0.00264	-0.04065
1990	GTW	0.13493	-0.15474	0.06946	0.00463	0.01310	0.00546	-0.000040	0.04923	0.00990
1991	GTW	0.06561	-0.00851	0.05956	0.00482	0.01360	0.00506	0.023401	0.00487	-0.06185
1992	GTW	-0.21127	0.00000	0.06850	0.00447	0.09878	0.00692	0.019014	-0.02697	-0.06051
1993	GTW	-0.58965	0.00000	0.09744	0.00500	-0.12567	0.01640	0.003664	-0.00154	-0.03682
1994	GTW	-0.16550	0.00000	0.10173	0.00400	-0.01256	0.00345	0.004187	0.02617	0.06131
1995	GTW	-0.01075	-0.05031	0.10346	0.00494	0.01025	0.00629	-0.006184	-0.06388	-0.04872
1996	GTW	-7.87468	0.06915	0.70272	0.00373	-0.01852	0.46822	-0.013855	0.26064	-0.08901
1997	GTW	0.02357	0.62619	-0.04357	0.00764	0.06802	0.07686	0.000419	0.00137	0.03436
1998	GTW	-0.02108	0.03635	-0.03745	0.00101	-0.06684	0.05878	-0.000107	0.01437	0.00779
1987	IC	.	.	-0.00851	.	.	.	.	.	.
1988	IC	-0.00246	-0.23819	0.00147	0.00735	0.05303	-0.00615	0.003334	-0.01479	0.03156
1989	IC	-0.02810	-0.00996	0.00016	0.02604	0.05447	-0.02702	0.004816	0.01535	0.00494
1990	IC	-0.01939	-0.08938	0.00509	0.00553	-0.04698	-0.01314	-0.000032	0.01546	-0.04064
1991	IC	-0.17266	-0.00598	0.01298	0.00651	-0.02795	-0.00314	0.020368	-0.00637	-0.02961
1992	IC	0.05470	-0.02802	0.01506	0.00542	0.02846	0.00452	0.016999	-0.00990	0.01197
1993	IC	-0.14521	-0.01330	0.02329	0.00568	-0.01797	0.00267	0.003042	-0.00477	-0.04864
1994	IC	-0.07585	-0.05026	0.03291	0.00531	0.00846	0.01574	0.003652	-0.00222	0.00927
1995	IC	-0.34625	-0.02751	0.05095	0.00485	-0.00855	0.00447	-0.005740	-0.01359	-0.06189
1996	IC	0.20874	-0.01916	0.04435	0.00450	-0.00369	0.00175	-0.005409	0.02323	0.01942
1997	IC	-0.00224	-0.02487	0.04768	0.00406	-0.01074	0.00050	0.000629	-0.00859	0.00657
1998	IC	-0.10476	-0.00519	0.05341	0.00456	0.00391	-0.00335	-0.000145	-0.04723	0.00971

CR

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	CR	.	.	-0.037349	.	.	.	.	.	.
1988	CR	-0.04880	-0.02352	-0.031922	0.00582	0.01126	0.00109	0.003355	-0.014076	-0.003630
1989	CR	0.03444	-0.00413	-0.029320	0.00643	0.00589	0.00247	0.005299	0.008613	0.005939
1990	CR	-0.02121	-0.02344	-0.024228	0.00665	0.00644	0.00111	-0.000036	0.015183	-0.000251
1991	CR	0.01683	-0.03656	-0.019534	0.00678	-0.01771	0.00051	0.022041	0.011343	-0.005209
1992	CR	-0.01963	-0.05956	-0.013535	0.00690	-0.02022	-0.00636	0.018834	-0.017151	-0.000877
1993	CR	-0.02902	-0.00701	-0.008772	0.00681	-0.01380	0.00230	0.003318	-0.003617	0.002259
1994	CR	-0.08504	-0.06017	-0.000671	0.00711	0.00287	0.00783	0.003883	-0.006749	-0.010286
1995	CR	0.02000	-0.08822	0.005114	0.00687	0.02107	0.00714	-0.005735	-0.007856	-0.005313
1996	CR	-0.02361	-0.02228	0.010187	0.00654	-0.00764	0.00154	-0.005557	0.018030	-0.001945
1997	CR	-0.03277	0.03535	0.010887	0.00636	0.16073	0.00082	0.000598	-0.007766	-0.002371
1998	CR	-0.04042	-0.00054	0.016866	0.00630	-0.10568	0.00396	-0.000146	-0.033453	-0.000080

CSX

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	CSX	.	.	-0.044816	.	.	.	.	.	.
1988	CSX	-0.01094	-0.06547	-0.038912	0.006010	0.006887	-0.000575	0.003315	-0.014615	-0.02081
1989	CSX	-0.02208	-0.05146	-0.033165	0.006321	0.002651	-0.006994	0.005233	0.009972	-0.00777
1990	CSX	-0.01423	-0.04152	-0.027694	0.006231	0.007187	-0.000687	-0.000035	0.019575	-0.00315
1991	CSX	0.02430	-0.00569	-0.024699	0.006193	-0.017456	-0.001441	0.021865	-0.003787	-0.00897
1992	CSX	-0.01257	0.00319	-0.020958	0.007049	0.002583	0.002403	0.018377	-0.006312	-0.00503
1993	CSX	0.01166	-0.00760	-0.017459	0.008146	0.003095	0.005504	0.003215	-0.004439	-0.01171
1994	CSX	-0.04673	-0.00125	-0.012353	0.007344	0.004579	0.007580	0.003748	-0.010800	0.00051
1995	CSX	-0.03130	-0.00722	-0.007364	0.007502	-0.005316	0.005834	-0.005568	-0.002346	-0.00187
1996	CSX	0.01126	-0.00868	-0.003424	0.005795	0.006352	0.014533	-0.005437	0.006462	0.00626
1997	CSX	-0.04474	-0.01411	0.001902	0.005691	0.000613	0.001120	0.000633	-0.009397	-0.00696
1998	CSX	0.00139	-0.00663	0.004734	0.004087	0.015280	-0.005351	-0.000145	-0.037662	0.00569
1999	CSX	-0.07985	0.21510	-0.057051	0.003585	-0.022882	-0.016746	-0.006606	0.005499	-0.01912
2000	CSX	-0.07078	-0.00144	-0.034112	-0.054426	-0.009699	0.008332	-0.009324	0.087728	-0.00998
2001	CSX	-0.04835	-0.00094	-0.014237	0.005335	0.035643	-0.000191	0.001782	-0.011112	-0.01564
2002	CSX	-0.00178	-0.00548	0.004422	0.004829	0.004995	-0.002412	-0.009205	-0.024834	-0.00367
2003	CSX	-0.01551	-0.01273	0.024554	0.004043	-0.010590	-0.007993	-0.007742	0.028261	-0.00287
2004	CSX	-0.04311	-0.03020	0.046356	-0.026085	0.009422	0.007642	0.014218	0.013610	-0.00294
2005	CSX	0.00302	-0.03624	0.067361	0.006524	-0.005659	0.011522	0.019821	0.029419	0.00257
2006	CSX	-0.01530	-0.01102	0.087382	0.003182	0.000111	-0.010467	0.025874	0.052956	-0.00186

KCS

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	KCS	.	.	0.07425	.	.	.	.	.	.
1988	KCS	0.00632	0.04655	0.06218	0.006393	-0.007426	0.009297	0.003882	-0.020773	-0.003043
1989	KCS	-0.01657	0.00000	0.05755	-0.001891	-0.001455	0.003739	0.006016	0.018268	-0.002157
1990	KCS	-0.10927	0.00000	0.05966	0.003215	0.007189	0.000377	-0.000040	0.050588	0.015809
1991	KCS	-0.04226	0.00253	0.06256	0.004847	-0.011169	-0.004767	0.025131	-0.022160	0.001849
1992	KCS	-0.26649	-0.00567	0.07822	0.002941	0.010175	-0.002277	0.021671	-0.025391	-0.001080
1993	KCS	-0.11427	0.08342	0.07438	0.001693	-0.010527	0.007304	0.003718	-0.026402	0.024647
1994	KCS	-0.17620	0.92114	0.01511	-0.033304	-0.023843	-0.006240	0.003782	-0.013926	0.088037
1995	KCS	-0.30131	0.03560	0.02514	-0.003180	0.016009	0.000012	-0.005571	0.011254	-0.069860
1996	KCS	0.05626	0.01412	0.02416	0.004327	-0.000696	-0.021306	-0.005235	0.009551	0.007501
1997	KCS	-0.08978	-0.07298	0.03035	0.004631	0.067302	-0.016571	0.000580	0.000011	-0.035794
1998	KCS	-0.19035	-0.07040	0.04205	0.005109	-0.089532	-0.004890	-0.000141	-0.032477	0.001257
1999	KCS	-0.04448	0.00000	-0.01235	0.002859	0.018429	-0.005672	-0.006432	-0.001291	-0.022729
2000	KCS	0.15608	-0.03771	0.00200	0.005872	-0.006387	0.000581	-0.008941	0.079711	0.029332
2001	KCS	-0.01047	0.20460	0.01087	-0.007138	0.035023	-0.001968	0.001671	-0.017484	0.016722
2002	KCS	-0.00066	-0.00842	0.02973	-0.004092	-0.005309	0.002806	-0.008673	-0.018139	0.006751
2003	KCS	-0.02067	0.00000	0.04890	0.002470	-0.001649	-0.001666	-0.007250	0.032760	-0.003753
2004	KCS	-0.03819	-0.00535	0.06902	0.001311	-0.013967	-0.002649	0.013097	0.039864	-0.010890
2005	KCS	-0.20127	0.05824	0.09171	-0.005185	0.004422	0.010834	0.017944	0.063391	-0.037854
2006	KCS	-0.25343	-0.01111	0.11651	0.004937	0.005421	-0.019792	0.023811	0.030437	-0.032571

NS

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	NS	.	.	-0.044557	.	.	.	.	.	.
1988	NS	-0.05181	-0.01635	-0.039168	0.00506	0.012685	-0.000913	0.003352	-0.014323	-0.001424
1989	NS	0.00537	-0.07491	-0.032968	0.00541	0.011599	-0.000049	0.005288	0.013367	0.002316
1990	NS	-0.07596	-0.09712	-0.023357	0.00593	-0.005587	0.004636	-0.000036	0.022907	-0.022625
1991	NS	0.03774	-0.01030	-0.020813	0.00557	-0.004386	-0.000551	0.022408	-0.008395	-0.007952
1992	NS	-0.02586	-0.00154	-0.016694	0.00392	-0.001769	-0.000324	0.018970	-0.014698	-0.003511
1993	NS	-0.03674	-0.00993	-0.011910	0.00538	0.002558	0.000429	0.003327	-0.008386	-0.009261
1994	NS	-0.08581	0.00577	-0.005997	0.00445	-0.005904	0.004012	0.003880	-0.006523	-0.009051
1995	NS	-0.03795	-0.02245	-0.000764	0.00452	0.014317	0.004066	-0.005708	-0.001877	-0.005442
1996	NS	-0.01994	-0.01260	0.004222	0.00542	-0.019720	0.002021	-0.005544	0.022265	0.003064
1997	NS	-0.04470	0.01260	0.008497	0.00455	0.000139	0.003558	0.000646	-0.009771	-0.003524
1998	NS	0.01728	0.00072	0.010837	0.00165	-0.009776	-0.005251	-0.000150	-0.043997	0.009561
1999	NS	-0.12531	0.33523	-0.056805	0.00303	0.004327	-0.028964	-0.006571	0.021182	-0.011227
2000	NS	-0.11499	-0.00124	-0.032532	-0.06635	-0.038178	-0.002272	-0.009512	0.063479	-0.005024
2001	NS	0.04690	-0.00715	-0.014886	0.00504	-0.040739	-0.004720	0.001869	-0.012163	0.011080
2002	NS	0.00988	-0.00039	0.003005	0.00485	0.006639	-0.002983	-0.009661	-0.026006	0.001872
2003	NS	-0.01242	-0.00133	0.022516	0.00543	0.008478	0.003748	-0.008178	0.012028	-0.002324
2004	NS	-0.04718	-0.00694	0.044113	-0.04153	0.002648	0.018713	0.015141	0.010860	-0.004343
2005	NS	-0.01270	-0.00559	0.065030	0.00559	-0.007066	0.014793	0.020623	0.061065	0.001944
2006	NS	-0.00273	-0.00147	0.083918	0.00427	0.005490	-0.020661	0.026859	0.036320	0.002558

SOO

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	SOO	.	.	-0.03518	.	.	.	.	.	.
1988	SOO	0.05059	-0.00035	-0.03413	0.00481	0.01686	-0.010136	0.003094	-0.007844	0.002437
1989	SOO	0.00444	-0.00623	-0.03071	0.01456	-0.00015	-0.008502	0.004857	0.008730	-0.002798
1990	SOO	-0.10443	-0.10344	-0.01976	-0.00522	-0.01888	0.000548	-0.000033	0.017545	-0.013123
1991	SOO	0.00248	-0.05944	-0.01422	0.00472	-0.01265	-0.002757	0.021096	-0.014852	0.007010
1992	SOO	-0.00148	-0.00284	-0.01096	0.00279	-0.00866	-0.007385	0.017686	-0.006652	0.028755
1993	SOO	-0.00235	0.00659	-0.00722	0.00301	-0.01252	0.012645	0.003135	-0.004889	-0.014796
1994	SOO	0.08844	0.01451	-0.00693	0.00240	0.00891	0.024041	0.003637	-0.008225	-0.001096
1995	SOO	-0.17771	-0.00203	0.00260	0.04456	-0.01898	0.018772	-0.005541	-0.002464	-0.015098
1996	SOO	0.00743	-0.03424	0.00761	0.00056	0.01123	0.011001	-0.005344	0.016578	0.002240
1997	SOO	0.18777	-0.68175	0.02855	-0.00212	-0.00697	-0.000313	0.000636	0.002823	0.043928
1998	SOO	0.06582	-0.00293	0.02993	-0.00236	0.01322	0.013620	-0.000147	-0.044717	-0.004747
1999	SOO	-0.01073	-0.04848	-0.02194	0.00234	-0.00921	0.006214	-0.006830	0.020239	-0.009375
2000	SOO	-0.08580	-0.01841	-0.00172	0.00338	0.02963	-0.023623	-0.009358	0.071824	-0.026743
2001	SOO	-0.04543	0.00000	0.01721	0.00247	-0.00197	-0.013663	0.001795	-0.009979	0.014533
2002	SOO	0.01143	0.00000	0.03524	0.00156	-0.02455	-0.004041	-0.009352	-0.021303	0.000898
2003	SOO	-0.04036	0.01546	0.05330	0.00119	0.02189	-0.014145	-0.007730	0.018395	-0.005883
2004	SOO	-0.06192	-0.00325	0.07351	-0.00001	0.00985	-0.004634	0.013743	0.047253	-0.008299
2005	SOO	0.03919	0.09330	0.08731	0.00341	-0.00280	0.012708	0.018486	0.054944	-0.012927
2006	SOO	-0.01738	-0.09325	0.10942	-0.00055	-0.00057	-0.024632	0.024490	0.019618	-0.008258

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	Ton-Mile	Road Miles	Time	Capital	Labor	Equipment	Material	Fuel	Ave. Haul
1987	CNW	.	.	-0.033745	.	.	.	.	.	.
1988	CNW	-0.11237	-0.10346	-0.024568	0.00587	0.04841	-0.00167	0.003139	-0.01847	-0.003893
1989	CNW	0.10251	-0.03382	-0.022032	0.01228	-0.00919	0.01705	0.005036	0.01051	0.018987
1990	CNW	-0.03480	-0.00605	-0.017865	0.00548	-0.01953	-0.01857	-0.000033	0.02253	0.002964
1991	CNW	-0.02975	-0.01183	-0.014241	-0.00499	-0.01482	-0.02438	0.020485	-0.00988	0.000596
1992	CNW	-0.02606	-0.03742	-0.008884	0.00494	-0.01318	-0.00485	0.017388	-0.01120	0.002074
1993	CNW	-0.09037	-0.02173	-0.002244	0.00474	-0.01485	-0.00432	0.003063	-0.00301	-0.020799
1994	CNW	-0.14969	-0.03817	0.006186	0.00399	-0.00228	-0.00629	0.003540	0.00118	-0.015394
1987	DRGW	.	.	0.001003	.	.	.	.	.	.
1988	DRGW	-0.15879	-0.00113	0.008265	0.00549	0.02342	-0.00077	0.003421	-0.00413	0.002145
1989	DRGW	-0.22268	0.00000	0.017382	0.00477	-0.01300	-0.00270	0.005507	0.00658	0.002395
1990	DRGW	-0.07115	0.00000	0.020897	0.00428	-0.00060	-0.00232	-0.000037	0.02658	-0.009336
1991	DRGW	-0.04692	0.00000	0.024334	0.00503	-0.04595	-0.00343	0.023165	-0.01455	-0.005354
1992	DRGW	-0.28163	0.00129	0.034180	0.00447	-0.01279	-0.00832	0.019508	-0.01643	0.001932
1993	DRGW	-0.19020	-0.09975	0.046910	0.00995	-0.03123	-0.00154	0.003496	-0.00695	0.008772
1987	MKT	.	.	-0.025360	.	.	.	.	.	.
1987	SP	.	.	-0.026743	.	.	.	.	.	.
1988	SP	0.00382	-0.00354	-0.023796	0.00119	0.00846	-0.00083	0.003474	-0.01271	-0.001614
1989	SP	-0.05268	0.00000	-0.019719	0.00345	0.02991	-0.00724	0.005385	0.01521	0.000533
1990	SP	-0.20223	0.32442	-0.023259	0.00523	0.02894	-0.00873	-0.000035	0.01553	-0.001687
1991	SP	-0.00536	-0.05026	-0.017535	0.00681	-0.02579	0.00200	0.022208	-0.00667	-0.000169
1992	SP	-0.08503	-0.00012	-0.011987	0.00409	-0.00491	-0.00537	0.018748	-0.01079	-0.000001
1993	SP	-0.07444	-0.02762	-0.005317	0.00434	-0.01290	0.00091	0.003293	0.00414	0.000434
1994	SP	-0.29715	0.21818	-0.001086	0.00909	0.00927	0.00326	0.003841	-0.01676	0.000256
1995	SP	-0.09093	0.17827	-0.001240	0.00415	0.01985	0.01584	-0.005642	-0.00383	0.000047
1996	SP	-0.07043	-0.12369	0.007984	0.00673	0.01313	-0.00334	-0.005429	0.02458	0.000458
1987	SSW	.	.	-0.006525	.	.	.	.	.	.
1988	SSW	-0.12911	0.00000	0.000264	0.00209	0.03569	0.00458	0.003501	-0.02660	-0.002779
1989	SSW	-0.20691	0.00000	0.009402	0.00436	0.03199	0.00355	0.005559	0.01999	0.005805
1987	UP	.	.	-0.038961	.	.	.	.	.	.
1988	UP	-0.10240	0.10420	-0.036457	0.00286	0.00025	-0.00399	0.003440	-0.01286	0.000612
1989	UP	-0.03263	-0.04781	-0.030143	-0.00184	0.00116	0.00270	0.005477	0.01294	0.000915
1990	UP	-0.03341	-0.04995	-0.023705	-0.00584	-0.01388	-0.00141	-0.000037	0.02306	-0.000433
1991	UP	-0.05919	-0.06420	-0.016831	0.00484	0.00107	-0.00300	0.023212	-0.01402	0.001927
1992	UP	-0.04525	-0.10550	-0.009105	0.00380	0.01251	0.00000	0.019550	-0.00880	0.001201
1993	UP	-0.06705	-0.11837	-0.000242	0.00412	-0.01031	-0.00074	0.003463	-0.00638	0.001409
1994	UP	-0.08696	-0.03698	0.006368	-0.00528	0.00569	0.00004	0.004024	-0.01442	0.000551
1995	UP	-0.29391	0.43823	0.002147	-0.04276	-0.02232	-0.02012	-0.005785	0.00366	0.006069
1996	UP	-0.09369	-0.04066	0.009452	0.00505	-0.00530	-0.00024	-0.005649	0.01318	0.042841
1997	UP	-0.24786	0.56562	-0.001259	-0.02890	0.01363	0.00224	0.000631	0.00581	0.013663
1998	UP	0.03595	-0.04437	0.002105	0.00351	0.01070	-0.00291	-0.000144	-0.02804	-0.002266
1999	UP	-0.07880	-0.01438	-0.048982	0.00221	-0.00203	0.00755	-0.006816	-0.01720	0.002341
2000	UP	-0.02185	-0.01191	-0.028617	0.00287	0.00981	0.00083	-0.009582	0.07894	0.000809
2001	UP	-0.03070	0.02088	-0.009901	0.00308	0.00022	-0.00268	0.001848	-0.00882	0.001013
2002	UP	-0.02496	-0.01713	0.009483	0.00168	0.00905	-0.00587	-0.009561	-0.03648	0.001953

2003	UP	-0.02275	-0.01194	0.029389	0.00215	0.00462	-0.00404	-0.007973	0.03864	0.002739
2004	UP	-0.02045	-0.00813	0.049109	0.00207	-0.00707	-0.01108	0.014243	0.04726	0.001948
2005	UP	-0.00350	-0.00691	0.068638	0.00015	0.00611	-0.00037	0.019210	0.06305	0.000712
2006	UP	-0.02263	-0.00310	0.087817	-0.00061	-0.00463	-0.01866	0.025424	0.02196	0.001299

Exhibit 13: Railroad-Specific Comparison Estimates of Year-to-Year Factor Impacts to Year-to-Year Marginal Cost Changes

ATSF, BN, BNSF

Year	Railroad	Impact Sum	% Δ MC
1987	ATSF	.	.
1988	ATSF	-0.07873	-0.07571
1989	ATSF	0.00625	0.00306
1990	ATSF	-0.10527	-0.10358
1991	ATSF	-0.23138	-0.19991
1992	ATSF	-0.26264	-0.21920
1993	ATSF	-0.17930	-0.16295
1994	ATSF	-0.15469	-0.14105
1995	ATSF	0.07726	0.09043
1987	BN	.	.
1988	BN	-0.12075	-0.11384
1989	BN	-0.05263	-0.05377
1990	BN	-0.02024	-0.02244
1991	BN	-0.01488	-0.01552
1992	BN	-0.03727	-0.03898
1993	BN	-0.07959	-0.07840
1994	BN	-0.10649	-0.10105
1995	BN	-0.11437	-0.10751
1996	BNSF	.	.
1997	BNSF	-0.03998	-0.04108
1998	BNSF	-0.09183	-0.08671
1999	BNSF	-0.05813	0.04936
2000	BNSF	-0.03316	-0.04174
2001	BNSF	-0.02866	-0.03781
2002	BNSF	0.00355	-0.00462
2003	BNSF	0.02101	0.01027
2004	BNSF	0.00562	-0.00157
2005	BNSF	0.12690	0.12331
2006	BNSF	0.07249	0.06398

CNFT, GTW, IC

Year	Railroad	Impact Sum	% Δ MC
2002	CNGT	.	.
2003	CNGT	0.06611	0.05728
2004	CNGT	0.20734	0.20893
2005	CNGT	0.17062	0.17417
2006	CNGT	0.10143	0.09480
1987	GTW	.	.
1988	GTW	-0.20140	-0.17866
1989	GTW	0.08970	0.11305
1990	GTW	0.13194	0.14492
1991	GTW	0.10655	0.12294
1992	GTW	-0.10107	-0.09549
1993	GTW	-0.63118	-0.45416
1994	GTW	0.02278	0.01784
1995	GTW	-0.05491	-0.05580
1996	GTW	-6.49161	-0.90856
1997	GTW	0.79487	-8.42921
1998	GTW	-0.00718	-0.01472
1987	IC	.	.
1988	IC	-0.16484	-0.14459
1989	IC	0.04069	0.03839
1990	IC	-0.18348	-0.17099
1991	IC	-0.20584	-0.18670
1992	IC	0.09922	0.10307
1993	IC	-0.19521	-0.17980
1994	IC	-0.05300	-0.05126
1995	IC	-0.40327	-0.31846
1996	IC	0.27373	0.33866
1997	IC	0.01298	0.01083
1998	IC	-0.08909	-0.08518

CR

Year	Railroad	Impact Sum	% Δ MC
1987	CR	.	.
1988	CR	-0.10042	-0.09602
1989	CR	0.03564	0.03578
1990	CR	-0.03978	-0.04156
1991	CR	-0.02150	-0.02415
1992	CR	-0.11160	-0.10700
1993	CR	-0.04753	-0.04883
1994	CR	-0.14122	-0.12887
1995	CR	-0.04693	-0.04714
1996	CR	-0.02474	-0.02714
1997	CR	0.17182	0.18488
1998	CR	-0.15319	-0.14988

CSX

Year	Railroad	Impact Sum	% Δ MC
1987	CSX	.	.
1988	CSX	-0.13510	-0.12759
1989	CSX	-0.09729	-0.09457
1990	CSX	-0.05433	-0.05546
1991	CSX	-0.00969	-0.01132
1992	CSX	-0.01126	-0.01337
1993	CSX	-0.00959	-0.01185
1994	CSX	-0.04737	-0.04777
1995	CSX	-0.04765	-0.04868
1996	CSX	0.03312	0.03125
1997	CSX	-0.06525	-0.06461
1998	CSX	-0.01860	-0.01898
1999	CSX	0.02193	0.16619
2000	CSX	-0.09369	-0.09980
2001	CSX	-0.04771	-0.05715
2002	CSX	-0.03313	-0.04139
2003	CSX	-0.00058	-0.01120
2004	CSX	-0.01109	-0.01941
2005	CSX	0.09833	0.09144
2006	CSX	0.13086	0.12808

KCS

Year	Railroad	Impact Sum	% Δ MC
1987	KCS	.	.
1988	KCS	0.10339	0.12063
1989	KCS	0.06350	0.06860
1990	KCS	0.02753	0.02499
1991	KCS	0.01656	0.01333
1992	KCS	-0.18789	-0.16477
1993	KCS	0.04395	0.04620
1994	KCS	0.77455	2.35774
1995	KCS	-0.29190	-0.25171
1996	KCS	0.08868	0.09836
1997	KCS	-0.11225	-0.10765
1998	KCS	-0.33937	-0.28372
1999	KCS	-0.07167	0.03361
2000	KCS	0.22054	0.24804
2001	KCS	0.23182	0.28587
2002	KCS	-0.00601	-0.01545
2003	KCS	0.04914	0.03972
2004	KCS	0.05224	0.04266
2005	KCS	0.00223	-0.01013
2006	KCS	-0.13579	-0.12977

NS

Year	Railroad	Impact Sum	% Δ MC
1987	NS	.	.
1988	NS	-0.10289	-0.09780
1989	NS	-0.06458	-0.06449
1990	NS	-0.19121	-0.17093
1991	NS	0.01333	0.01227
1992	NS	-0.04150	-0.04281
1993	NS	-0.06453	-0.06452
1994	NS	-0.09517	-0.09218
1995	NS	-0.05130	-0.05164
1996	NS	-0.02081	-0.02338
1997	NS	-0.02800	-0.02962
1998	NS	-0.01912	-0.02037
1999	NS	0.13490	0.36149
2000	NS	-0.20662	-0.19176
2001	NS	-0.01476	-0.02272
2002	NS	-0.01280	-0.02082
2003	NS	0.02796	0.01799
2004	NS	-0.00851	-0.01732
2005	NS	0.14370	0.14261
2006	NS	0.13455	0.13330

SOO

Year	Railroad	Impact Sum	% Δ MC
1987	SOO	.	.
1988	SOO	0.02532	0.02788
1989	SOO	-0.01581	-0.01733
1990	SOO	-0.24680	-0.20981
1991	SOO	-0.06862	-0.06864
1992	SOO	0.01126	0.00735
1993	SOO	-0.01640	-0.01932
1994	SOO	0.12568	0.14070
1995	SOO	-0.15590	-0.13743
1996	SOO	0.01707	0.01421
1997	SOO	-0.42744	-0.29687
1998	SOO	0.06769	0.07008
1999	SOO	-0.07777	0.02707
2000	SOO	-0.06082	-0.07616
2001	SOO	-0.03504	-0.04410
2002	SOO	-0.01012	-0.01906
2003	SOO	0.04212	0.03238
2004	SOO	0.06625	0.05675
2005	SOO	0.29362	0.35296
2006	SOO	0.00888	0.00013

CNW, DRGW, MKT, SP, SSW, UP

Year	Railroad	Impact Sum	% Δ MC
1987	CNW	.	.
1988	CNW	-0.20702	-0.17510
1989	CNW	0.10133	0.10641
1990	CNW	-0.06587	-0.06627
1991	CNW	-0.08882	-0.08652
1992	CNW	-0.07720	-0.07620
1993	CNW	-0.14953	-0.13960
1994	CNW	-0.19693	-0.17507
1987	DRGW	.	.
1988	DRGW	-0.12206	-0.11415
1989	DRGW	-0.20174	-0.18113
1990	DRGW	-0.03168	-0.03436
1991	DRGW	-0.06367	-0.06508
1992	DRGW	-0.25778	-0.22303
1993	DRGW	-0.26054	-0.22410
1987	MKT	.	.
1987	SP	.	.
1988	SP	-0.02556	-0.02665
1989	SP	-0.02514	-0.02749
1990	SP	0.13817	-0.02406
1991	SP	-0.07478	-0.07515
1992	SP	-0.09536	-0.09204
1993	SP	-0.10716	-0.10269
1994	SP	-0.07110	-0.21770
1995	SP	0.11652	0.12854
1996	SP	-0.15001	-0.13508
1987	SSW	.	.
1988	SSW	-0.11236	-0.10418
1989	SSW	-0.12626	-0.11675
1987	UP	.	.
1988	UP	-0.04435	-0.04464
1989	UP	-0.08923	-0.08716
1990	UP	-0.10561	-0.04526
1991	UP	-0.12620	-0.11794
1992	UP	-0.13158	-0.12091
1993	UP	-0.19410	-0.17292
1994	UP	-0.12698	-0.11874
1995	UP	0.06520	0.11858
1996	UP	-0.07500	-0.09624
1997	UP	0.32357	0.49148
1998	UP	-0.02546	-0.02658
1999	UP	-0.15612	-0.04675
2000	UP	0.02131	0.00914
2001	UP	-0.02505	-0.03379
2002	UP	-0.07184	-0.07701
2003	UP	0.03083	0.02014
2004	UP	0.06789	0.05939
2005	UP	0.14709	0.14704
2006	UP	0.08686	0.08019

Chapter 10 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 10.
AN OVERVIEW OF COSTS AND REVENUE

INTRODUCTION

This chapter presents a high-level analysis and comparison of the railroad industry's costs and revenues. In particular, we examine how rail revenue per ton-mile (RPTM), on average, is marked up over the competitive benchmark of marginal cost. We investigate how this markup has changed over time, and identify how much of the change in markups reflects the need to achieve revenue adequacy versus the pursuit of monopoly profits.

10A. DATA

Our analysis relies upon data reported annually to the STB in Railroad Form 1 (R-1 data). For each railroad, we calculate the average annual revenue per ton-mile. That is, RPTM = REVENUE / Revenue Ton-Miles. We also calculate for each railroad by year: average cost per ton-mile, average variable cost per ton-mile, and average fixed cost per ton mile. That is, ATC = TOTAL COST / Revenue Ton-Miles, AVC = VARIABLE COST / Revenue Ton-Miles, and AFC = ROADCOST / Revenue Ton-Miles. Details on the construction of REVENUE, TOTAL COST, VARIABLE COST, and ROADCOST are provided in the appendix to Chapter 9.

Additionally, we use our marginal cost estimates obtained from the variable cost function analysis presented in Chapter 9. The estimated variable cost function and resulting marginal cost estimates are also founded on the R-1 data.

All revenue per ton-mile and cost measures are reported in constant dollars (base year 2000).

10B. REVENUE PER TON-MILE AND COSTS

Figure 10-1 presents industry averages[1] for revenue per ton-mile and short-run marginal cost over the 1987-2006 period.[2] As described in the

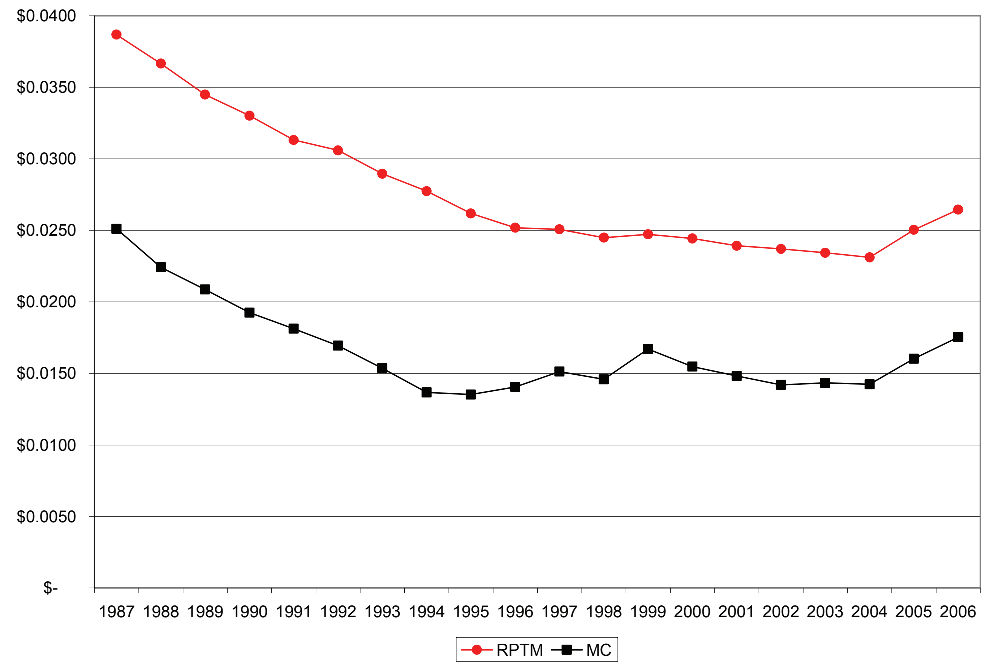
[1] Firm variable cost shares are used as weights in averaging. For 1987 through 1995, the industry averages are calculated using data for ATSF, BN, CSX, NS, SP, and UP. For 1996, the industry averages are calculated using data for BNSF, CSX, NS, SP, and UP. For 1997-2006, the industry averages are calculated using data for BNSF, CSX, NS, and UP.

[2] Our use of the term marginal cost refers to short-run marginal cost. The measure of short-run marginal cost is the change in variable cost as ton-miles increase, holding average length of haul constant.

previous chapter, marginal cost steadily decreased 1987-1994, increased 1995-1999 (seemingly as a result of the ATSF-BN merger in 1995, the UP-SP merger in 1997, and the Conrail absorption by CSX and NS in 1999), decreased 2000-2004, and then increased 2005-2006. The average revenue per ton-mile steadily decreased through 1995, continued to trend downward, but at a slower rate, through 2004, then strongly increased in 2005 and 2006. The fact that revenue per ton-mile and marginal cost tend to move together, but not in proportion or consistently, suggests that the industry does not behave as either a purely competitive or a purely monopolistic industry.

FIGURE 10-1
INDUSTRY AVERAGE ANNUAL REVENUE PER TON-MILE AND MARGINAL COST FOR A TON-MILE

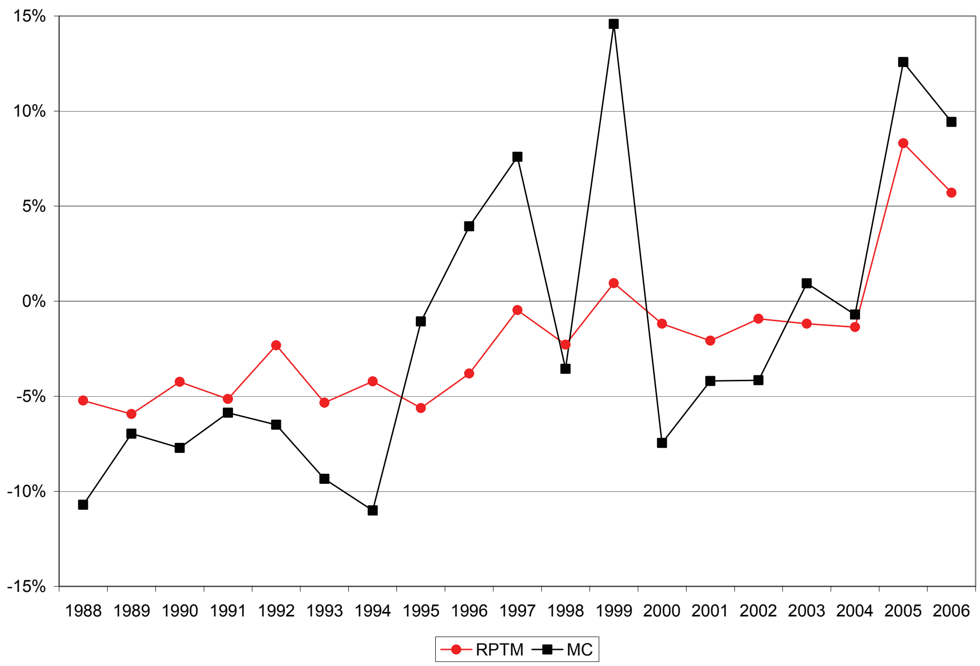
(Year 2000 Dollars)



We look with more detail at how revenue per ton-mile and marginal costs change over time. Figure 10-2 shows the percent changes in average annual revenue per ton-mile and marginal cost. This figure shows that decreases in marginal cost have not, in general, been matched by proportional decreases in revenue per ton-mile. There are two periods of sustained marginal cost decreases. In the 1987-1994 period, marginal cost decreased, on average, by about 8.3 percent per year, but the average revenue per ton-mile decreased by only about 4.6 percent per year. In the 2000-2002 period, marginal cost decreased an average of 5.3 percent per year, while the average revenue per ton-mile decreased by only about 1.4 percent per year. We also note three periods of marginal cost spikes: 1995-1997, 1999, and 2005-2006. In the first period, the industry average revenue per ton-mile continued to decrease by an average of 3.3 percent per year. In 1999, the dramatic increase in marginal cost (likely reflective of the Conrail acquisition meltdown), was accompanied by a 0.9 percent increase in real revenue per ton-mile. The 2005-2006 period yielded significant increases in both marginal cost and revenue per ton-mile.

Railroad-specific figures corresponding to Figures 10-1 through 10-5 can be found in the appendix to this chapter. When the railroads are examined individually, BNSF and UP display lower marginal costs and lower average revenues per ton-mile than do CSX and NS. This observation likely represents geographical, product, and length-of-haul differences.

FIGURE 10-2
PERCENT CHANGES FOR INDUSTRY AVERAGE ANNUAL REVENUE PER TON-MILE AND MARGINAL COST

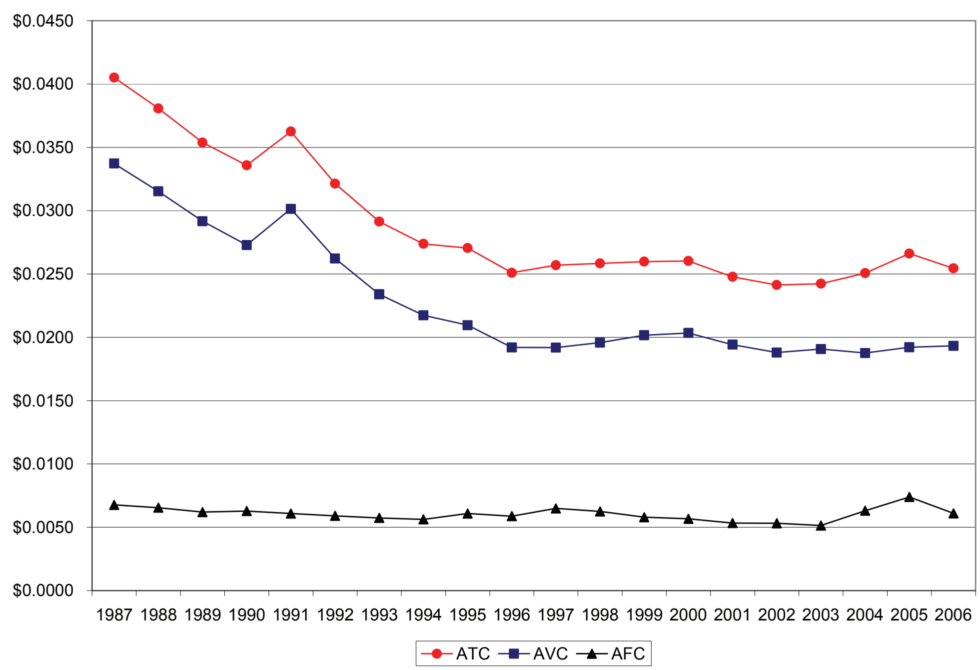


We now examine how average annual cost has changed over time. Figure 10-3 provides annual values for the average total cost of shipping a ton-mile (ATC), as well as its components, average variable cost (AVC) and average fixed cost (AFC). With the exception of 1991, ATC and AVC declined over the 1987-1996 period. ATC and AVC increased slightly between 1997 and 2000, and then decreased slightly between 2001 and 2003. ATC then increased in 2004 and 2005, but declined in 2006. Figure 10-3 shows that the 2006 ATC value is well below its 1987 level. AVC increased slightly over the 2004-2006 period. It should be noted that a changing shipment mix, such as an increase in the share of express intermodal service (e.g., BNSF's Z-train service), could be a factor in increasing marginal cost.

AFC decreased slightly through 1994, increased slightly with the ATSF-BN merger, had another slight increase with the UP-SP merger, and then gradually returned to its pre-mergers level by 2000. Notably, the Conrail absorption by CSX and NS had no noticeable effect on AFC (but, as shown in Figure 10-2, a very noticeable effect on marginal cost). More recently, AFC increased substantially in 2004 and 2005, as is consistent with the explanation of major road enhancements occurring over that period.[3] As shown in Chapter 16, real dollar expenditures in road increased by 7.4 percent per year between 2002 and 2006. If that indeed is the reason for the 2004-2005 increases in AFC, then as those enhancements become operational and traffic flow increases, AFC should decline. Preliminary evidence of an AFC decline is seen in 2006.

FIGURE 10-3
INDUSTRY AVERAGE TOTAL COST, AVERAGE VARIABLE COST, AND AVERAGE FIXED COST

(Year 2000 Dollars)



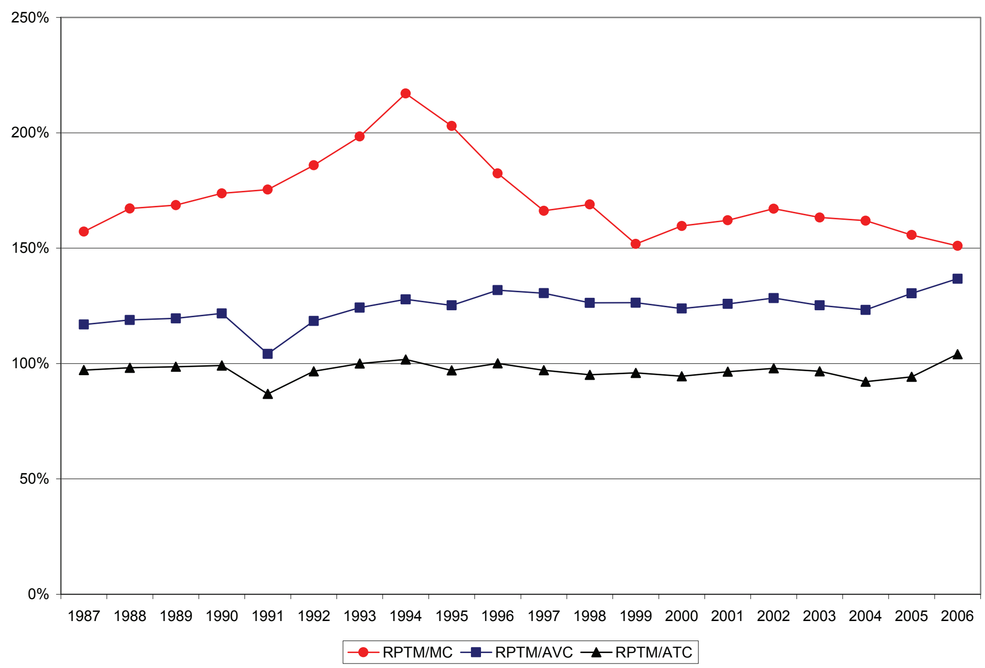
When the railroads are examined individually in the appendix to this chapter, we discover interesting patterns with respect to average fixed cost. The western railroads, BNSF and UP, each have two episodes when their fixed costs increased. The first seemingly permanent increase in average fixed costs for these railroads corresponds to the large mergers (1995 for ATSF-BN and 1997 for UP-SP). The second increase in average fixed costs appears as a spike in 2005, which began to subside in 2006. In contrast, the eastern

[3] AFC decreased in 2006 to approximately its 2004 level.

railroads share a different pattern with respect to fixed cost. Neither CSX nor NS displayed any noticeable effect on average fixed costs as a result of the Conrail absorption. However, both of these railroads showed substantial increases in fixed costs over the 2004-2006 period.

Figure 10-4 presents three different markup ratios for the industry. The top series shows the ratio of the average revenue per ton-mile to the marginal costs estimated in Chapter 9.

FIGURE 10-4
INDUSTRY MARKUP RATIOS



This ratio reflects the extent to which market power is being exercised in the industry. The RPTM/MC[4] ratio in Figure 10-4 mirrors what is shown in Figure 10-2. That is, the industry gained market power primarily during periods of marginal cost decreases and ceded some of that market power during periods of cost increases. Our estimate of the RPTM/MC ratio peaked at 217 percent in 1994 and has ranged in recent years between 150 and 170 percent.

The second series in Figure 10-4 displays the revenue per ton-mile to average variable cost ratio. This ratio is conceptually equivalent to the revenue to variable cost ratio (R/VC) that is a threshold measure in captive shipper rate cases. The RPTM/AVC ratio has gradually increased from 117 percent to 137 percent over the twenty-year study period. Interestingly, we note that the RPTM/AVC measure remains well below the 180 percent threshold for the

[4] MC, which represents marginal cost, is defined in equation (9.18) in Chapter 9.

R/VC ratio used by the STB in captive shipper rate cases. We further note that the RPTM/AVC ratio does not track very well with the market power indicator of RPTM/MC. This may be indicative of the weakness of the R/VC measure as an indicator of market power abuse.[5]

The third series in Figure 10-4 shows the revenue per ton-mile to average cost ratio. This graph conveys the information about revenue adequacy for the overall industry. Values of the RPTM/ATC ratio greater than or equal to 100 percent indicate revenue sufficiency while values less than 100 percent imply that revenues are insufficient to cover costs. The series, based on R-1 data, shows that the industry has remained close to being revenue sufficient for most years in our study, but more often than not it has fallen short. When the railroads are examined individually, we find that BNSF and NS both reported that their R-1 revenues exceeded costs in thirteen of the twenty years studied. UP's R-1 revenues were greater than or equal to their costs in eight of the twenty years, while this was the case for CSX in only three years.[6]

We introduce the Lerner Markup Index (LMI).[7] The LMI reflects the percentage markup of the revenue per ton-mile over marginal cost. That is,

$$(10.1) \quad LMI \equiv (RPTM - MC) / RPTM \, .$$

The LMI has a theoretical range of zero to one, zero being the limiting case of perfect competition, and one being the limiting case of zero marginal cost. For the profit-maximizing firm, the LMI would be the negative of the inverse of the elasticity of demand.[8] Thus, in an imperfect competition setting, the LMI reveals the "equivalent monopoly elasticity of demand."[9]

---

[5] We are not suggesting that the aggregate average revenue per ton-mile to the aggregate average variable cost ratio presented in Figure 10-4 is the appropriate R/VC measure for rate cases. The R/VC measure used in rate cases is market-, shipper-, railroad-, and route-specific. We further note that the R/VC measure is based on the Uniform Rail Costing System (URCS), while our RPTM/AVC ratio is based on R-1 data. We don't know how comparable or consistent these different data sources are.

[6] We note that the measures of costs that we develop from the R-1 data do not include any current assets, such as cash. Furthermore, our calculations are based on some variables defined for the econometric analysis undertaken in Chapter 9, and may not conform to conventional financial analysis. Thus, the ratio of revenue to cost presented in Figure 10-4 is revealing, but should not be viewed as the definitive indicator of revenue adequacy.

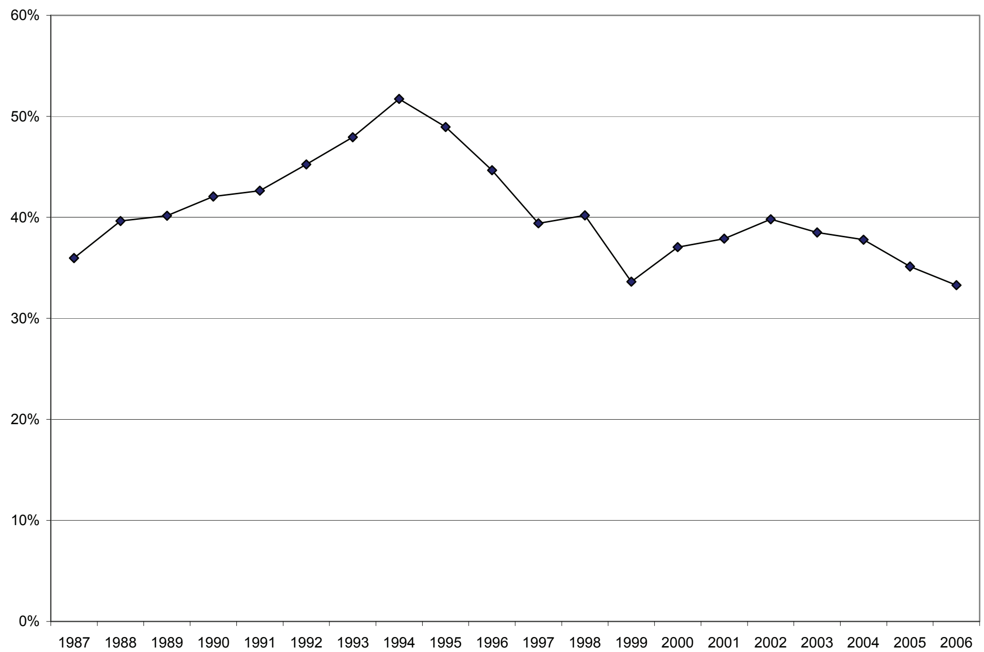
[7] The Lerner Markup Index is sometimes referred to as the Lerner Market Power Index or simply the Lerner Index.

[8] This result is derived from a manipulation of the profit-maximization condition that marginal revenue equals marginal cost. The next chapter contains an exposition of the result that profit maximization implies that $(r - MC) / r = -1/\text{elasticity of demand}$, where r represents the railroad revenue per ton-mile.

[9] For example, an oligopolistic industry with and LMI = 50% is effectively equivalent to a monopolist facing an elasticity of demand equal to -2.0.

Figure 10-5 presents the industry average LMI. This graph reflects what we have observed in Figures 10-2 and 10-4, namely that market power in the industry has increased during periods of marginal cost decreases and diminished during periods of marginal cost increases, remaining relatively low in the recent period of cost increases.

FIGURE 10-5
INDUSTRY LERNER MARKUP INDEX



The industry LMI in 2006 is about the same as it was in 1999, approximately 34 percent. Between 2000 and 2002, a period of marginal cost decline, the industry LMI increased to about 40 percent. As marginal cost increased in the 2004-2006 period, the LMI fell back to around 33 percent, implying an "equivalent monopoly elasticity of demand" of -3.0.

The LMI measure is not without its critics. For example, a Federal Trade Commission staff discussion paper notes:

> There are both theoretical and practical difficulties in using the Lerner Index to measure market power. The main theoretical difficulty is that the Lerner Index does not offer a competitive benchmark except in perfectly competitive markets, where the Lerner Index should be zero. The most significant practical obstacle to broader application of the Lerner Index is determining the firm's marginal cost of production at any given point in time. Without a measurement or reasonable estimate of

> marginal cost, the ratio is incalculable. Moreover, exogenous economic factors, such as shifts in consumer demand or the cost of inputs, could result in dramatic and misleading changes. [Three footnotes omitted.][10]

Nevertheless, we find the LMI a useful summary measure. In our analysis below, we address the theoretical difficulty of the competitive benchmark by incorporating the revenue adequacy requirement. Our variable cost function, estimated in Chapter 9, appears to provide the needed reasonable estimate of marginal cost. We do observe the sensitivity of the LMI measure to significant cost changes, but the gradual change in LMI values over many of the years in our study suggests that the underlying demands for railroad shipping services are not changing dramatically. We also use the aggregate LMI presented in Figure 10-5 as a benchmark for commodity-specific LMIs presented in the subsequent pricing chapters.

Examination of the data for individual railroads reveals that since 2000, NS and BNSF have mostly larger markups over marginal cost, displaying LMIs between 38 and 46 percent. In contrast, CSX and UP have mostly smaller LMIs in these years, between 27 and 39 percent.

10C. Revenue Sufficiency

As was shown in Figure 10-4, revenue sufficiency has been a continual challenge for the railroad industry. In Chapter 9, we discussed how the existence of economies of density means that marginal cost pricing, the competitive ideal, is insufficient to recover variable costs. The presence of fixed costs adds to the collection burden. Consequently, it is a necessity that the average revenue per ton-mile received by a railroad exceeds its marginal cost. This fact can be summarized by two basic equations. The first states that in order to just achieve revenue sufficiency, the rate must equal the sum of average variable and average fixed costs.

(10.2) $$RPTM = AVC + AFC = AC \ .$$

The second equation states that the marginal cost is marked up by some proportion τ.

(10.3) $$RPTM = (1 + \tau) \times MC \ .$$

[10] Federal Trade Commission, Staff Discussion Draft, "How Do Courts and Agencies Evaluate Market Power?" in *The Role and Assessment of Classical Market Power in Joint Venture Analysis*, October 1997, at http://www.ftc.gov/opp/jointvent/classic3.shtm.

Substituting (10.3) into (10.2) and manipulating[11] the terms gives:

(10.4) $\tau = Density \times (1 + FC / VC) - 1$

where Density is the economies of density measure, $[\partial \ln C^V / \partial \ln Y]^{-1}$, defined in Chapter 9, and FC/VC is the ratio of fixed to variable costs. Inspection of equation (10.4) confirms that the presence of density economies (Density > 1) requires a positive markup of marginal cost ($\tau > 0$), and that the markup increases as fixed cost increases relative to variable cost. We also note that in the special case of constant returns to density (Density = 1) and no fixed cost, there would be no markup required. Thus, in viewing market power as the ability to price above marginal cost, we can conclude that the existence of economies of density mandates that some market power be exercised if revenue sufficiency is to be achieved.

10D. MARKET POWER PRICING

A profit-maximizing firm will mark up its price, thereby restricting output, until the marginal loss in revenue because of diminished sales just equals the avoided marginal cost. This can be summarized by two basic equations. The first says that the firm marks up marginal cost.

(10.5) $RPTM = (1 + \mu) \times MC$.

The second basic equation is that marginal revenue equals marginal cost, which can be expressed as

(10.6) $MR \equiv RPTM(1 + 1/\varepsilon) = MC \ \ [\text{Note}: \varepsilon \equiv \partial \ln Q_D / \partial \ln RPTM < 0]$

where ε is the price elasticity of demand perceived by the firm and Q_D is the quantity demanded. Equations (10.5) and (10.6) can be solved for the profit-maximizing markup factor μ. That is,

(10.7) $\mu = -1/(1 + \varepsilon)$.

---

[11] Substituting equation (10.3) into equation (10.2) gives: $(1 + \tau) \times MC = AVC + AFC$. Dividing both sides of this new equation by MC gives: $(1 + \tau) = AVC/MC + AFC/MC$. Multiplying AFC/MC by AVC/AVC gives $(1 + \tau) = AVC/MC + (AVC/MC) \times (AFC/AVC)$. So, $\tau = (AVC/MC) \times (1 + AFC/AVC) - 1$. We note that AFC/AVC = FC/VC. We also recall that AVC/MC = Density. Thus, $\tau = \text{Density} \times (1 + FC/VC) - 1$.

10E. EXCESS MARKUP

The concept of an “excess markup” can be simply written as the difference between the markup the firm with market power imposes and the markup necessary to just achieve revenue sufficiency.[12] That is,

$$\gamma = \mu - \tau \tag{10.8}$$

where γ is the excess markup factor.

We can take the derivative of equation (10.8) with respect to time to analyze the causes of changes in the excess markup factor. That is,

$$\begin{aligned} d\gamma / dt &= d\mu / dt - d\tau / dt \\ &= 1/(1+\varepsilon)^2 \, d\varepsilon / dt - (1 + FC/VC) dDensity/dt - Density\, d(FC/VC)/dt \end{aligned} \tag{10.9}$$

Thus, changes in the excess markup factor can be separated into three distinct components: a market power impact, a density impact, and a fixed cost impact. We note that dε/dt > 0 implies an increase in market power, and dDensity/dt > 0 implies a decrease in marginal cost relative to average variable cost.

The excess markup γ is simply the difference between revenue per ton-mile and average cost divided by marginal cost, and is constructed using the R-1 data and the marginal cost estimates from Chapter 9. It is straightforward to approximate dγ/dt as the year-to-year changes in γ. Likewise, the FC/VC ratio is constructed from the R-1 data, and d(FC/VC)/dt can be approximated as year-to-year changes in this ratio. Density estimates are calculated as the ratios of AVC to the marginal cost estimates.[13] Estimates for dDensity/dt are obtained by the quotient rule for differentiation.[14] Estimates of the perceived elasticity of demand, ε, are calculated using revenue information from the R-1 data and the estimates of marginal cost from Chapter 9. We note that –ε is the reciprocal of the Lerner Index. The dε/dt term can be calculated as year-to-year differences in ε.

Table 10-1 presents an accounting for changes in the railroad industry’s average excess markup factor over the period 2000-2006. The discrete year-to-year changes in variables, instead of continuous changes, mean that the calculated effects presented in this table do not add up exactly to the discrete change in the excess markup factor. The values presented in Table

---

[12] As shown in Figure 10-4, the railroad industry’s “excess markup” is negative for most years.

[13] This corresponds to the Density_1 measure from Chapter 9. This measure holds the average length of haul (ALOH) constant. We believe this is appropriate because in recent years both the ALOH elasticity and changes in ALOH have been relatively small in magnitude.

[14] dDensity = [(MC × dAVC) – (AVC × dMC)] / MC^2.

10-1 indicate that in 2000, 2005 and 2006, the density measure was the primary factor explaining the change in the excess markup factor. The market power change measure had a positive impact on the change in the excess markup factor in the 2000-2002 period, but a negative impact in the 2003-2006 period. For the 2004-2006 period, the fixed cost impact became a more significant factor than in previous years. In the 2005-2006 period, the density measure had a strongly positive impact on the change in the excess markup factor. Also noteworthy, in 2006 fixed cost declined (see Figure 10-3), which reduced the markup needed to cover fixed costs. This explains the positive sign for the 2006 fixed cost impact. In 2006, the market power change measure had a negative impact, but the combination of the positive density and fixed cost effects pushed the change in the excess markup factor strongly positive.

TABLE 10-1
CHANGES IN THE EXCESS MARKUP FACTOR, 2000-2006

	2000	2001	2002	2003	2004	2005	2006
Excess Markup	-9.18%	-5.65%	-3.34%	-5.59%	-13.59%	-9.24%	6.16%
Density Impact (1 + FC/VC) dDensity/dt	-13.55%	0.24%	-2.14%	-0.47%	-0.91%	14.91%	10.66%
Fixed Cost Impact Density d(FC/VC)/ dt	0.44%	0.77%	-0.80%	1.92%	-5.11%	-5.48%	7.67%
Market Power Change $1/(1 + \varepsilon)^2$ dε/dt	10.13%	2.53%	5.40%	-3.65%	-1.21%	-5.80%	-4.36%
Total Change in Excess Markup	-2.98%	3.55%	2.46%	-2.21%	-7.22%	3.64%	13.97%

CONCLUSIONS

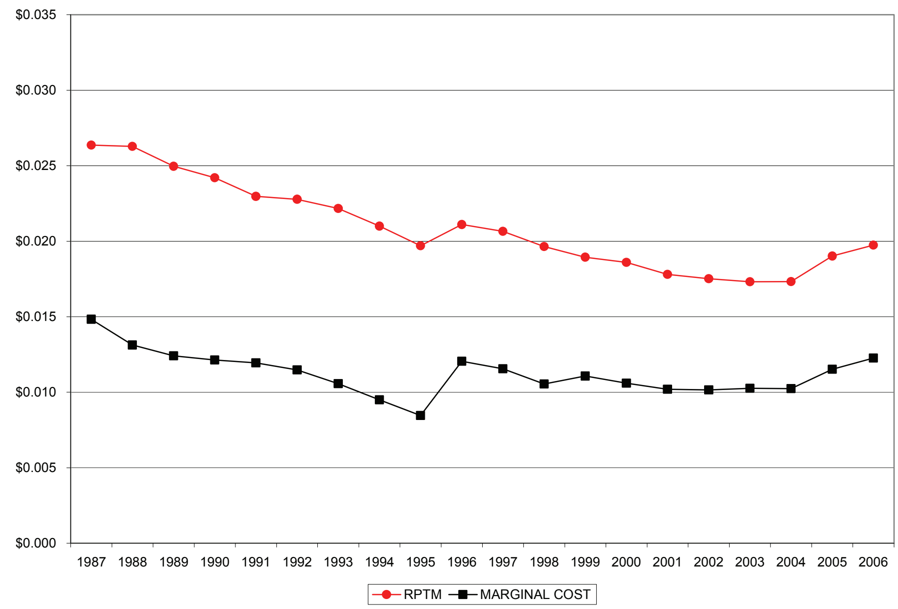
This overview of costs and revenues leads us to several basic findings. First, the last twenty years includes periods of increasing exercise of market power and periods of declining exercise of market power. The largest increases in market power appear to occur in periods when marginal cost was declining. In these periods, the average revenue per ton-mile did not decline proportionately with marginal cost. In periods of cost increases, market power either declined or held steady. Second, it does not appear that excess net revenues were generated during the periods when there was an increased exercise in market power during most of the last twenty years, as the railroad industry was still attempting to achieve revenue sufficiency. Only in the most recent year does industry revenue noticeably exceed industry cost. Third, economies of density and fixed costs are the primary factors driving the markup of marginal cost. Finally, the recent substantial increase in revenue per ton-mile appears to be largely the result of increases in fixed and marginal costs, and not due to an increased exercise of market power.

APPENDIX 10A

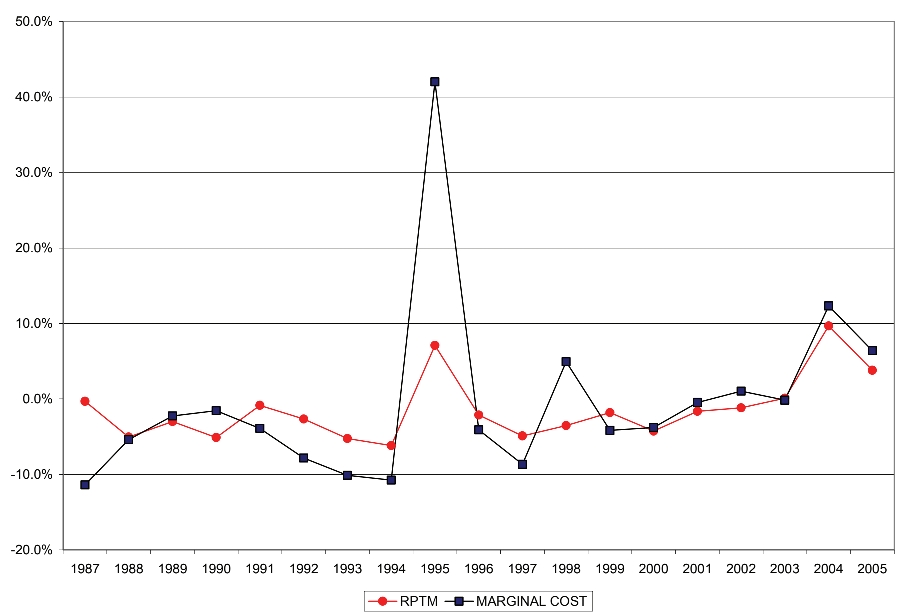
Exhibit 1: BNSF RPTM, Costs, Markup Ratios, and Lerner Markup Index
Exhibit 2: CSX RPTM, Costs, Markup Ratios, and Lerner Markup Index
Exhibit 3:NS Costs, Markup Ratios, and Lerner Markup Index
Exhibit 4: UP RPTM, Costs, Markup Ratios and Lerner Markup Index

Exhibit 1: BNSF RPTM, Costs, Markup Ratios, and Lerner Markup Index

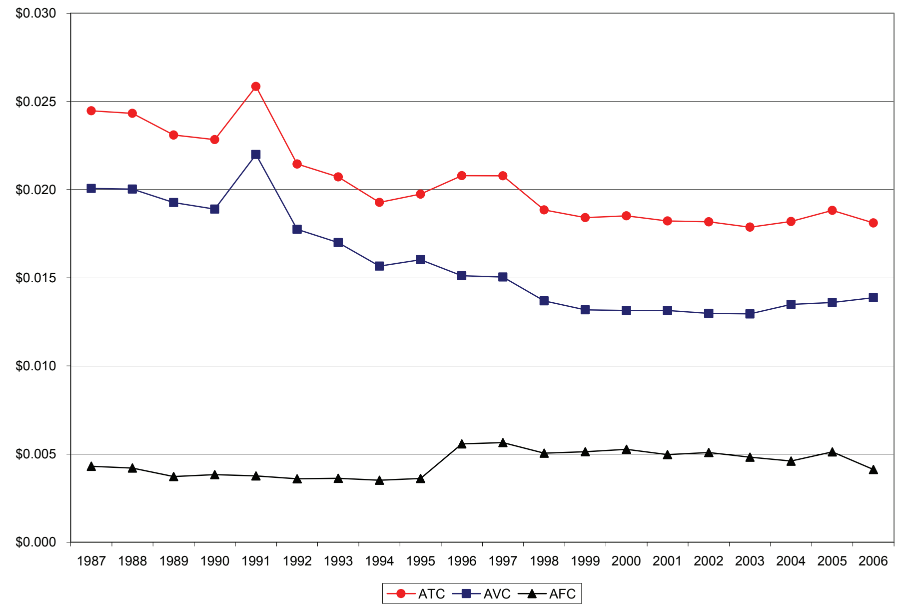
BN (1987-1995) and BNSF (1996-2006)
Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



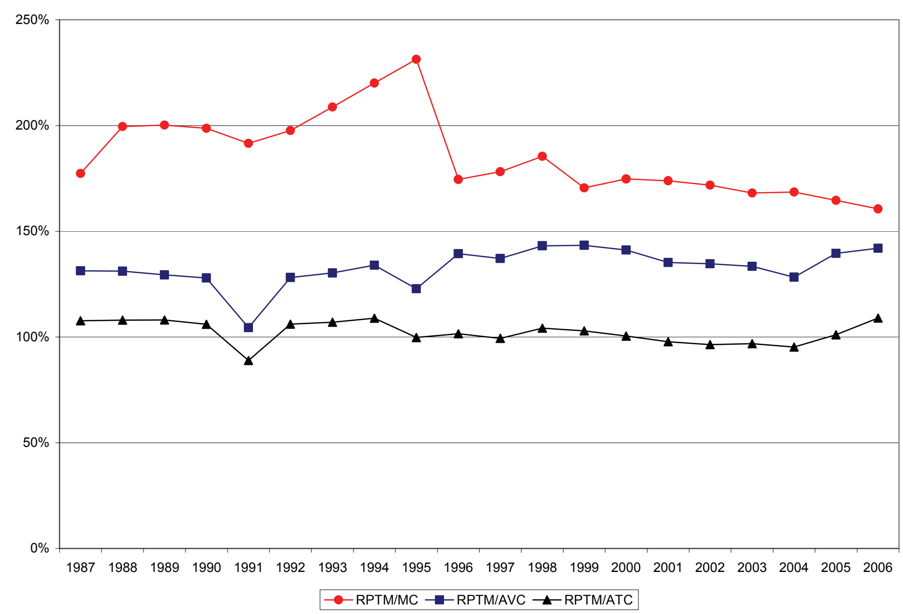
BN (1987-1995) and BNSF (1996-2006)
Percent Changes in Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



BN (1987-1995) and BNSF (1996-2006)
Average Total Cost, Average Variable Cost, and Average Fixed Cost of a Ton-Mile



BN (1987-1995) and BNSF (1996-2006)
Markup Ratios



BN (1987-1995) and BNSF (1996-2006)
Lerner Markup Index

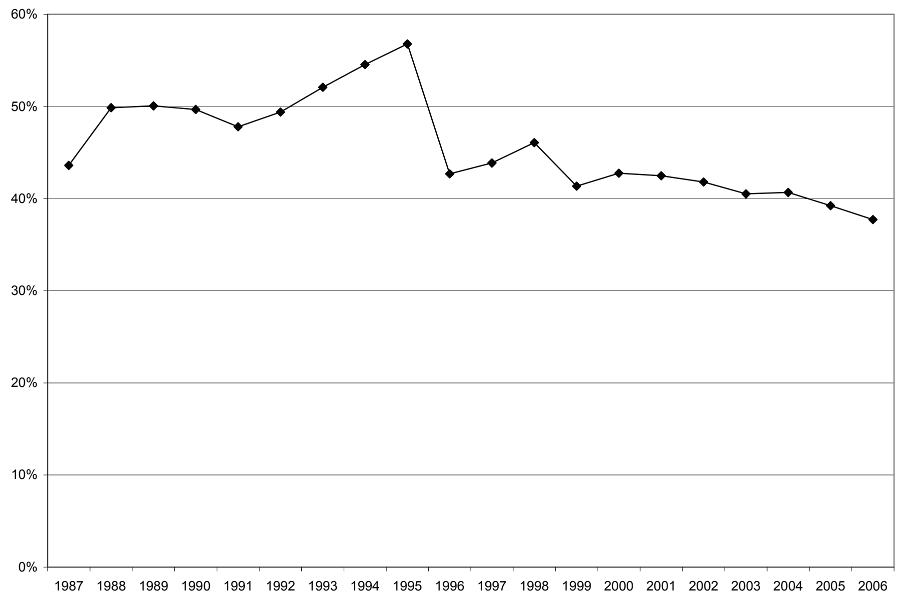
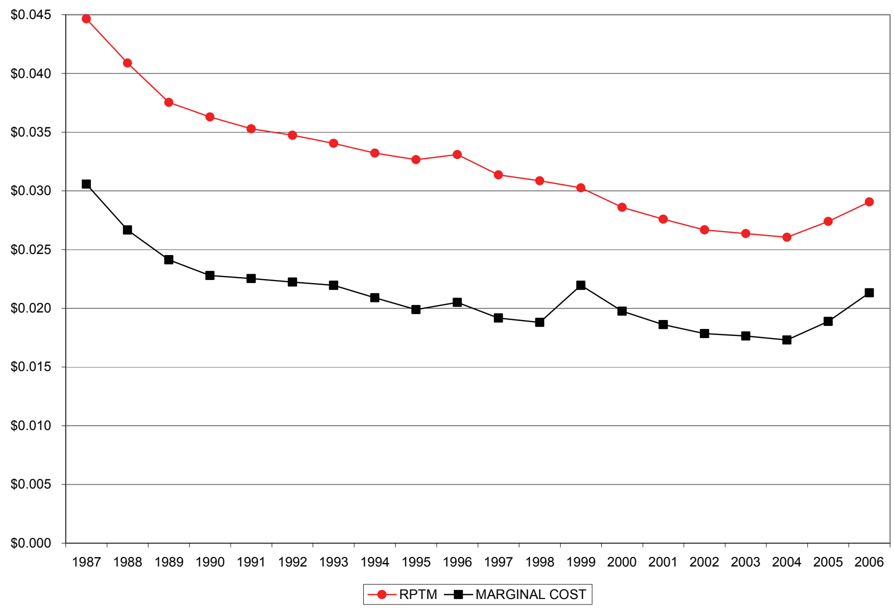
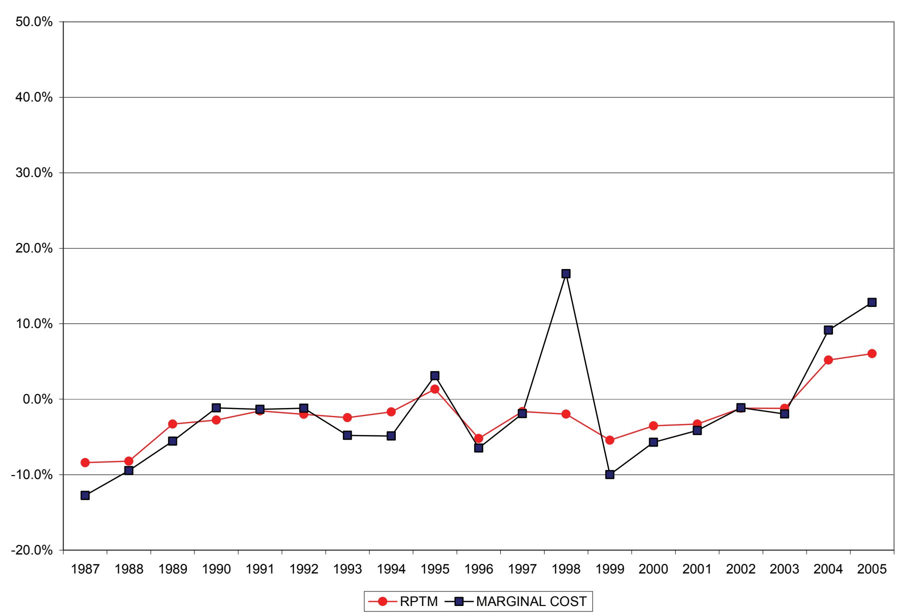


Exhibit 2: CSX RPTM, Costs, Markup Ratios, and Lerner Markup Index

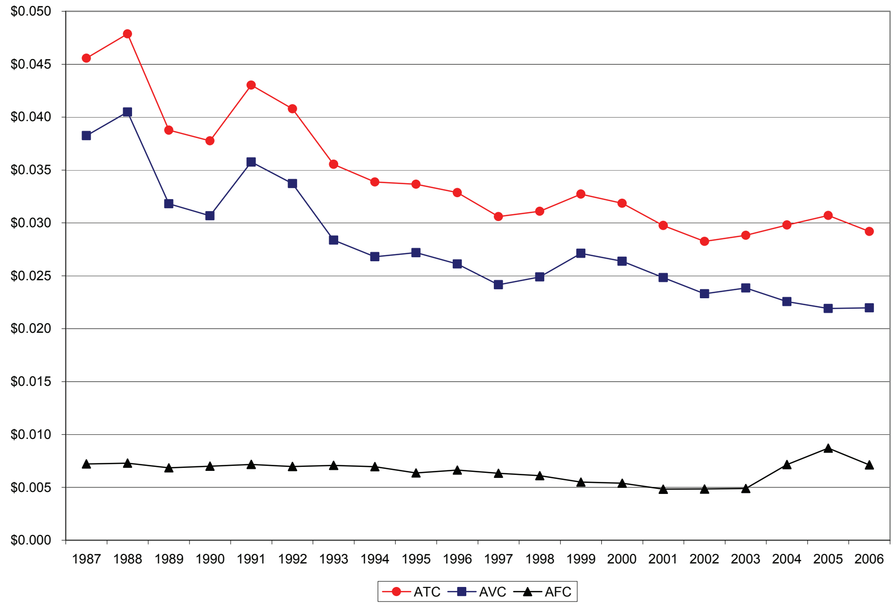
CSX
Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



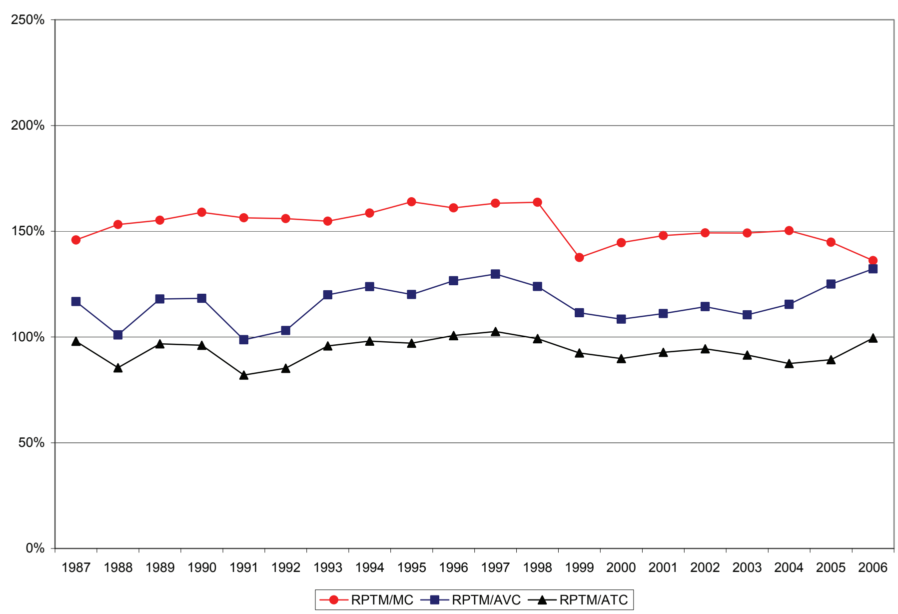
CSX
Percent Changes in Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



CSX
Average Total Cost, Average Variable Cost, and Average Fixed Cost of a Ton-Mile



CSX
Markup Ratios



CSX
Lerner Markup Index

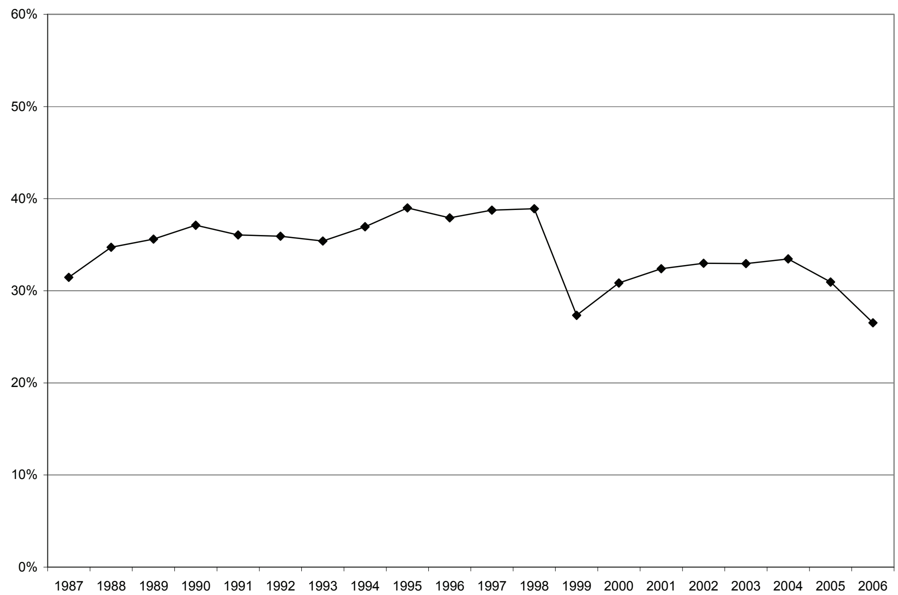
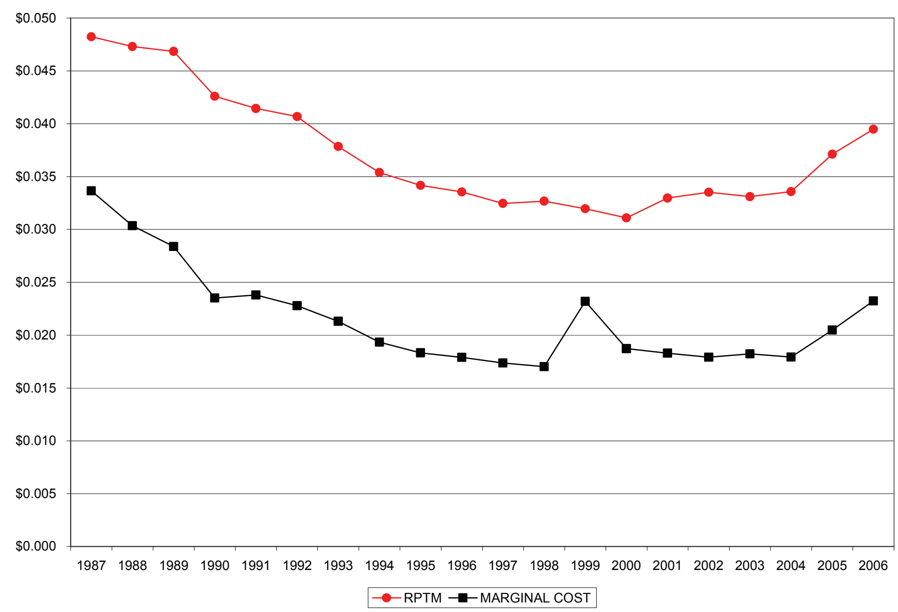
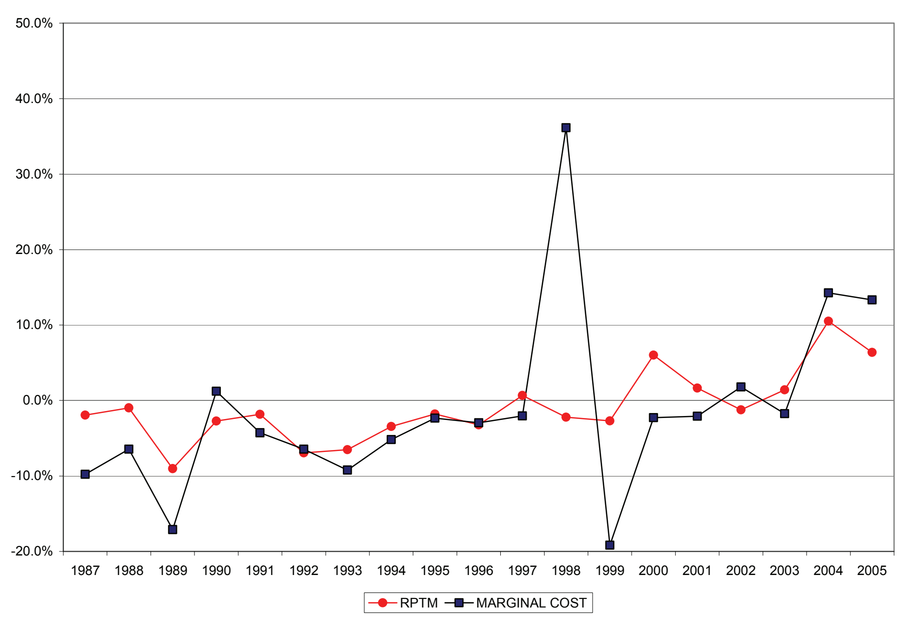


Exhibit 3:NS Costs, Markup Ratios, and Lerner Markup Index

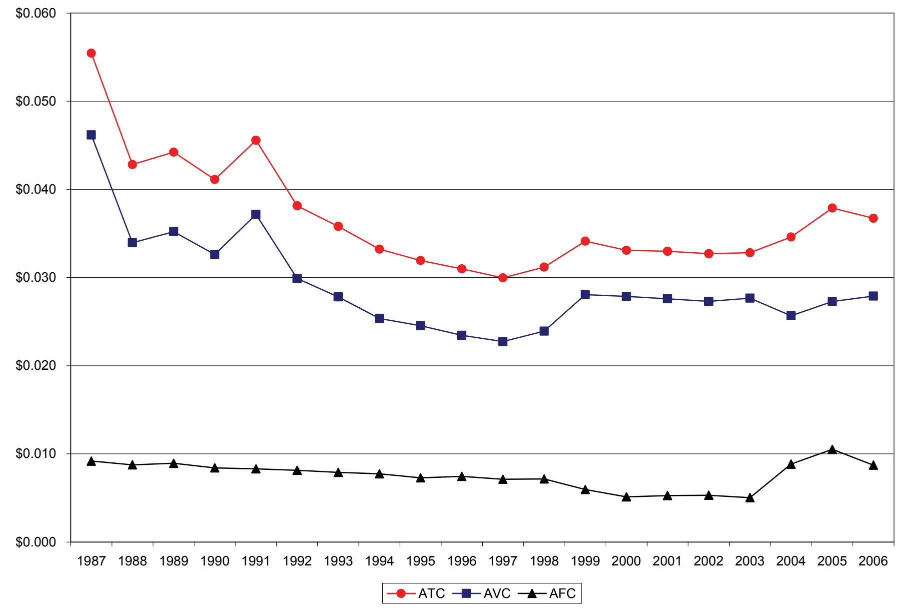
NS
Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



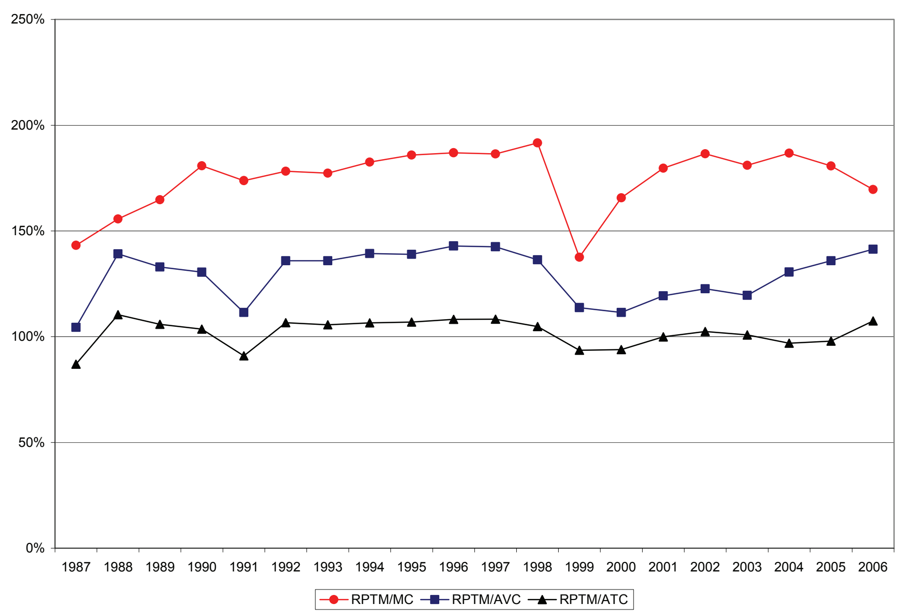
NS
Percent Changes in Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



NS
Average Total Cost, Average Variable Cost, and Average Fixed Cost of a Ton-Mile



NS
Markup Ratios



NS
Lerner Markup Index

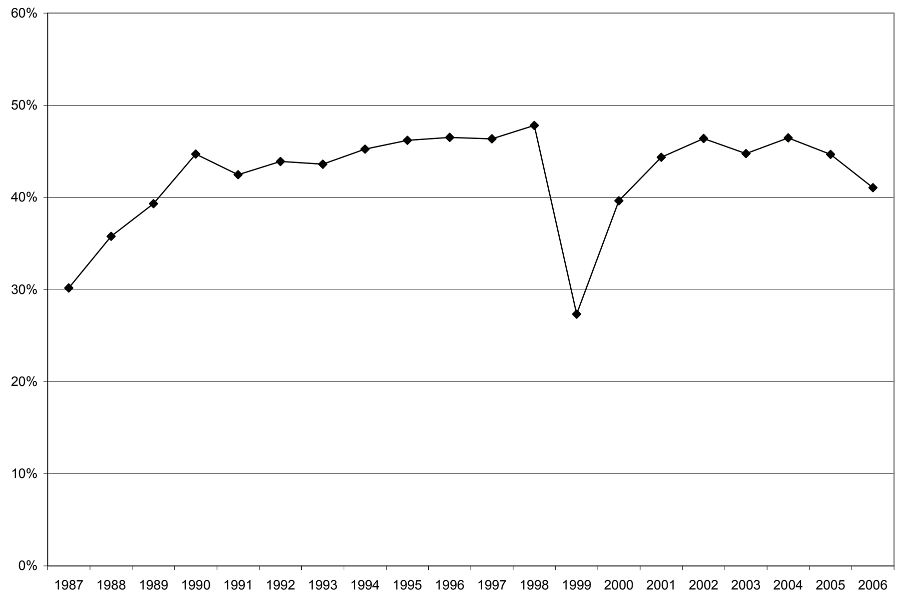
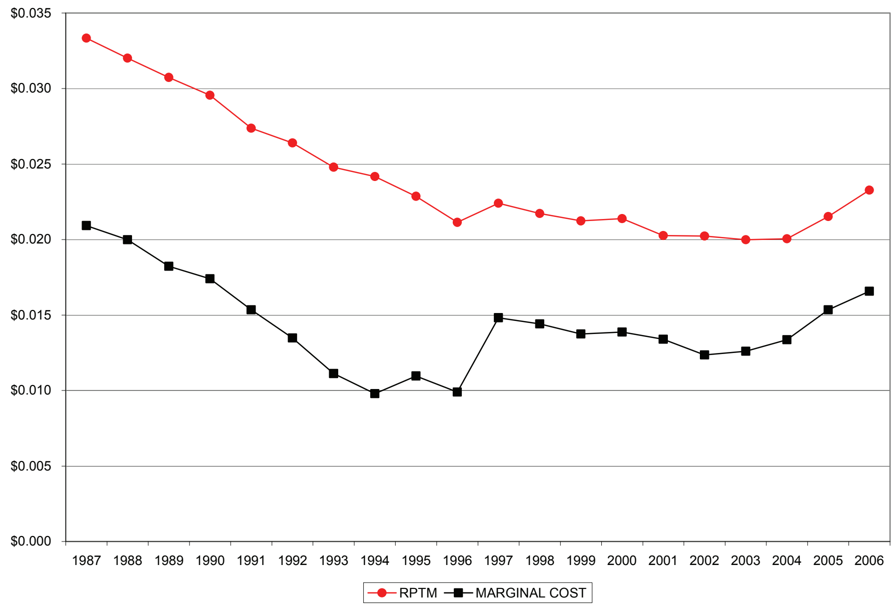
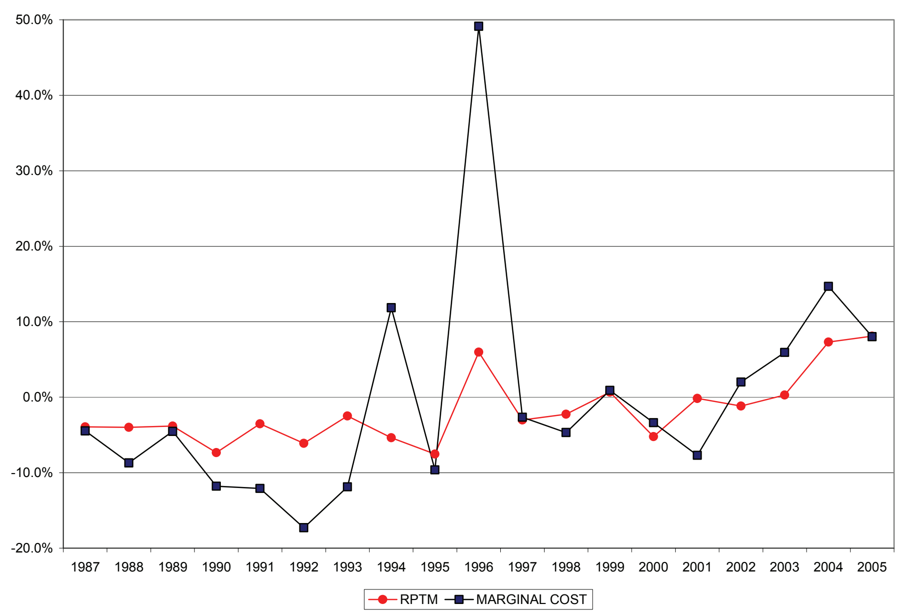


Exhibit 4: UP RPTM, Costs, Markup Ratios, and Lerner Markup Index

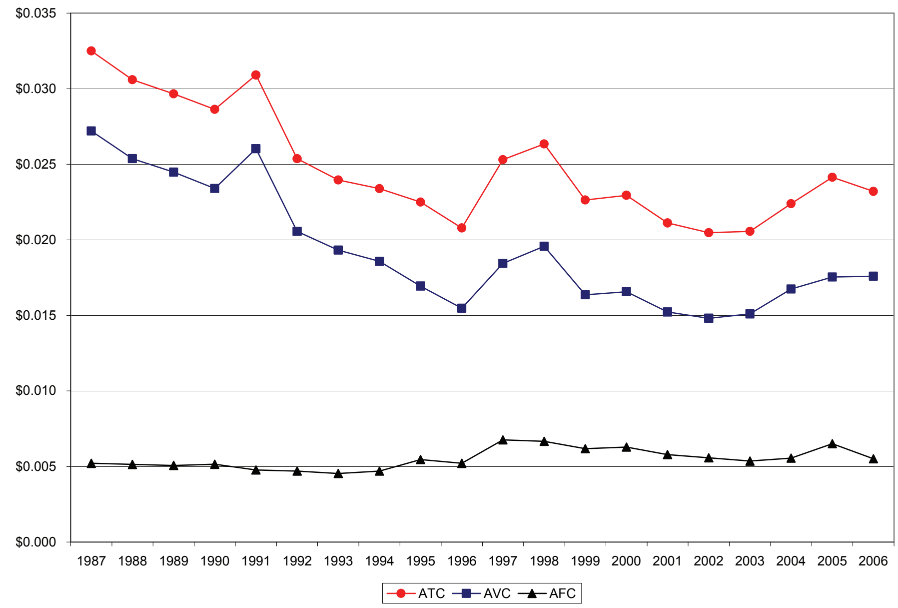
UP
Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



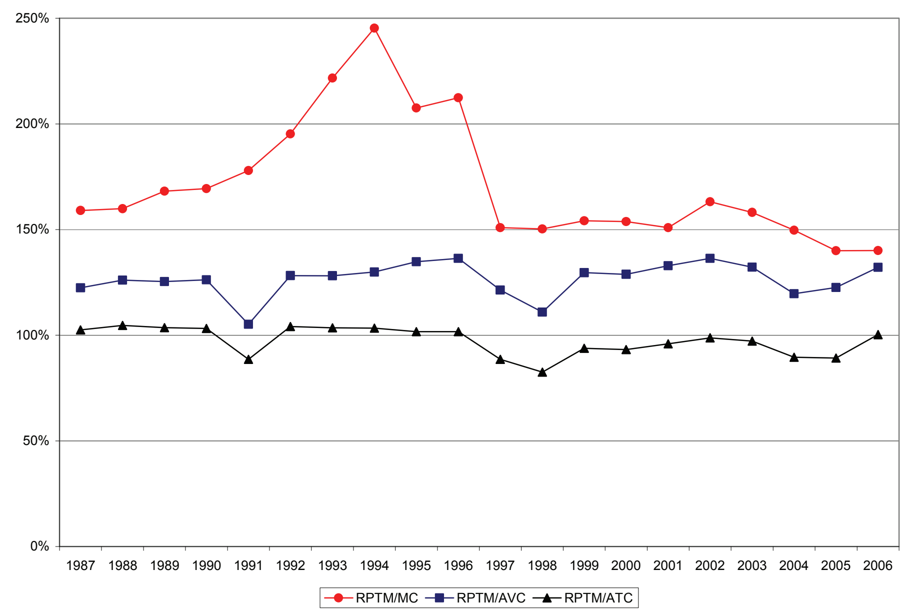
UP
Percent Changes in Revenue per Ton-Mile and Marginal Cost of a Ton-Mile



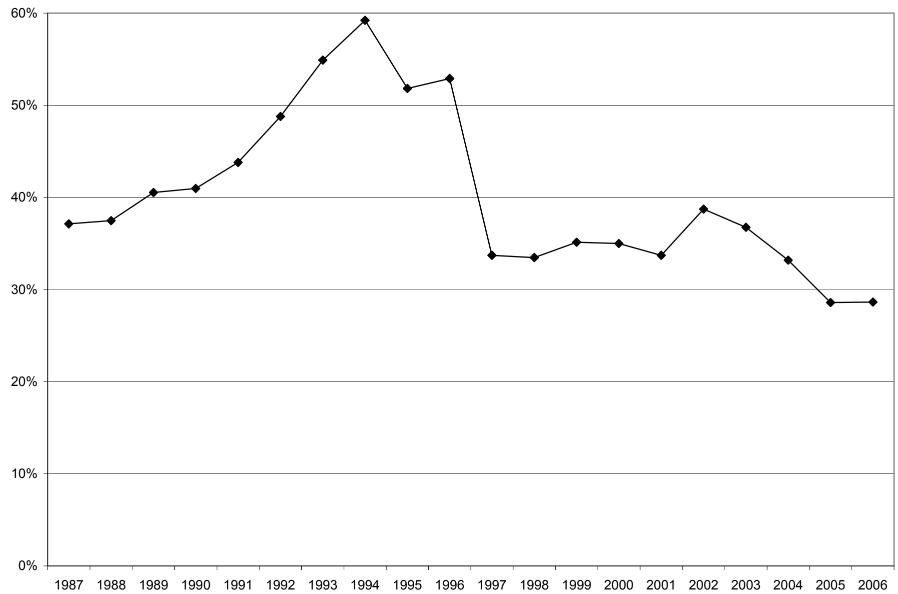
UP
Average Total Cost, Average Variable Cost, and Average Fixed Cost of a Ton-Mile



UP
Markup Ratios



UP
Lerner Markup Index



Chapter 11 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 11.
RAILROAD PRICING BEHAVIOR

INTRODUCTION

In this chapter, we characterize railroad pricing behavior at the shipment level with an econometric analysis of a panel of Carload Waybill Sample data. We use a profit-maximization model of railroad behavior, subject to constraints from alternative shipping modes, to develop “reduced form” pricing equations that relate reported revenue per ton-mile (RPTM) to cost and market-structure features of sampled shipments.

The pricing equations allow us to characterize the extents to which cost and market structure features of shipments account for variations in unit revenues at the commodity level. The model’s yearly intercepts also may be used to estimate changes in commodity-level “real” RPTMs with more explicit control for shipment and market characteristics than are employed in most rate-indexing methods. The pricing equations do not allow direct identification of the underlying costs (or markups) in observed RPTMs. However, by combining information on “generic” marginal costs per ton-mile from the variable cost function results of Chapter 9 with estimates of pricing equation parameters, we characterize costs and markups at finer levels than is practical in aggregated analyses, though not to the full extent of identifying shipment-level costs.

Using the pricing models, we estimate the effects of two factors which may limit a railroad’s ability to exert local market power: the availability of water-transportation alternatives and the presence of railroad competition. The large sample sizes from the Carload Waybill Sample allow us to investigate whether the effects of these factors have changed over time. Since a number of legislative initiatives involve efforts to increase intramodal competition, these estimates also inform our policy analysis in Volume 3 of this report.

Section 11A briefly reviews pricing under profit maximization, and in section 11B we extend the basic model to incorporate the constraints on railroad pricing from shippers’ alternatives. Section 11C describes how we incorporate information from our variable cost model, found in Chapter 9, to allow identification of commodity-level markups. Section 11D describes the specifications of the pricing models, as well as the data and estimation methods. Section 11E provides the main results of our model estimation.

11A. PRICING BEHAVIOR UNDER PROFIT MAXIMIZATION

In this model, a firm is assumed to pursue maximum profit. That leads to the familiar optimization condition that a firm will supply (or price) its output such that marginal revenue equals marginal cost for the last unit supplied:

(11.1) $MR = MC$.

The second-order condition for profit-maximization is that marginal revenue changes as output (Y) increases by more than does marginal cost (i.e., $\partial MR / \partial Y < \partial MC / \partial Y$). The law of demand guarantees that marginal revenue is non-increasing in Y, and is decreasing in Y if the firm has any market power (price-setting ability). The second-order condition may be satisfied even when marginal cost is declining with Y, as is the case with economies of density.

The elasticity of demand perceived by the seller, ε, links output price (the railroad rate, r) and marginal revenue, i.e.:

(11.2) $MR = r(1 + 1/\varepsilon)$. [note: $\varepsilon \leq 0$]

Incorporating the profit-maximization condition (11.1) into the marginal revenue definition (11.2) and rearranging terms yields the following markup equation, often referred to as the Lerner Markup Index (LMI):

(11.3) $LMI \equiv (r - MC)/r = -1/\varepsilon$.

Since MC > 0, the LMI for a profit maximizer lies between zero and 1. Consequently, the perceived elasticity of demand, ε, is less than −1 to satisfy the equality in equation (11.3). That is, the profit maximizer, including a monopolist, will operate in the elastic region of the perceived demand curve.

The LMI formulation can be rearranged to give the behavioral pricing equation for a profit-maximizing firm:

(11.4) $r = MC[\varepsilon/(\varepsilon + 1)]$,

or in logarithmic form:

(11.5) $\ln r = \ln MC + \ln[\varepsilon/(\varepsilon + 1)]$.

However, a practical consideration for railroads is that many shippers have access to alternative means of satisfying their transportation demands. Shippers' options may include, for example, which railroad, which transportation mode, which product shipped, and where the product is shipped to (in the case of an originator) or from (in the case of a receiver).[1] When shippers have options, the railroad must price not only to maximize profit, but also to ensure that shippers choose a rail shipment option. The shippers' options (constraints for the railroad) will tend to lower railroad prices relative to unconstrained monopoly rates.

11B. CONSTRAINED "MARKET DOMINANCE" AND "CAPTIVE DEMANDERS" IN RAILROAD MARKETS[2]

In this section, we extend the basic profit-maximizing model to consider pricing constraints arising from shippers' transportation alternatives. This provides a framework by which factors such as intramodal competition, intermodal competition, geographic, and product-market aspects enter into the railroad pricing decision.

Let the options that a shipper has be enumerated 1, 2, …, N. The shipper is envisioned as calculating its profit or net payoff (π_i) for each option.[3] Such profit functions may reflect the cost of the inputs necessary to produce the product shipped or other costs of the product shipper (in the case where the shipper does not manufacture or otherwise transform the product). It also includes the price of transportation (the rate) and the service-induced costs as in Baumol and Vinod (1970).[4]

The shipper chooses the option that yields the greatest payoff. That is, the option chosen *i* is such that $\pi_i = \max(\pi_1, \pi_2, ..., \pi_N)$. The shipper's maximal profit received from any given option is a function of the output prices, the input prices, and any fixed factors of production for the shipper. Note that the derivative of the shipper's profit function with respect to the railroad rate (r_i) is the negative of the demand for railroad services in that

[1] These options frame intramodal, intermodal, geographic, and product-competitive aspects. The 4-R Act and the Staggers Rail Act of 1980 introduce these factors to regulation as the "market dominance" criteria. More specifically, market dominance requirements initially required revenue to variable cost ratios in excess of 180 percent and a qualitative evaluation of these factors. Only if R / VC > 180% and none of these factors were deemed present, could the reasonableness of a rate be questioned. In more recent years, the product and geographic factors were removed and intermodal competitive factors almost always are found to be present.

[2] This model generally follows Wesley W. Wilson, "Legislated Market Dominance," *Research in Transportation Economics* 4(1), 1986, pp. 33-48.

[3] These may be shown to exist under standard regularity conditions on the shipper's technology.

[4] William J. Baumol and Hrishikesh D. Vinod, "An Inventory Theoretic Model of Freight Transport Demand," *Management Science* 16(7), 1970, pp. 413-421. The service-induced costs include time in transit (e.g., inventory costs), reliability (demurrage of ocean vessels, contract penalties for late delivery), etc.

option, i.e., $\partial\pi_i(r_i,\ldots)/\partial r_i = -R_i(r_i,\ldots)$,[5] where r_i is the rail rate and R_i the rail demand for the i[th] option.

Captive Shipper with Participation Constraint

Consider the case in which the shipper is "captive" in the sense that a rail movement is the shipper's only transportation option. The shipper may, nevertheless, be priced out of the transportation market. The participation constraint may be modeled as $\pi^s(r) \geq 0$. The railroad's profit maximization problem becomes:

$$(11.6)\quad \max rR(r) - C(R(r)) \text{ s.t. } \pi^s(r) \geq 0,$$

with first-order conditions:

$$(11.7)\quad R(r) + (\partial R/\partial r)(r - MC) + \lambda\partial\pi^s(r)/\partial r \leq 0$$

$$(11.8)\quad \pi^s(r) \geq 0.$$

In equation (11.7), the term λ is the Lagrangian multiplier and represents the value to the railroad of a less-stringent participation constraint for the shipper. In this case, the monopoly price would be observed if it satisfies the shipper's participation constraint, since equation (11.7) reduces to the usual monopoly pricing condition. Otherwise, the railroad charges the highest price at which the shipper is still willing to make the movement. (We assume that the railroad wants the traffic.)

Shipper with Modal Options

More commonly, the shipper has a number of options. For example, it could use a different mode, a different railroad, or a number of different modal combinations and options. It could also ship to or receive from different locations. In this setting, assuming again that the railroad wishes to provide the service, it must price the movement in order to dominate the other options. Thus, the other options serve as constraints on the railroad's pricing. Assume that the rail shipment option may be preferred for some rates, and let O represent the shipper's next best (non-rail) option. The profit maximization problem of the railroad is:

$$(11.9)\quad \max rR(r) - C(R(r)) \text{ s.t. } \pi^s(r) \geq \pi^O$$

[5] This result is known as Hotelling's Lemma.

with first-order conditions:

$$(11.10)\ R(r) + (\partial R / \partial r)(r - MC) + \lambda \partial \pi^{s}(r) / \partial r \leq 0$$

$$(11.11)\ \pi^{s}(r) - \pi^{O} \geq 0\ .$$

The first order condition (10) can be written as:

$$(11.12)\ \frac{r\ \ -\ MC}{r} \ = \ \frac{(\lambda\ -\ 1)}{\varepsilon}. \qquad \text{[note: } \partial \pi^{s}(r) / \partial r \ = \ -R\text{]}$$

As in equation (11.7), the term λ reflects the value to the railroad of relaxing the shipper's participation constraint by increasing the differences between the shipper's payoff with rail shipment and the payoff under the shipper's next best alternative(s). The larger the difference, in principle, the higher the railroad is able to price the movement (closer to monopoly). The value of λ lies between 0 and 1. If $\lambda = 0$, the monopoly solution obtains, while if $\lambda = 1$ then rates reflect marginal costs. There is no incentive for the railroad to price above the monopoly rate—λ cannot be less than zero—and λ cannot be greater than one because if the railroad rate were below marginal cost, the railroad would be unwilling to accept the movement. Since λ is obtained by solving the system of equations (11.10) and (11.11), in general it depends on market structure, firm-specific, and shipment-specific factors.

Rearranging terms in equation (11.12) yields a pricing equation that is a generalization of equation (11.5), above:

$$(11.13)\ \ln r = \ln MC + \ln[\varepsilon / (\varepsilon - \lambda + 1)].$$

Equation (11.13) serves as the basis for our reduced-form pricing model. We linearize (11.13) to take the form:

$$(11.14)\ \ln r = \alpha_0 + \textstyle\sum_j \beta_j\ \textit{cost variable}_i + \sum_k \gamma_k \textit{market structure variable}_k\ .$$

Applications of equation (11.14) in the literature measure r with revenue per ton-mile; cost variables include shipment size, shipment distance, and load characteristics; and market structure variables include measures of railroad concentration (e.g., Herfindahl indexes) and modal competition indicators.[6] This approach allows the estimation of commodity-specific and/or market-specific cost and competition effects that would be impossible to estimate in more highly aggregated analyses such as the cost modeling described in Chapter 9.

11C. INCORPORATING MARGINAL COST INFORMATION IN THE PRICING MODEL

A limitation of equation (11.14) is that it allows estimation of factors that cause *variations* in costs and markups for railroad movements, but not the *levels* of costs and markups themselves.[7] As a result, pricing models following this scheme can be used to estimate the effects of factors indicating the exercise of market power but not the resulting markups. In our analysis, we relax this limitation by incorporating estimated marginal costs from the variable cost model from Chapter 9 with pricing equation estimates. This step allows us to analyze pricing at the commodity and/or railroad level for Class I railroads.

Our approach is based on a decomposition of a shipment's marginal cost per revenue ton-mile (RTM) into a "generic" marginal cost and a shipment-specific adjustment (SSA) factor:

(11.15) $MC_i = MC^{Generic} \times SSA_i$.

We estimate the "generic" marginal cost using the variable cost model, that is:

(11.16) $MC^{Generic} = \partial C^V / \partial RTM$.[8]

In implementing equation (11.16), we evaluate the marginal cost function to yield estimates of marginal cost by railroad and year. The SSA is estimated from the "cost variable" terms in equation (11.14):

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[6] See, e.g., James M. MacDonald, "Competition and Rail Rates for the Shipment of Corn, Soybeans, and Wheat," *Rand Journal of Economics* 18(1), 1987, pp. 151-163; James M. MacDonald, "Railroad Deregulation, Innovation, and Competition: Effects of the Staggers Act on Grain Transportation," *Journal of Law and Economics* 32, 1989, pp. 63-96; Mark L. Burton, "Railroad Deregulation, Carrier Behavior, and Shipper Response: A Disaggregated Analysis," *Journal of Regulatory Economics* 5, 1993, pp. 417-34; and Wesley W. Wilson, "Market-Specific Effects of Rail Deregulation," *Journal of Industrial Economics* 42, 1994, pp. 1-22.

[7] In equation (11.14), the constant term would be expected to combine cost and markup components, and the components cannot be recovered from an estimate of the constant term.

[8] Chapter 9 defines variable cost in equation (18) as $MC = (\partial \ln C^V / \partial \ln Y) \times (C^V / Y)$, where C^V represents variable cost and Y represents revenue per ton-mile. This measure of generic marginal cost holds average length of haul constant.

$$(11.17)\ SSA_i = \exp\left(\sum_j \hat{\alpha}_j cost\_variable_j\right) / \exp\left(\sum_j \hat{\alpha}_j \overline{cost\_variable_j}\right),$$

where $\overline{cost\_variable_j}$ is a value for the cost variable consistent with the evaluation of the generic marginal cost. Using equation (11.17), the estimated LMI is:

$$(11.18)\ LMI_i = (r_i - MC^{Generic} \cdot SSA_i) / r_i\ .$$

Due to cost data limitations, we cannot evaluate equation (11.18) at the shipment level, but the available data mostly allow us to evaluate (11.18) at the commodity level for Class I railroads. We present our results below.

11D. Data and Estimation

We estimate pricing equations by commodity group using shipment-level observations drawn primarily from the unmasked confidential 2001-2006 Carload Waybill Sample (CWS) files. We estimate pricing models for the full 2001-2006 period, as well as for the 2001-2003 and 2004-2006 periods partitioning the main sample period.

The principal advantage of the CWS is that it provides revenue data reflecting tariff or contract rates as applicable—though not the effects of after-the-fact contracted price adjustments such as volume discounts—along with information on a number of shipment cost characteristics. Additionally, CWS data may be used to compute sample-based estimates for revenue, tonnage, and carloads at levels of detail (railroad, commodity, and/or geography) that are unavailable from other sources of railroad operating statistics. Furthermore, CWS coverage includes non-Class I railroads, so our analysis is not limited to characterizing the pricing behavior of the Class I railroads.

Table 11-1 lists the commodity groups covered by the pricing model. The included commodity groups represent nearly 94 percent of tonnage, 93 percent of ton-miles, and 88 percent of revenue in the 2006 CWS.

TABLE 11-1
COMMODITY GROUPS USED IN PRICING ANALYSIS

Commodity Group	Standard Transportation Commodity Code (STCC)	Share of Revenue (2006)	Share of Tonnage (2006)	Share of Ton-Miles (2006)
Farm Products	1	8.2%	8.1%	10.0%
Corn	1132	3.8%	4.0%	5.2%
Wheat	1137	2.2%	2.2%	2.3%
Barley	1131	0.2%	0.2%	0.1%
Soybeans	1144	1.0%	1.0%	1.4%
Metallic Ores	10	1.1%	3.1%	0.9%
Coal	11	19.9%	40.5%	38.1%
Nonmetallic Minerals	14	2.9%	7.4%	2.5%
Food Products	20	6.9%	5.2%	6.4%
Lumber or Wood Products	24	5.3%	3.2%	4.6%
Chemicals*	28	11.8%	8.9%	9.3%
Petroleum or Coal Products*	29	3.5%	3.0%	2.7%
Clay, Concrete, Glass or Stone Products	32	3.2%	2.9%	2.2%
Primary Metal Products	33	4.2%	3.3%	2.8%
Transportation Equipment	37	8.1%	2.6%	2.8%
Intermodal Shipments (COFC/TOFC)	Various	19.4%	8.1%	14.5%
Total in Analysis		88.2%	93.8%	93.1%

*Including hazardous materials.

Pricing Model Specification

The pricing model specifications used in our implementation of equation (11.14) roughly follow the form of the estimating equations from MacDonald.[9] The explanatory variables include:

• Shipment Cost Characteristics

- Length of haul
- Size of load
- Tons per car
- Private car ownership
- Volume in tons between origin and destination states

We expect negative signs on the coefficients of the variables indicating shipment cost characteristics. This reflects railroad cost components that are fixed or non-increasing with respect to distance or shipment size, for instance costs of switching and classifying cars. Shippers supplying their own cars should avoid implicit rental charges for use of railroad-owned cars. The volume of shipments between the origin and destination states was used by MacDonald as an indicator of the ability to form unit trains or other relatively efficient shipment configurations.[10]

• Market Structure (Railroad and Modal Competition) Indicators

- Distance from origin to nearest port or waterway facility
- Distance from destination to nearest port or waterway facility
- Railroad competitors at origin
- Railroad competitors at destination

Increasing the distances to port and waterway facilities would tend to reduce railroad pricing constraints from water transport, as the cost of accessing the alternative mode increases. Thus, we would expect increasing distances to waterway facilities would tend to increase rail rates, other things equal. Conversely, the presence of additional railroad competitors would be expected to reduce rail rates. We also allow for discontinuity in counties with a single railroad competitor. While the absence of railroad competition in an area may be associated with local market power, the exercise of market power may be constrained by regulatory mechanisms.

In our analysis, we consider the truck transportation alternative to be both ubiquitous—unlike rail or water alternatives, theoretically accessible to any shipper—and generally a high-cost alternative. Thus, for long-distance

[9] James M. MacDonald, "Railroad Deregulation, Innovation, and Competition: Effects of the Staggers Act on Grain Transportation," *Journal of Law and Economic,* 32, 1989, pp. 63-96.

[10] James M. MacDonald, "Competition and Rail Rates for the Shipment of Corn, Soybeans, and Wheat," *Rand Journal of Economics* 18(1), 1987, pp. 151-163; and James M. MacDonald, "Railroad Deregulation, Innovation, and Competition: Effects of the Staggers Act on Grain Transportation," *Journal of Law and Economic,* 32, 1989, pp. 63-96.

bulk commodity hauls, we would not expect trucks to be a constraining mode for railroad pricing. Otherwise, the effect of the truck alternative would be absorbed in the models' intercepts, which as discussed below are designed to capture effects of local variations in the elasticity of demand for rail service.

• Other Control Variables

- Year indicators
- Quarter indicators
- Originating and terminating railroad indicators
- Origin and destination location indicators

These sets of categorical control (dummy) variables allow for seasonal, secular, and locational differences in demand elasticities. They also help control for the effects of unmeasured or "latent" cost and competition factors. The origin-destination state variable used for the shipment location indicator allows the effects of shipments from state A to state B to differ from the effects of shipments from state B to state A. The coefficients on the year indicator variables will show trends (if any) in commodity-level "real" RPTM, controlling for the other factors included in the pricing model.

The main model specification is given in equation (11.19), below. As a sensitivity check, we also estimated restricted versions of and alternative specifications to equation (11.19). Results from alternative specifications are presented in the appendix to this chapter.

(11.19)

$$
\begin{aligned}
&\ln RPTM = \alpha_0 + \alpha_{ORTR} \\
&+ \beta_1 \ln MILES \\
&+ \beta_2 \ln TONS \\
&+ \beta_3 \ln TONSCAR \\
&+ \beta_4 \ln VOL\_TONS \\
&+ \beta_5 D\_OWN \\
&+ \gamma_1 DLM\_ORG \\
&+ \gamma_2 RRCOMP\_ORG \\
&+ \gamma_3 DLM\_TER \\
&+ \gamma_4 RRCOMP\_TER \\
&+ \gamma_5 \ln KMWATER\_ORG \\
&+ \gamma_6 \ln KMWATER\_TER \\
&+ \sum_i \delta_i QTR_i \\
&+ \sum_j \phi_j YEAR_j \\
&+ \sum_k \gamma_k RAILROAD\_ORG_k \\
&+ \sum_l \eta_l RAILROAD\_TER_l \\
&+ \omega
\end{aligned}
$$

Table 11-2 lists the definitions and sources of the variables included in equation (11.19).

We employ unmasked CWS data provided by the STB to avoid data analysis issues related to omissions of sensitive routing information and contract revenue masking as described by Wolfe.[11] Measuring railroad competition and the availability of waterborne alternatives requires data on shipment geography.

[11] K. Eric Wolfe, "The Interstate Commerce Commission's Public Use Waybill File: Concern for Misinterpretation," *Journal of the Transportation Research Forum* 32(1), 1991. The availability of unmasked data facilitates our analysis, though it is not strictly necessary. The revenue masking procedure, as described by Wolfe, introduces multiplicative error components into the masked revenue observations, which leads to additive error components in natural logarithms. Since the (confidential) revenue adjustment factors are unique to combinations of railroads and 3-digit STCCs, it is theoretically possible to control for their effects on other coefficient estimates by adding railroad-STCC dummy variables. However, this would involve both a cost to model parsimony (using model 'degrees of freedom' in part to estimate constants that include the masking factors) as well as increased computational cost. We also observe that the effect of revenue masking on regression-based models of RPTM is ambiguous and depends on the presence of coincidental correlations between masking factors and other explanatory variables.

TABLE 11-2
PRICING EQUATION VARIABLE DEFINITIONS AND SOURCES

Variable	Definition	Source*
RPTM	(TOTAL_REV ∕ (MILES × TONS)) ∕ GDPPI	
TOTAL_REV	Total (unmasked) freight revenue for waybill	CWS, item 15
TONS	Billed weight for waybill, in tons	CWS, item 99
TONSCAR	TONS ∕ NUM_CARS	
NUM_CARS	Number of carloads	CWS, item 5
MILES	Shortline miles for shipment	CWS, item 24
GDPPI	Price Index for Gross Domestic Product, quarterly (2000 Q1 = 1)	Bureau of Economic Analysis
ORTR	Concatenation of alphabetic origin and termination state codes	CWS, items 124 and 134
α_{ORTR}	Fixed effect for origin-termination state combination, derived from ORTR	
VOL_TONS	EXP_TONS summed by origin-termination state combination, for the 2-digit STCC and waybill year associated with the sampled waybill	
EXP_TONS	Expanded tonnage	CWS, item 100
D_OWN	Dummy variable = 1 for privately-owned cars (CAR_OWNER = “P”), 0 otherwise	
CAR_OWNER	Car ownership indicator	CWS, item 93
RRCOMP_ORG	Reciprocal of Herfindahl index for origin county, based on railroad shares of originated tonnage (EXP_TONS) for the two-digit STCC, computed using 2000-06 CWS data	
DLM_ORG	Dummy variable = 1 if RRCOMP_ORG = 1, 0 otherwise	
RRCOMP_TER	Reciprocal of Herfindahl index for termination county, based on railroad shares of originated tonnage (EXP_TONS) for the two-digit STCC, computed using 2000-06 CWS data	
DLM_TER	Dummy variable = 1 if RRCOMP_TER = 1, 0 otherwise	
KMWATER_ORG	Airline distance** from centroid of origin county to nearest port or waterway facility handling the same	Calculated using ESRI ArcView GIS

Variable	Definition	Source*
	2-digit STCC, in kilometers	
KMWATER_TER	Airline distance from centroid of termination county to nearest port or waterway facility handling the same 2-digit STCC, in kilometers	Calculated using ESRI ArcView GIS
County centroid coordinates	Calculated from Census Department geospatial data on U.S. counties	
Port and waterway facility locations	Latitude and longitude of U.S. port and waterway facilities	Port and Waterway Facilities, U.S. Army Corps of Engineers Navigation Data Center***
QTRn	Dummy variable = 1 for calendar quarter n (= 2, 3, 4), 0 otherwise, based on waybill month	CWS, item 3
YEARyyyy	Dummy variable = 1 for waybill year yyyy (= 2001-2006), 0 otherwise	CWS, item 3
RAILROAD_ORGk (RAILROAD_TERk)	Dummy variable = 1 if originating (terminating) railroad is k (k indexes Class I railroads), 0 otherwise. Non-Class I railroads are base group.	CWS, items 77 and 86
ω	Stochastic disturbance term	

* CWS item numbers are from the 900-byte Carload Waybill Sample record.
** I.e., the shortest great circle route, not accounting for actual routings over the ground.
*** Data obtained at http://www.iwr.usace.army.mil/ndc/data/datapwd.htm.

The county level is the finest level of geographical detail available in the CWS data from public sources.[12] We approximate shipment origin and termination points with the centroids of the origin and termination counties, and use the distance from the county centroid to the nearest available port facility to measure the availability of waterborne transport. We additionally use county-level tonnage shares to measure local railroad competition.

In developing indicators of local competition between railroads, it is desirable that the units of geography be neither too big nor too small. The geographical units should be big enough so that the cost of avoiding railroads that solely serve them is nontrivial without being so large as to encompass railroad options that are, as a practical matter, unavailable to "captive" shippers. Our view is that the county level balances these two concerns better than other units of geography available in the CWS. In particular, states and BEA economic areas (the latter are agglomerations of counties and were used

[12] CWS records include origin and termination Standard Point Location Codes (SPLCs), which theoretically can identify specific origin and destination locations. However, our review of the data indicated that the CWS SPLCs often were coded to approximately county-equivalent levels of geographical detail. Additionally, since SPLC is a proprietary coding system, county-level geography is much more easily matched with other geographical data.

in the GAO's analysis) are large enough to raise issues of measuring the presence of railroad competition that is not actually available to shippers. The average county area in the 48 contiguous states is approximately 1,000 square miles, the equivalent of a square with 31.6-mile sides. While some counties are much smaller than average, the small-area counties tend to be highly urbanized and would be expected to exhibit relatively high ground transportation costs. Thus, we aggregate shipments by county to compute railroads' shares of originated and terminated tonnage. The share computations also aggregate tonnage data over the 2000-2006 period to reduce the potential that small sample sizes for some commodity/county combinations could lead us to miss the presence of railroad competition as a matter of sampling variation.

Sample Definition

The pricing model lightly screens the CWS data for "anomalous" observations. Wolfe observes that the CWS is mandated to exhibit low (no more than one percent) error rates overall, and to avoid "repetitive" or "serial" errors.[13] Thus, our aim was to lightly screen out anomalous CWS observations. We avoid screening directly on (log) revenue or RPTM to avoid econometric problems associated with truncating the distributions of dependent variables in regression models.[14] However, zero values of RPTM and other regressors in levels are undefined when transformed by natural logs, and thus are dropped from the regression sample as unusable. Our main results exclude waybills for shipments originating or terminating outside of the 48 contiguous U.S. states, for which county-equivalent-level competition variables are unavailable.

Screening on explanatory variables normally does not adversely affect the theoretical properties of regression estimates. Indeed, it is desirable to avoid admitting anomalous observations which may act as "leverage points" distorting the estimates of the regression parameters. We exclude waybills with unusually heavy average tons per car, extremely light average tons per car, very high numbers of carloads on the waybill, and very short shipment distances (shortline miles). In the upper tail of the distribution of tons per carload, we observe tonnages that exceed the maximum loads possible at a gross weight above 315,000 pounds. Conversely, the minimum loads recorded in the CWS data are small fractions of a ton per car. We expect that such cases involve incorrect entries of carloads and/or shipment tonnage. We trimmed the minimum load per car at approximately the first percentile for the 2-digit STCC. Some waybills indicate more carloads than we would expect to see in large unit trains; we exclude waybills over 150 carloads. Intermodal shipment waybills by convention are billed as single carloads; we exclude a small number of multiple-carload observations for the intermodal samples only. Last,

[13] K. Eric Wolfe, "The Carload Waybill Statistics: A Content Analysis," *Transportation Research Forum – Proceedings* 27(1), 1986, pp. 244-252.

[14] See, e.g., G. S. Maddala, *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge University Press, 1983.

we exclude observations indicating distances under 20 shortline miles (100 miles for intermodal shipments).

Table 11-3 presents sample sizes and selected descriptive statistics by commodity group.

TABLE 11-3
SAMPLE SIZE AND SUMMARY STATISTICS BY COMMODITY GROUP (2001-2006 PERIOD)

Commodity Group	Regression N*	Mean** RPTM***	Mean** Tons	Mean** Tons/Car	Mean** Shortline Miles	Mean** Carloads
Farm Products	88,490	3.2	461.86	71.19	1130.37	6.49
Barley	3,207	3.8	401.75	93.76	942.57	4.28
Corn	31,597	3.5	1457.03	100.17	720.29	14.55
Wheat	22,054	3.3	1129.48	99.99	682.64	11.30
Soybeans	8,345	3.5	1346.78	86.42	741.04	15.58
Metallic Ores	18,328	4.0	1415.10	94.59	842.95	14.96
Coal	209,859	3.0	3550.62	106.70	563.31	33.28
Nonmetallic Minerals	79,188	3.9	621.99	95.19	627.09	6.53
Food Products	211,074	3.4	77.44	67.23	1112.48	1.15
Lumber or Wood Products	97,252	4.5	80.27	77.16	915.26	1.04
Chemicals	247,368	4.9	98.28	86.70	870.71	1.13
Petroleum or Coal Products	64,945	4.9	135.47	77.48	824.48	1.75
Clay, Concrete, Glass, or Stone Products	81,622	4.5	110.58	88.50	725.31	1.25
Primary Metal Products	95,058	4.6	100.13	84.01	774.67	1.19
Transportation Equipment	331,450	14.4	22.18	21.48	894.96	1.03
Intermodal	1,817,185	4.8	13.53	13.53	1,430.18	1.00

*2001-2006 Sample Period.

**2000 Weighted by the CWS theoretical expansion factor.

***2000 Quarter 1 cents per ton-mile.

Estimation Method

We estimate equation (11.19) using panel data "fixed effects" models, with the individual effects developed from the origin-destination state combinations to provide the location-specific intercepts. We do not weight the data for potential heteroskedasticity (non-constant error variances). The presence of heteroskedasticity would not affect the bias or consistency properties of the least-squares coefficient estimates. We estimated the model for the full 2001-06 period as well as for sub-periods to check the stability of the results over time. We allow the econometric software to drop the excess 'YEAR' dummy variables.

11E. MAIN RESULTS FROM MODEL ESTIMATION

Shipment Cost Characteristics

Table 11-4 presents coefficient estimates for the variables representing shipment cost characteristics, based on the pricing model estimated over the 2001-2006 sample period.[15]

The results for the cost-characteristic coefficients are mostly consistent with our expectations of negative signs. We find that increased length of haul and shipment weight per car, which we expect to reduce unit costs other things equal, are associated with lower RPTM for all commodities. The coefficients on ln TONS also are negative, except for a small and statistically insignificant positive estimate for transportation equipment. Even in the case of transportation equipment, the net effect of shipment size may still be negative, since ln TONS and ln TONSCAR are not independent. For instance, holding the number of carloads constant, increasing TONS by 10 percent will increase shipment weight per car (TONSCAR) by 10 percent, thus the total effect of increasing shipment size is negative as expected. Given the relative magnitudes of the coefficients, TONSCAR needs only to increase modestly for the overall effect to be negative. We also find that many shippers pay lower rates when using non-railroad-owned cars, though we observe positive effects for chemical and intermodal shipments.

[15] The estimates reported in Tables 11-4 and 11-5 are from the same set of commodity-specific regressions. Thus, the R^2 statistics reported in Table 11-4 also apply to Table 11-5.

TABLE 11-4
SELECTED ESTIMATION RESULTS (2001-2006 SAMPLE PERIOD), SHIPMENT COST CHARACTERISTICS

Coefficient
(t-statistic)

Commodity Group	Ln TONS	ln TONSCAR	ln MILES	D_OWN	R^2
Farm Products	-0.042 (-53.856)	-0.354 (-89.875)	-0.554 (-185.978)	-0.095 (-45.17)	0.426
Barley	-0.033 (-8.519)	-0.880 (-20.072)	-0.607 (-49.099)	-0.011 (-1.092)	0.633
Corn	-0.061 (-57.252)	-0.874 (-91.437)	-0.680 (-140.772)	-0.094 (-33.973)	0.574
Wheat	-0.021 (-18.392)	-0.918 (-67.96)	-0.560 (-113.341)	-0.046 (-14.432)	0.515
Soybeans	-0.016 (-5.595)	-0.590 (-41.86)	-0.593 (-62.384)	-0.144 (-20.334)	0.498
Metallic Ores	-0.011 (-5.577)	-0.828 (-122.019)	-0.558 (-65.397)	-0.027 (-4.634)	0.682
Coal	-0.006 (-8.64)	-0.801 (-92.347)	-0.479 (-253.607)	-0.123 (-71.233)	0.470
Nonmetallic Minerals	-0.133 (-129.911)	-0.348 (-51.623)	-0.607 (-295.895)	-0.229 (-96.211)	0.636
Food Products	-0.070 (-48.491)	-0.260 (-115.336)	-0.569 (-205.989)	-0.146 (-82.432)	0.341
Lumber or Wood Products	-0.082 (-19.964)	-0.468 (-91.508)	-0.532 (-173.039)	-0.189 (-51.923)	0.422
Chemicals	-0.046 (-22.093)	-0.177 (-47.49)	-0.523 (-221.658)	0.069 (17.978)	0.214
Petroleum or Coal Products	-0.055 (-31.317)	-0.415 (-74.949)	-0.620 (-183.527)	-0.041 (-7.886)	0.454
Clay, Concrete, Glass, or Stone Products	-0.068 (-42.313)	-0.416 (-121.291)	-0.566 (-173.356)	-0.111 (-50.14)	0.470
Primary Metal Products	-0.075 (-54.126)	-0.322 (-72.462)	-0.581 (-245.508)	-0.211 (-50.235)	0.474
Transportation Equipment	0.002 (0.551)	-0.762 (-219.559)	-0.732 (-310.5)	-0.961 (-350.297)	0.523
Intermodal Shipments	n/a n/a	-0.841 (-1824.838)	-0.639 (-282.321)	0.103 (154.203)	0.664

Market Structure Characteristics

Table 11-5 presents coefficient estimates for variables representing local railroad and modal competition characteristics based on the 2001-2006 sample period. We find generally expected effects on RPTM from increasing the number of effective railroad competitors at the origin and from increasing the distance from the origin to the nearest available water transportation. That is, rates tend to be lower given increased competition from other railroads at the origin or from increased proximity of the water alternative, and higher for shippers with more limited railroad and water options. This result is not unexpected in light of our findings in Chapter 9. Railroads' economies of density imply that they must implement positive markups over marginal cost per ton-mile in order to cover their total variable and “quasi-fixed” costs. Employing such local market power as is available is one means by which railroads remain “revenue adequate.” Results for competition at the destination end are mixed.

We observe a counterintuitive positive and significant coefficient on RRCOMP_ORG for intermodal shipments. A possible explanation is that we are observing a result of competition in service quality dimensions (e.g., high-speed or scheduled intermodal trains), with cost consequences that are unobservable in the waybill sample.

The dummy variables for the “edge effect” of a single railroad serving the origin county (DLM_ORG = 1) indicate that rates for counties without railroad competition are commonly higher than they would be in the presence of even very limited railroad competition. We may expect railroads to exercise local market power where possible, though our expectations are tempered somewhat by the prospect that rates in this limiting case may be moderated by regulatory attention if not direct intervention. That is, railroads may effectively cede some market power to avoid regulatory intervention, or otherwise may be subject to implicit or explicit regulatory constraints. Interestingly, some farm products are among the exceptions to the general pattern; farm products have been a long-standing focus of attention for the “captive shipper” issue.

TABLE 11-5
SELECTED ESTIMATION RESULTS (2001-2006 SAMPLE PERIOD)

Market Structure Characteristics

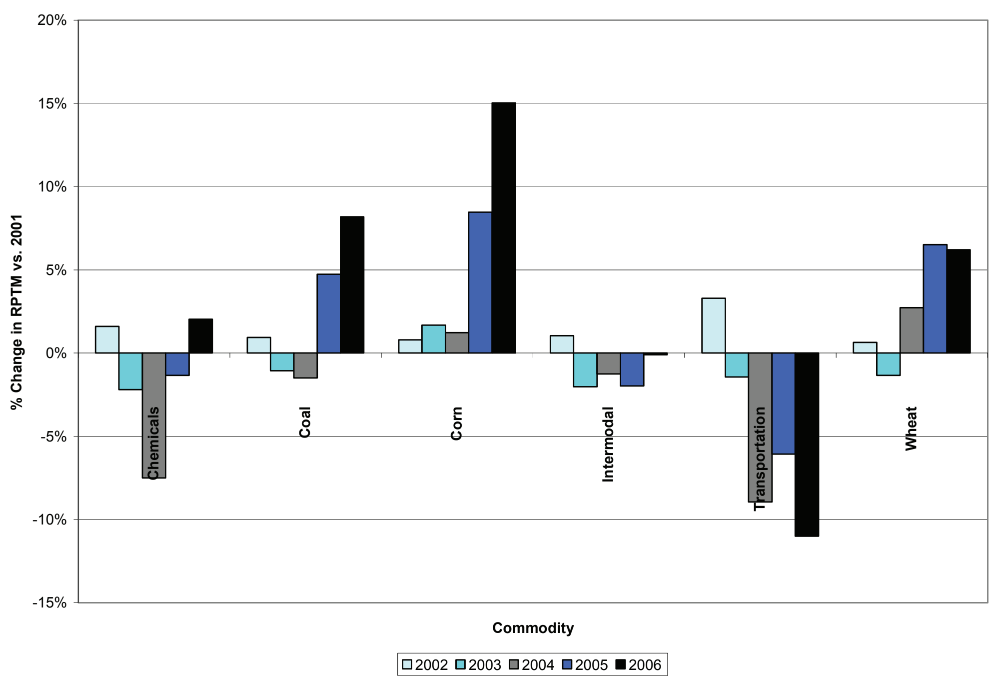
Coefficient
(t-statistic)

Commodity Group	ln KMWATER _ORG	RRCOMP _ORG	DLM_ORG	ln KMWATER _TER	RRCOMP _TER	DLM_TER
Farm Products	0.027	-0.015	0.002	0.009	0.014	0.070
	(24.181)	(-6.493)	(0.804)	(8.946)	(6.458)	(22.067)
Barley	0.088	-0.080	-0.037	-0.001	0.040	-0.005
	(13.51)	(-7.337)	(-2.654)	(-0.26)	(2.614)	(-0.271)
Corn	0.001	-0.018	-0.023	0.010	0.021	0.064
	(0.748)	(-6.601)	(-6.843)	(6.172)	(6.301)	(16.968)
Wheat	0.110	-0.002	0.029	-0.000	0.003	0.025
	(43.272)	(-0.581)	(7.245)	(-0.248)	(0.888)	(4.125)
Soybeans	0.034	-0.005	-0.016	0.008	0.038	0.045
	(7.941)	(-0.627)	(-2.013)	(1.998)	(6.479)	(3.16)
Metallic Ores	-0.030	-0.018	0.118	0.040	-0.897	-0.126
	(-4.617)	(1.421)	(9.546)	(10.151)	(-28.631)	(-10.915)
Coal	0.029	0.016	0.074	0.001	-0.177	0.050
	(20.193)	(5.844)	(30.388)	(1.21)	(-90.08)	(27.404)
Nonmetallic	0.011	0.076	0.089	0.006	-0.065	0.041
Minerals	(5.752)	(13.236)	(18.991)	(5.443)	(-19.047)	(13.542)
Food	0.003	0.001	0.088	0.028	-0.039	0.018
Products	(3.327)	(0.702)	(31.584)	(34.891)	(-23.521)	(6.613)
Lumber or Wood	0.040	0.011	0.051	0.019	0.007	-0.006
Products	(25.084)	(3.023)	(12.822)	(13.8)	(2.271)	(1.442)
Chemicals	0.005	-0.040	0.071	0.037	-0.037	0.086
	(4.156)	(-24.114)	(19.908)	(37.372)	(-21.849)	(27.438)
Petroleum or Coal	0.026	-0.039	0.075	0.030	-0.046	0.042
Products	(14.888)	(-12.139)	(14.866)	(20.232)	(-15.315)	(9.364)
Clay, Concrete,	0.021	-0.010	0.073	0.002	-0.017	0.057
Glass or Stone Products	(14.273)	(-4.08)	(21.937)	(2.246)	(-9.886)	(19.159)
Primary Metal	0.020	-0.053	-0.070	0.032	0.017	0.036
Products	(14.763)	(-20.083)	(-15.625)	(29.234)	(10.829)	(10.731)
Transportation	0.011	-0.043	0.147	-0.001	-0.002	0.121
Equipment	(7.976)	(-19.33)	(40.65)	(-1.403)	(-1.85)	(37.482)
Intermodal	0.024	0.039	0.011	0.045	-0.013	-0.034
Shipments	(67.711)	(74.754)	(6.432)	(130.127)	(-18.384)	(-16.899)

Trends in Revenue per Ton-Mile

The pricing model results complement the analysis in Chapter 8 by indicating trends in real revenue per ton-mile while controlling for the shipment and market characteristics included in the model. That is, the YEAR dummy variables describe patterns of annual rate changes, holding shipment characteristics constant at the commodity level. Since RPTM is deflated by the price index for GDP, the resulting trend indicates price changes above (or below) GDP price inflation given fixed shipment characteristics. While there is variation across commodities, the general picture is of recent railroad rate increases in excess of GDP price inflation. See Figure 11-1.

FIGURE 11-1
TRENDS IN "REAL" RPTM, FROM PRICING MODEL YEARLY INTERCEPTS, SELECTED COMMODITIES



Some caveats for price indexing methods such as those employed in the Producer Price Index apply here as well. In particular, holding shipment characteristics constant will tend to overstate rail rate inflation as it does not allow for shippers responding to price changes by adopting lower-cost shipment characteristics where possible. Indeed, for some commodities, shipment cost characteristics did change towards lower-cost characteristics. However, shippers who did not or could not avail themselves of lower-cost shipment options would have been exposed to above-inflation increases in RPTM.

Commodity-Level Costs and Markups for Class I Railroads

As we noted above, a general limitation of the reduced-form pricing model is that while it can estimate the overall effects of factors that shift costs and market conditions, it cannot separately identify them. However, we may partly overcome this limitation by incorporating generic marginal cost information from the variable cost model.

We implemented the calculations in equations (11.15)-(11.18), above, for subsets of shipments originated and terminated by the same Class I railroad.[16] We obtain marginal costs per ton-mile by railroad and year from the variable cost function, along with the average length of haul used to evaluate the marginal costs. We adjust the generic marginal cost at the shipment level using the cost-shifting variables and their estimated coefficients (ln TONS, ln TONSCAR, ln MILES, ln VOL_TONS and D_OWN). We take the railroad's weighted annual averages of the variables as the base against which the shift is computed in equation (11.17).

We do not adjust the costs for the origin-destination factors, since those would combine latent cost, competition, and market demand factors. This limits our ability to capture features that may give specific shipments high- or low-costs relative to other shipments with similar measured cost characteristics. However, we can examine the adjusted costs and RPTM for "typical" shipments in order to analyze costs and markups at the commodity level.

We present median values of estimated marginal costs adjusted for observed cost-causing characteristics, and estimated markups (LMIs) by commodity in Table 11-6. The pattern of costs by commodity shows, as expected, relatively low costs for commodities typically hauled in large-scale bulk shipments, such as grains and coal. The highest adjusted marginal costs are for transportation equipment and intermodal shipments, both of which exhibit low average weight per carload and have relatively few average carloads per shipment, as seen in Table 11-3. Other commodities, which tend to have cost characteristics less favorable than coal or grains—i.e., shorter average hauls and/or fewer carloads per shipment—have costs closer to the "generic" costs.

[16] We exclude interchange shipments to avoid the need to apply suitable costs piecewise to each segment of the movement. Also, since the variable cost analysis is of Class I railroads, we do not have generic marginal costs to apply to segments served by non-Class I railroads.

TABLE 11-6
MEDIAN ESTIMATED ADJUSTED MARGINAL COSTS AND MARKUPS BY COMMODITY
CLASS I RAILROADS, 2001-2006

Commodity Group	Adjusted MC*	LMI
Farm Products (Aggregate)	0.9	0.59
Barley	0.7	0.69
Corn	0.7	0.70
Wheat	0.7	0.68
Soybeans	0.9	0.58
Metallic Ores	2.2	0.43
Coal	0.9	0.41
Nonmetallic Minerals	2.0	0.41
Food Products	1.2	0.54
Lumber or Wood Products	1.4	0.58
Chemicals	1.6	0.56
Petroleum or Coal Products	1.5	0.59
Clay, Concrete, Glass, or Stone Products	1.7	0.56
Primary Metal Products	1.9	0.49
Transportation Equipment	5.0	0.40
Intermodal Shipments (COFC/TOFC)	4.3	-0.52

*2000 Q1 cents per ton-mile.

The estimated markups are relatively low for bulk commodity shipments including metallic ores, coal, and nonmetallic minerals. Transportation equipment shipments have relatively high adjusted marginal costs but a relatively low estimated LMI of 0.40. The estimated markups for grains are relatively high. Our results suggest that grain shippers are not unjustified in viewing themselves as paying relatively high markups. The estimated LMI markups for other commodities are mostly in the vicinity of 60 percent over marginal cost.

Since coal, in particular, accounts for a very large share of ton-miles, relatively low coal markups require other commodities collectively to pay relatively high markups to satisfy the railroads' overall revenue-sufficiency constraints. Railroad-level LMI calculations show that the low estimated coal markups are driven largely by the western railroads. This may imply that the joint BNSF-UP line serving Powder River Basin (PRB) mines is producing reasonably effective competition at origin for PRB coal shipments.

While we expect modal competition to keep markups for intermodal shipments low, we believe that the negative estimated LMI is an anomaly mainly reflecting limitations of the CWS in determining intermodal shipments' cost characteristics. The modeled cost adjustments effectively treat intermodal shipments as having the cost characteristics of low-weight carload shipments, when, in fact, trailers and containers travel long distances as a unit, avoiding substantial switching and classification costs typical of other shipments with low carload counts. Additionally, since intermodal shipments are billed as single carloads, we cannot observe shipments of multiple trailers or containers from individual shippers on a given train, which may also be expected to lower unit costs.

Table 11-7 shows the estimated marginal costs and LMIs for the 2001-2003 and 2004-2006 periods.

TABLE 11-7
MEDIAN ESTIMATED ADJUSTED MARGINAL COSTS AND MARKUPS BY COMMODITY BY PERIOD
CLASS I RAILROADS

	Adjusted MC*		LMI	
Commodity Group	**2001-2003**	**2004-2006**	**2001-2003**	**2004-2006**
Farm Products (Aggregate)	0.9	0.9	0.60	0.58
Barley	0.8	0.6	0.66	0.72
Corn	0.6	0.6	0.70	0.71
Wheat	0.8	0.7	0.66	0.69
Soybeans	0.9	0.9	0.61	0.56
Metallic Ores	2.3	2.7	0.41	0.39
Coal	1.0	0.9	0.39	0.45
Nonmetallic Minerals	1.8	2.3	0.46	0.30
Food Products	1.2	1.3	0.55	0.53
Lumber or Wood Products	1.4	1.4	0.58	0.56
Chemicals	1.6	1.6	0.59	0.54
Petroleum or Coal Products	1.6	1.5	0.60	0.58
Clay, Concrete, Glass, or Stone Products	1.7	1.7	0.57	0.56
Primary Metal Products	1.8	2.2	0.52	0.47
Transportation Equipment	4.9	5.1	0.45	0.35
Intermodal Shipments	4.3	4.3	-0.51	-0.54

*2000 Q1 cents per ton-mile.

Table 11-7 provides an indication of whether recent rate increases have been mainly cost-driven or markup-driven. Interestingly, we do not see the increases in the generic marginal costs in the 2004-2006 period uniformly translating into increased commodity-level costs adjusted for shipment characteristics. To some extent, this reflects lower-cost average shipment characteristics at the commodity level. For example, the median coal shipment in the 2004-2006 period is larger overall and in tons per car, and hauled a longer distance, than the median 2001-2003 coal shipment. In contrast, nonmetallic mineral and primary metal product shipments are very similar in tons per car and length of haul in the two periods, so there is little offset to the industry-level cost increases.

Likewise, we see little in the way of systematic changes in markups by commodity. For higher-markup categories, rates are likelier to be subject to regulatory constraints—that is, high-markup commodities will be more likely to have shipments moving at rates over 180 percent of regulatory variable costs. In some cases, it appears that cost decreases may not be passed through (e.g., coal, barley, and wheat), but there likewise are cases in which cost increases are not fully transmitted to markups (e.g., metallic ores, nonmetallic minerals, and transportation equipment).

Relationship of R/VC Ratio and Market Structure Factors

GAO Analysis

The 2006 GAO report's analysis of shipper captivity includes computation of shares of shipments generating revenues in excess of 180 percent and 300 percent of URCS variable cost, and examination of changes in those shares over time. GAO presented its analysis, in part, in the context of the statutory role played by the 180 percent revenue/variable cost (R/VC) threshold in triggering rate reviews and the limited availability of data to properly measure shipper captivity.

> Nevertheless, our analysis of available measures indicates that the extent of captivity appears to be dropping, but the percentage of industry traffic traveling at rates substantially over the statutory threshold for rate relief has increased. For example, the amount of traffic traveling at rates over 300 percent of the railroad's variable cost increased from 4 percent in 1985 to 6 percent in 2004. Furthermore, some areas with access to one Class I railroad have higher percentages of traffic traveling at rates that exceed the statutory threshold for rate relief.[17]

We examined 2000-2001 and 2005-2006 Carload Waybill Sample (CWS) data and found that the fractions of tonnage and ton-miles exceeding 180 percent R/VC were relatively constant, but the fractions exceeding 300 percent R/VC increased. See Table 11-8. The results are consistent with the GAO findings in the direction of the changes. We also examined the shares of traffic traveling at rates less than 100 percent R/VC, which are substantial and, interestingly, also increased slightly between the two periods.

Analyzing high R/VC traffic requires that variable costs be closely aligned with actual shipment costs throughout the R/VC distribution, since 300 percent R/VC is well into the upper tail, not just at central or modal points. The presence of large fractions of below-variable-cost traffic suggests that the R/VC extremes are due in large part to latent cost-causing factors or other shipment features that are not reflected in the measured variable cost. We also find apparent methodology changes with large effects on measured R/VC for

[17] Government Accountability Office, *Freight Railroads: Industry Health Has Improved, but Concerns about Competition and Capacity Should Be Addressed,* GAO-07-94, October 6, 2006, p. 3.

large categories of shipments, and large variation in R/VC for shipments aggregated to county-level geography.

TABLE 11-8
PERCENT OF TONS AND TON-MILES BY R/VC CATEGORY
2000-2001 VS. 2005-2006 CARLOAD WAYBILL SAMPLE DATA

Period	Percent of Tons by R/VC Category				
	R/VC < 100 Percent	**R/VC Between 100 and 180 Percent**	**R/VC Between 180 and 300 Percent**	**R/VC > 300 Percent**	**Subtotal R/VC > 180 Percent**
2000-2001	16%	50%	28%	6%	34%
2005-2006	21%	45%	25%	9%	34%

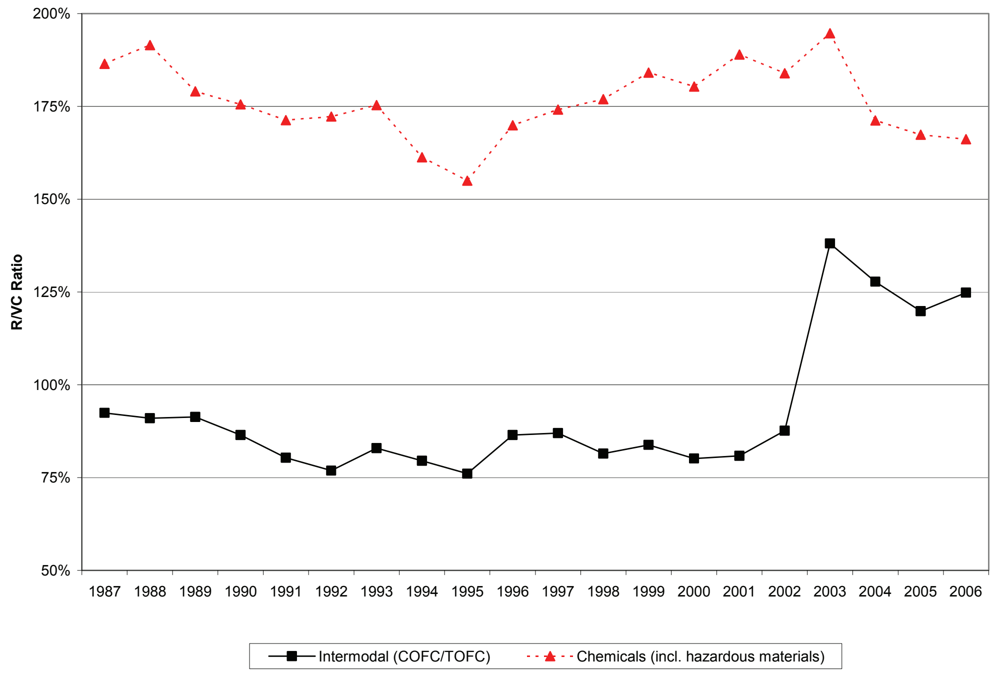
Period	**Percent of Ton-Miles by R/VC Category**				
	R/VC < 100 Percent	**R/VC Between 100 and 180 Percent**	**R/VC Between 180 and 300 Percent**	**R/VC > 300 Percent**	**Subtotal R/VC > 180 Percent**
2000-2001	22%	57%	19%	2%	21%
2005-2006	29%	51%	16%	4%	19%

The R/VC ratio is problematic as an indicator of market-dominant behavior as it inextricably combines local market structure factors with various other cost and demand-related factors. Nevertheless, as a pricing-related statistic with a statutory role in railroad regulation, R/VC could be useful were it a good indicator of other market structure indicators. We find that R/VC, aggregated by commodity and county, is in fact weakly correlated with railroad and water competition measures and in our view should not serve as a stand-alone measure of market-dominant behavior.

R/VC Data Issues

We found two main issues with the R/VC data in the CWS. First, there is evidence of methodological changes that might materially affect the measured shares of shipments exceeding 180 percent R/VC. For example, Figure 11-2 shows trends in R/VC from 1987 to 2006 for chemical and intermodal (COFC/TOFC) shipments. According to the CWS, intermodal shipments' average R/VC is below 100 percent from 1987 to 2002; in 2003, the measured ratio jumped to 138% before moderating to about 125% in the 2004-2006 period. The jump in the average R/VC for intermodal shipments is apparently due to a measurement change in 2003. The apparent effects of methodological changes and other large shifts in R/VC ratios over time complicate an evaluation of R/VC trends.

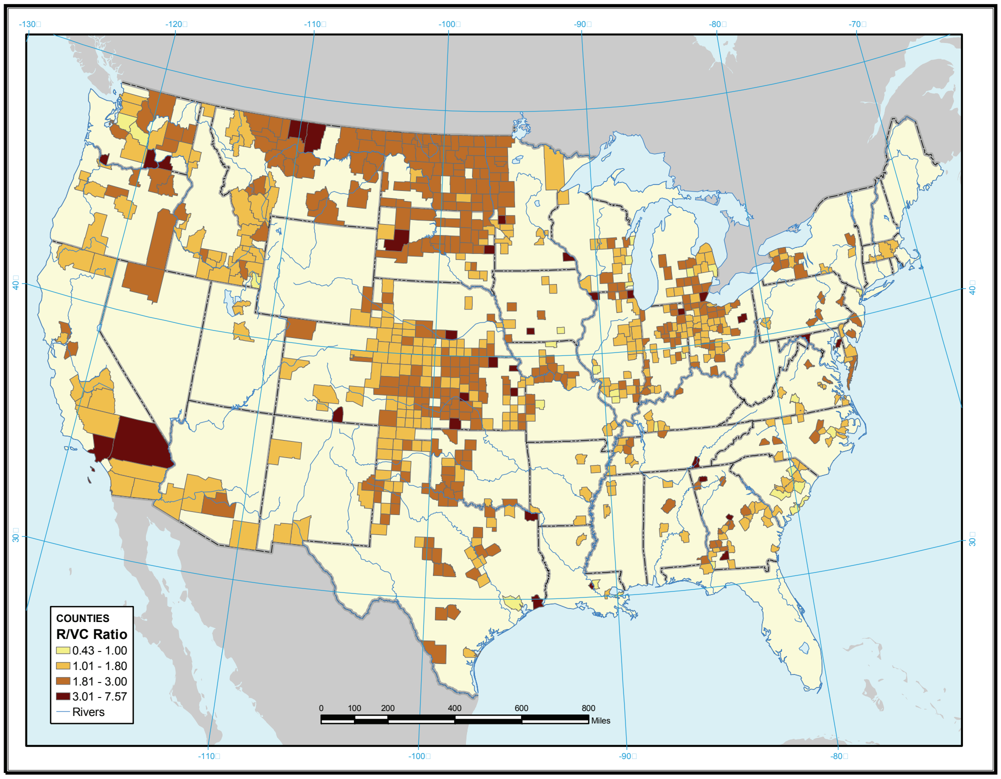
FIGURE 11-2
ANNUAL R/VC RATIOS FOR CHEMICAL AND INTERMODAL SHIPMENTS
1987-2006 CARLOAD WAYBILL SAMPLE



Additionally, captivity measures based on categorizing shipment-level R/VC (or markup) data are dependent on good alignment of actual and measured costs in the tails of the R/VC distribution. As we noted with respect to our “adjusted marginal cost” calculations, measuring shipment-level costs is limited by latent cost-causing factors, which may include shipment characteristics unmeasured or not measurable using available data. The prolonged period over which URCS variable costs exceeded revenue for intermodal shipments, for instance, suggests that R/VC has had similar problems to our adjusted marginal cost approach in correctly registering low-cost features of intermodal shipments. Whatever information may be obtained from average R/VC, the absence of information on shipment cost characteristics will lead to high variability of R/VC. Indeed, the shipment-level R/VC distributions show very large ranges of markups.

R/VC ranges remain very large even after aggregation over time and geography. Figure 11-3 shows the distribution of R/VC at the origin county level for wheat shipments for 2001-2006. The county-level R/VC ratios range from 43 percent to 516 percent. While substantial variation in actual R/VC is certainly possible, the R/VC variations are large relative to the estimated effects of the market structure factors in the pricing models. The implication is that much of the R/VC variation is related to factors other than market structure features that determine shipper captivity. Thus, R/VC as a measure of captivity may be suspect.

FIGURE 11-3
R/VC AVERAGES BY ORIGIN COUNTY
2001-2006 CARLOAD WAYBILL SAMPLE



R/VC and Market Structure Factors

Our theoretical model characterizes a railroad's pricing behavior as profit maximizing subject to constraints from railroad and intermodal competition. In this approach, relative captivity arises for shippers whose next best alternatives provide less-binding constraints on railroad rates. The effects of captivity may be continuous and have no definite relationship to markup thresholds. For instance, a shipper may pay a rail rate under the 180 percent R/VC threshold and nevertheless experience a degree of "captivity" relative to another shipper with similar cost characteristics, in the sense that better access to intramodal or intermodal competition might give the other shipper access to lower rail rates. Conceptually, more appropriate measures of captivity should focus on the effects of the transportation market structure on rail rates—and, by extension, markups—rather than on markups as *per se* indicators of market-dominant behavior. In this regard, the GAO was justified in examining additional measures using information on market structure, such as rates and R/VC in areas without Class I railroad competition.[18]

[18] Government Accountability Office, *Freight Railroads: Industry Health Has Improved, but*

Nevertheless, established measures such as the R/VC ratio may have some utility to the extent they serve as effective proxies for conceptually more appropriate market structure measures. In this regard, R/VC does not appear to perform well. We find that R/VC is weakly related to measures of railroad and water competition. Table 11-9 shows correlations between county-level R/VC ratios and market structure factors for selected commodities, including an RPTM shift factor derived from the market structure variables in the pricing models.

TABLE 11-9
CORRELATIONS OF ORIGIN COUNTY* R/VC WITH REVENUE PER TON-MILE AND MARKET STRUCTURE FACTORS, 2001-2006 DATA, SELECTED COMMODITIES

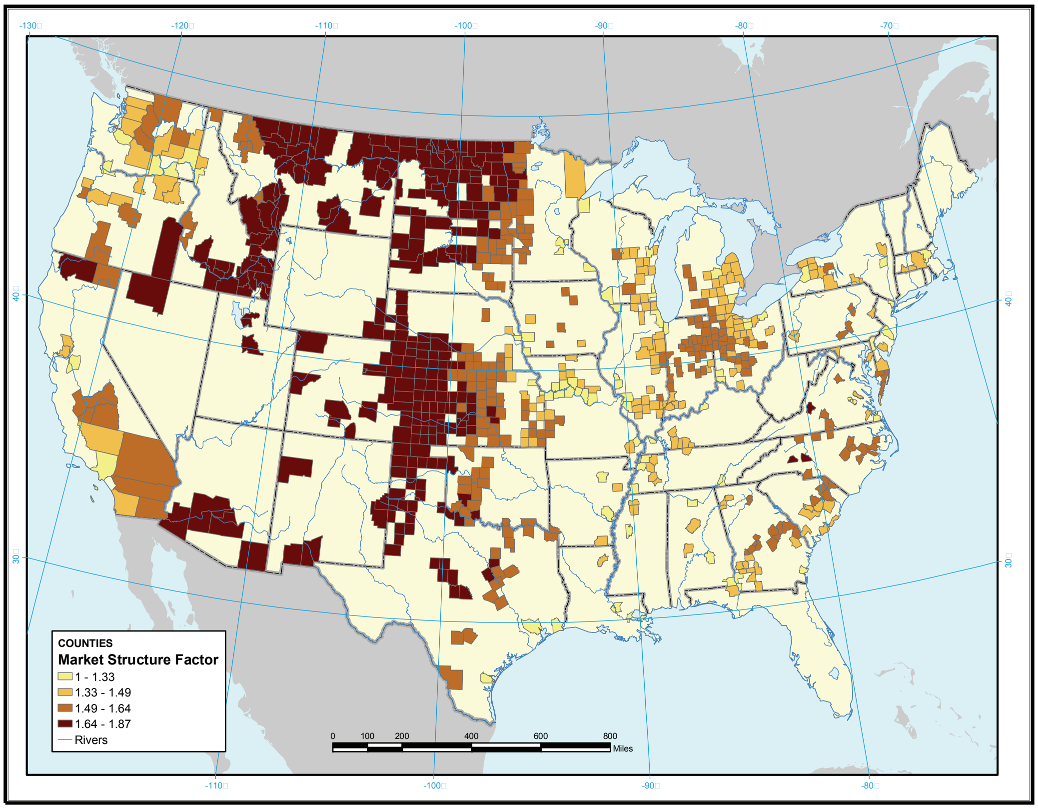
	Correlation Coefficient with R/VC Ratio					
Commodity Group	RPTM	Distance to Water (Origin)	Distance to Water (Destination)	Railroad Competition at Origin	Railroad Competition at Destination	Econometric Market Structure Shifter
Chemicals	0.29	-0.02	0.00	-0.12	-0.11	0.14
Coal	0.65	-0.23	0.06	-0.25	-0.13	0.01
Corn	0.19	-0.02	0.11	-0.03	-0.03	0.01
Intermodal	0.10	-0.04	0.12	-0.04	-0.23	0.19
Transportation	0.15	-0.16	-0.15	0.04	-0.01	-0.06
Wheat	0.21	0.21	-0.03	-0.07	0.07	0.19

* Note: Coal based on destination county data.

Our coal pricing models find evidence of strong competitive effects from railroad competition at the destination counties, but the correlation between county-level R/VC and our measure of destination competition in Table 11-9 is only -0.13. The pricing models for wheat imply a strong effect of distance from the origin county to water transportation on wheat rates; that effect dominates the market structure effect as may be seen in Figure 11-4. However, the correlation between R/VC and the distance to water at origin is 0.21. Comparing Figures 11-3 and 11-4, we observe that relatively high R/VC ratios are observed in some areas implicated in wheat shippers' "captivity" complaints—notably, the far northern Plains—but not in other areas well-removed from water alternatives such as western Kansas. Meanwhile, high R/VC ratios are observed in Pacific Northwest counties and other areas that would be expected to have better modal alternatives. These results are typical of the weak relationships between R/VC and market structure measures.

Concerns about Competition and Capacity Should Be Addressed, GAO-07-94, October 6, 2006, p. 36.

FIGURE 11-4
COUNTY-LEVEL EFFECTS OF MARKET STRUCTURE VARIABLES IN WHEAT PRICING MODELS ON REAL REVENUE PER TON-MILE



Evaluating "Captivity" and Market Structure Factors

While R/VC may, applied carefully, be able to identify categories of shipments that travel at high rates relative to costs, the R/VC ratio is not very useful as an indicator of the presence of market structure factors that would increase shippers' "captivity" to railroads. The weak relationships between R/VC ratios and market structure factors imply that correctly assessing the presence of market-dominant behavior requires direct assessment of relevant market structure factors. Thus, regulatory reforms that would establish R/VC tests as the sole quantitative indicator of a railroad's market dominance are inappropriate.

In contrast, analyses of railroad rates (real revenue per ton-mile or RPTM) using data sources such as the CWS can indicate the effects of railroad and water competition factors on RPTM directly. These analyses permit us to identify market structure factors that have greater effects on RPTM by commodity, and by extension to identify small areas such as counties with combinations of market structure factors that will tend to increase a shipper's relative captivity.

CONCLUSIONS

In this chapter, we estimated reduced-form pricing models for a set of commodity groups covering most railroad revenue, tonnage, and ton-miles as measured by the CWS (88%, 94%, and 93% of the totals, respectively). The explanatory variables are sets of cost-related variables, market structure indicators, and other control factors. The results inform our discussion of selected commodities in Chapters 12-15, below. The results also inform our discussion of policy alternatives in Chapter 22.

The estimated effects of the cost variables are in line with our intuition and expectations based on past analyses of waybill sample data. We observe that increased length-of-haul and car loading, and in most cases overall shipment size, which we would associate with lower railroad costs, also are associated with lower rail rates. We also find that shippers of most commodities (the notable exceptions being chemical and intermodal shippers) are compensated for the use of privately-owned (non-railroad) cars through lower rates.

Also consistent with previous studies of waybill data, we find evidence that relatively "captive" shippers—shippers with less access to railroad or water competition—tend to pay higher rates than otherwise similar shippers with access to more rail and/or water competition. This result is in line with the underlying model of railroads' profit-maximizing behavior under competition constraints. It also is an expected consequence of the post-Staggers Act regulatory structure's grant to railroads of pricing flexibility (subject to review for high-markup shipments). That is, given railroads' needs to charge markups over marginal costs to recover their costs, the railroads' pricing problem is how to allocate the markups over customers.

The estimates of year-specific intercepts in the pricing model reinforce results from other price-indexing methods showing recent increases in rail rates. Since our results hold shipment characteristics constant, they do not reflect shippers' ability to substitute lower-cost shipment characteristics. In fact, we do observe movements to lower-cost shipment characteristics over time; we discuss these further in the commodity chapters, below.

Our calculations of commodity-level markups show little or no evidence of markups systematically increasing for all commodities. We estimate that coal and intermodal shipments have below-average markups. Coal is widely viewed as "baseline load" for the railroads, and exact shipment timing is not essential (though overall regularity of shipments is). We believe that the intermodal markups in part reflect lower cost characteristics for intermodal shipments than is captured in the model, though the direction (if not magnitude) is consistent with the ability of intermodal shippers to alternatively place trailers and/or containers on highways. The highest estimated markups are for grains, where concerns about railroad markups and shipper "captivity" are common.

Chapter 12 Contents

LIST OF FIGURES

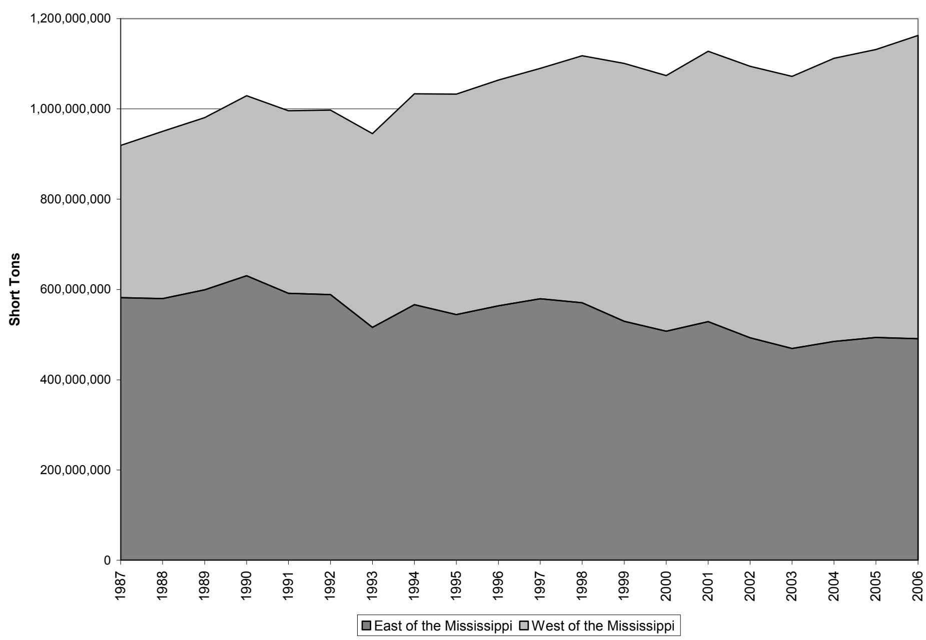
LIST OF TABLES

CHAPTER 12.
ANALYSIS OF COMPETITION: COAL

12A. DESCRIPTION OF THE MARKET

Coal is a major U.S. energy resource, accounting for approximately one-third of domestic energy production in 2006.[1] Over the 2001-2006 period covered by the pricing analysis in Chapter 11, U.S. coal production was at or near record levels, ranging from 1,072 million tons[2] (in 2003) to 1,163 million tons (2006). Production has gradually shifted westward, driven by rapid growth of production in the Powder River Basin (PRB) region of Wyoming and Montana. PRB coal has low sulfur content, and provisions of the Clean Air Act limiting sulfur dioxide emissions spurred demand for low-sulfur coal. Wyoming is the major coal-producing state with 446.7 million tons of 2006 production, and a majority of coal production now is located west of the Mississippi River. See Figure 12-1, below.

FIGURE 12-1
U.S. COAL PRODUCTION BY REGION, 1987-2006



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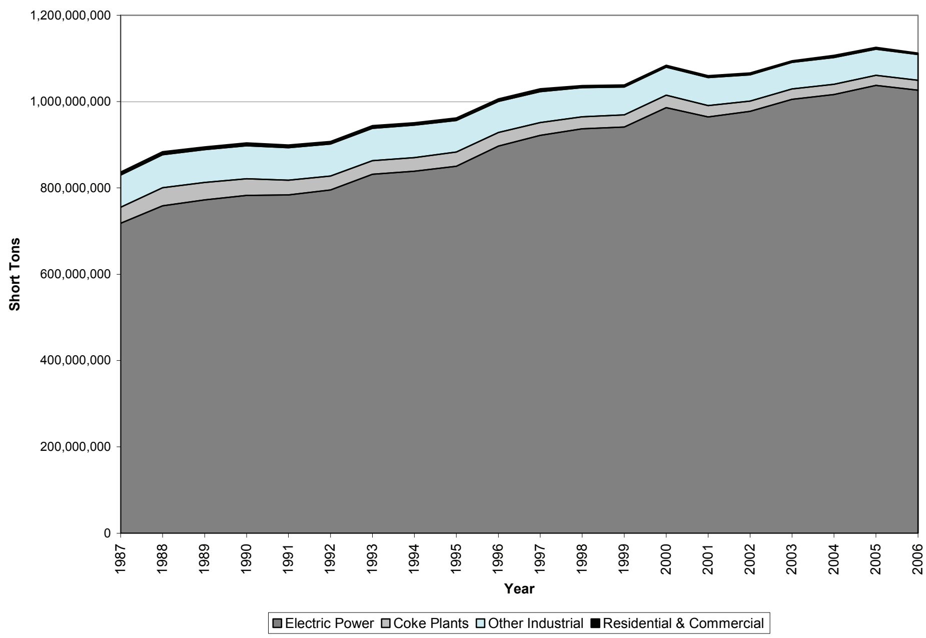
[1] U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 2008 (Report No.: DOE/EIA-0383[2008]), Table 1.

[2] Tons are short tons (2000 lb.) unless otherwise indicated.

The U.S. electric power generation sector is the major consumer of coal at 1,027 million tons in 2006.[3] Most other U.S. coal consumption is by coke plants and other industrial users. See Figure 12-2. The U.S. imports coal in small quantities, but is a net coal exporter. Thus, coal demands are largely derived from electricity demands, and vary with weather and general economic conditions. Coal supply to utilities is usually by long-term contract.[4]

FIGURE 12-2
U.S. COAL CONSUMPTION BY MAJOR SECTOR, 1987-2006



In 2006, railroads hauled 71 percent of total coal tonnage; trucks and river barges hauled 11 percent and 9 percent, respectively. Water transport, where available, tends to be the low-cost transportation mode. The rail share of coal tonnage increased 5 percentage points from 2001 to 2006, with reductions in modal shares for river barges and other modes (excluding trucking).[5] The shift of coal production to the West has aided

[3] U.S. Department of Energy, Energy Information Administration, Annual Coal Report 2006 (Report No.: DOE/EIA-0584[2006]).

[4] U.S. Department of Energy, Energy Information Administration, Average Duration of Utility Coal Contracts, 1979-1997, at http://www.eia.doe.gov/cneaf/coal/ctrdb/tab33.html (Accessed October 3, 2008). Note that the supply contract duration does not imply transportation contract duration.

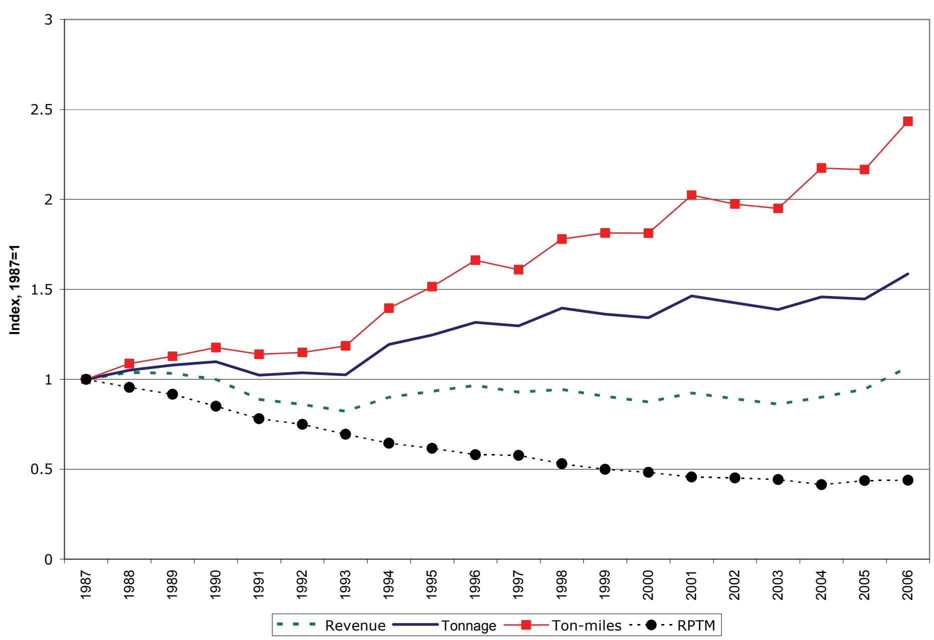
[5] U.S. Department of Energy, Energy Information Administration, Domestic Distribution of U.S. Coal by Origin State, Consumer, Destination and Method of Transportation, at http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/coal_distributions.html (Accessed October 3, 2008).

railroads' modal share for coal shipments. Campbell County, Wyoming, the highest-tonnage PRB origin county, is remote from both the nearest waterway facilities handling coal and from most PRB coal users. As a result, rail is the only feasible transportation mode for originating the incremental (Western) coal production.

Tonnage and Revenue Trends

In the Carload Waybill Sample (CWS) data for 1987-2006, coal (2-digit STCC 11) is the largest commodity by tonnage and revenue, and currently is second to miscellaneous mixed shipments (STCC 46, mainly intermodal shipments) in carloads. Figure 12-3 shows the trends in real revenue, tonnage, ton-miles, and real revenue per ton-mile (RPTM) for coal shipments. All dollar amounts reported are in constant dollars (base period 2000 quarter 1).

FIGURE 12-3
ANNUAL REAL REVENUE, TONNAGE, TON-MILES, AND REAL REVENUE PER TON-MILE COAL SHIPMENTS, 1987-2006
CARLOAD WAYBILL SAMPLE



Railroad coal tonnage in the CWS increased faster than coal production from 1987 to 2006. This partly reflects the overall modal shift to railroads. Additionally, long-distance end-to-end shipments may lead to portions of coal tonnage appearing on multiple waybills. Coal ton-miles increased much faster than tonnage over the same period as average length of haul increased. In 2006, the median coal waybill originating in an Appalachian state had a short-line distance of 409 miles, versus 1,113 miles for the median waybill for coal shipments originating in Campbell

County, Wyoming. Despite the large increases in coal tonnage and ton-miles, revenue remained nearly constant through 2003, as RPTM fell by more than half from 1987 to the early 2000s. Coal revenue increased from 2004 to 2006 as RPTM increased from a 2004 low. From 2001 to 2006, revenue increased by 16 percent, lagging ton-miles (+20 percent) but ahead of tons (+8 percent).

In 2004 and especially 2005, the coal industry faced major disruptions in both rail and water transportation.[6] Coal train derailments on the PRB joint line in May 2005 led to a major track maintenance and improvement project that disrupted PRB coal shipments for much of 2005. As a result, spot prices for PRB coal increased considerably, and a number of users drew down their coal stocks to unusually low levels. In 2006, according to the Department of Energy's *Annual Coal Report*, the coal transportation system had largely returned to normal functioning. Under the circumstances, it would not be unexpected to see a rise in rail rates to ration available capacity during the period in which shipments were disrupted, and subsequently to observe coal rail rates remaining high if not increasing to recover capital costs related to investments in lines serving PRB coal. The 2005 disruptions also suggest that the jumps in revenue, tonnage, and ton-miles in 2006 (over 2005) are byproducts of the return to normality in the coal transportation system, including coal users' efforts to rebuild stocks as well as fuel current coal consumption.[7]

Other Shipment Characteristics

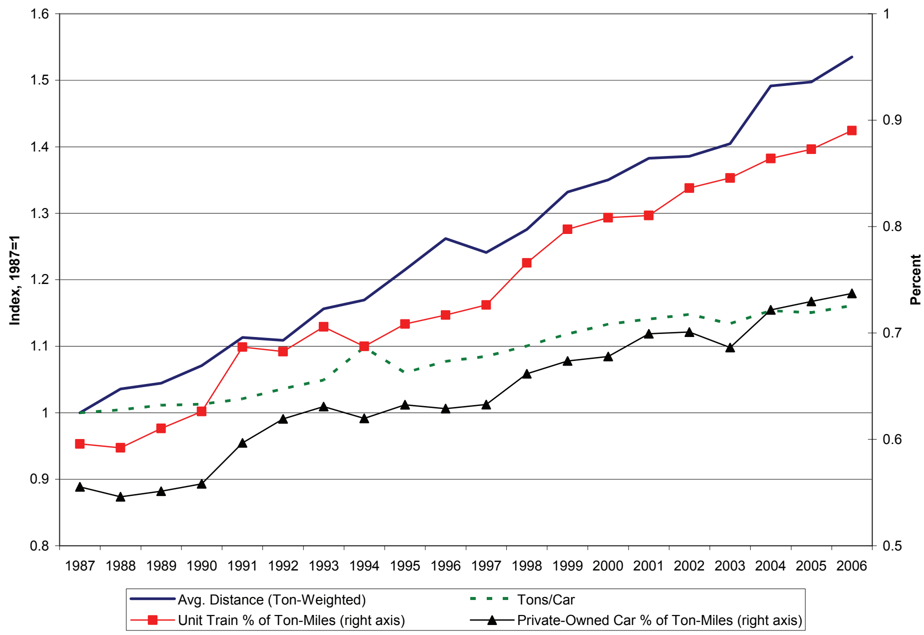
CWS data report major changes in the composition of coal shipments over the 20 years prior to 2006. In large part, these changes reflect the predominance of large unit trains for long-distance coal shipments, which is in turn an adaptation to the growth of PRB coal production. Average distance (weighted by tonnage) increased more than 50 percent, and tons per carload increased moderately. The fraction of annual ton-miles in shipments of more than 100 carloads increased from 60 percent to 89 percent. The share of shipments carried in privately owned cars[8] increased steadily from the mid-1990s through 2006. See Figure 12-4. This may reflect the westward shift of coal production, as PRB coal shipments are carried in privately owned cars to a greater extent than Appalachian coal, according to the CWS.

[6] U.S. Department of Energy, Energy Information Administration, Annual Coal Report 2005 (Report No.: DOE/EIA-0584 [2005]).

[7] U.S. Department of Energy, Energy Information Administration, Annual Coal Report 2006 (Report No.: DOE/EIA-0584 [2006]).

[8] Car ownership = "P" in "Car Ownership," item 93 in the 900-byte CWS record.

FIGURE 12-4
SELECTED COAL SHIPMENT CHARACTERISTICS
INDEXES FOR AVERAGE DISTANCE AND TONS/CAR (LEFT AXIS)
PERCENTAGES FOR UNIT TRAINS AND PRIVATE CAR OWNERSHIP (RIGHT AXIS)
1987-2006 CARLOAD WAYBILL SAMPLES



Average shipment size increased dramatically over this period, from 582 tons and 6 carloads per waybill in 1987, to 5,080 tons and 46 carloads in 2005. The 2006 averages are 9,634 tons and 86 carloads, which as we note above may represent a "bounceback" from operational disruptions in the 2004-2005 period.

12B. PRICING ANALYSIS[9]

Cost Factors

Table 12-1 reports coefficients for shipment cost factors in the pricing equations estimated for the full 2001-2006 period (see also Chapter 11, Table 11-4) and for equations estimated using samples split into 2001-2003 and 2004-2006 periods.[10]

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[9] See Chapter 11 for definitions of variable names appearing in the remainder of this chapter.

[10] The estimates reported in Tables 12-1 and 12-2 are from the same set of commodity-specific regressions. Thus, the R^2 statistics reported in Table 12-1 also apply to Table 12-2.

TABLE 12-1
COST FACTOR COEFFICIENTS, COAL PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

Variable	2001-2006	2001-2003	2004-2006
ln MILES	-0.479	-0.517	-0.445
	(-253.61)	(-208.00)	(-160.89)
ln TONS	-0.006	-0.006	-0.032
	(-8.64)	(-6.54)	(-24.85)
ln TONSCAR	-0.801	-0.717	-0.752
	(-92.35)	(-57.55)	(-64.85)
D_OWN	-0.123	-0.123	-0.119
	(-71.23)	(-53.84)	(-48.21)
R-squared	0.47	0.52	0.47
N	209,859	108,276	101,583

The estimates are similar in sign and magnitude for the coal models estimated with the full waybill panel period and the split periods. Increasing shipment size by 10 percent while holding the number of carloads constant—so both TONS and TONSCAR would increase 10 percent—is estimated to reduce rates by 8.1 percent for the full sample period, other factors equal; the coefficient on TONSCAR accounts for most of the combined effect. Between 2001 and 2005, the average coal waybill's length of haul increased 8 percent and the tons per shipment approximately doubled, while TONSCAR was effectively unchanged. The effect of the average shipment's increased length of haul dominated the effect of the increased average shipment size for that period.

The coefficient (β_5) on D_OWN indicates the implicit rent for the use of railroad-owned cars, or conversely the implicit payment (in the form of a rate reduction) for shipper-supplied cars.[11] We convert β_5 into a payment per carload with the following equation:

$$(12.1) \quad rent\_per\_carload = RPTM \cdot (1 - e^{\beta_5}) \cdot TONSCAR \cdot MILES \;.$$

Evaluating equation (12.1) using the 2006 values and the full-sample estimate of $\beta_{5,}$ the implicit rent per carload is \$128. The lower estimate of β_5 for the 2004-2006 sample period yields a slightly lower implied rents—\$123 when evaluated at the 2006 means (in 2000 Q1 dollars).[12]

[11] Equation (11.19) in Chapter 11 introduces the coefficients used in this chapter.

[12] Privately owned cars are more prevalent on PRB coal routes. Compared to the overall average for coal shipments, PRB coal has lower average RPTM, a heavier average load, and longer average length of haul.

Market Structure Factors

Table 12-2 reports coefficients for market structure factors in the pricing equations estimated for the full 2001-2006 period (see also Chapter 11, Table 11-5) and for the equations estimated using samples split into the 2001-2003 and 2004-2006 periods.

TABLE 12-2
MARKET STRUCTURE FACTOR COEFFICIENTS, COAL PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

Variable	2001-2006	2001-2003	2004-2006
DLM_ORG	0.074	0.105	0.028
	(30.39)	(35.09)	(7.50)
RRCOMP_ORG	0.016	0.063	-0.037
	(5.84)	(18.67)	(-8.48)
DLM_TER	0.050	0.047	0.053
	(27.40)	(19.65)	(20.33)
RRCOMP_TER	-0.177	-0.131	-0.212
	(-90.08)	(-50.52)	(-74.26)
ln KMWATER_ORG	0.029	0.038	0.013
	(20.19)	(20.66)	(6.56)
ln KMWATER_TER	0.001	0.006	0.001
	(1.21)	(5.35)	(0.85)

The pricing model results imply some railroad rate response from railroad and water competition at the origin. We calculate the railroad competition effect as an index (RRCOMP_ORG_Index or RRCOMP_TER_Index) equal to 1 when the reciprocal of the Herfindahl Index (RRCOMP_ORG or RRCOMP_TER) equals 1. This is the case when there is only one effective railroad firm in the market. When the market at the origin point includes more than one railroad, RRCOMP_ORG > 1, then the index representing the railroad competition effect at the origin is calculated by:

$$(12.2)\quad RRCOMP\_ORG\_Index = \frac{\exp\left(\beta_{RRCOMP\_ORG} \cdot (RRCOMP\_ORG - 1)\right)}{\exp(\beta_{DLM\_ORG})}.$$

Equation (12.2) gives the hypothetical shift in railroad rates when the number of railroads at the origin county increases from one. A similar calculation provides the estimated railroad competition effect at the termination county.

Table 12-3 shows the estimated competition effects based on equation (12.2) for several values of RRCOMP_ORG. It is important to note that the RRCOMP_ORG and RRCOMP_TER variables reflect both the number and the market shares of railroad firms at the origin and termination points, respectively. For example, increasing the number of firms at the origin from one to two, results in $1 < RRCOMP\_ORG \leq 2$.

When the two firms have equal market shares then RRCOMP_ORG = 2, while RRCOMP_ORG is close to 1 when one of the two firms has a very large market share and the other has a very small market share. For instance, if railroad A has a 90 percent share of originating tonnage in a county and railroad B has a 10 percent share, then the value of RRCOMP_ORG is 1.22.[13] We are interested in the effects on railroad rates at values of RRCOMP_ORG and RRCOMP_TER near 1 (as occurs when a competitor has a very small market share), as well as other values of RRCOMP_ORG and RRCOMP_TER, in investigating whether rail competition has an effect on rail rates when any competition is present—i.e., if one or more competitors have very small market shares—and whether the competition effects increase when more competitors or competitors with relatively equal market shares are present.

TABLE 12-3
ESTIMATED RAILROAD COMPETITION EFFECTS AT ORIGIN
COAL SHIPMENTS

RRCOMP_ORG	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00
1.05	0.93	0.90	0.97
1.50	0.94	0.93	0.95
2.00	0.94	0.96	0.94
3.00	0.96	1.02	0.90

The effects of RRCOMP_ORG increasing from 1 to 2 are similar in the full and split sample periods—rate decreases of 4 to 6 percent. However, much of the effect is from the coefficient on DLM_ORG, the indicator variable for exactly one railroad serving in the origin county, which indicates the effect of introducing railroad competition with competitors that have very small market shares (seen in the table as RRCOMP_ORG 1.05 versus 1). For the 2001-2003 period, the coefficient on RRCOMP_ORG (representing the number and shares of effective firms, via the reciprocal of the Herfindahl concentration index) is positive and significant. In the full sample, the positive (and still statistically significant) coefficient on RRCOMP_ORG leads to only small offsets of the initial competitive effect through three effective competitors at origin. In the 2004-2006 sample period, the estimated effect of railroad competition at the origin is negative and significant, and the model implies RPTM would decrease an additional 4 percent when RRCOMP_ORG increases from 2 to 3.

We note that most major coal originating counties have values of RRCOMP_ORG between 1 and 2, so over the relevant range for most coal

[13] Recall that RRCOMP_ORG is the reciprocal of the Herfindahl Index, which is the sum of the squares of the shares. (See Chapter 11.)

tonnage, RPTM is lower in counties with railroad competitors present than in counties served by a single railroad.

Table 12-4 shows the estimated effects of railroad competition at the termination county on RPTM. The larger magnitudes of the coefficients on RRCOMP_TER (versus RRCOMP_ORG) imply that the railroad competition effect at the termination county is relatively stronger. Furthermore, the competition effects are of relatively similar magnitudes in the models estimated with full and split sample periods. The magnitude of the effect of moving from a single serving railroad to having a second small competitor (RRCOMP_TER = 1 versus RRCOMP_TER = 1.05) is 5 to 6 percent. This marginal effect of increasing the number of competitors at the termination point is smaller than the effect at the origin point. At RRCOMP_TER = 1.5, representing the presence of two railroads with approximately 80 percent and 20 percent shares, rates are 11 to 15 percent lower than in the monopoly case. Increasing RRCOMP_TER from 1 to 2 reduces rates by 20 percent in the full period, 16 percent in the 2001-2003 period, and 23 percent in the 2004-2006 period. While railroads appear willing to compete on price for coal shipments at the destination, the results do also imply an exercise of local market power via higher RPTM for destinations without effective railroad competition.

TABLE 12-4
ESTIMATED RAILROAD COMPETITION EFFECTS AT TERMINATION COAL SHIPMENTS

RRCOMP_TER	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00
1.05	0.94	0.95	0.94
1.50	0.87	0.89	0.85
2.00	0.80	0.84	0.77
3.00	0.67	0.73	0.62

We calculate the effect of competition from water shipments in the origin county with equation (12.3):

$$(12.3)\quad Water\_Index = \begin{cases} 1, dist\_water = 0 \\ \exp\left(\beta_{\ln KMWATER\_ORG} \cdot \ln(dist\_water \cdot 1.61)\right), dist\_water > 0 \end{cases}.$$

In equation (12.3), *dist_water* represents the distance in miles from waterway facilities. It is straightforward to modify equation (12.3) to calculate the effect of competition from water shipments in the termination county.

Table 12-5 shows the effects on railroad rates of increasing the distance to waterways from the origin point. In the full period, the water competition effect implies a 16 percent rail rate increase for origin points 100 miles from waterways versus origin points with direct (zero distance) waterway access. The effect increases to 21 percent at 500 miles from waterways. The water competition effect is stronger in the 2001-2003 period, and weaker in the 2004-2006 period.

TABLE 12-5
ESTIMATED WATER COMPETITION EFFECTS AT ORIGIN COAL SHIPMENTS

Distance to Water (Miles)	2001-2006	2001-2003	2004-2006
1	1.01	1.02	1.01
50	1.13	1.18	1.06
100	1.16	1.22	1.07
500	1.21	1.29	1.09

Table 12-6 shows the effects on railroad rates of increasing the distance to water facilities from the termination point.

TABLE 12-6
ESTIMATED WATER COMPETITION EFFECTS AT TERMINATION, COAL SHIPMENTS

Distance to Water (Miles)	2001-2006	2001-2003	2004-2006
1	1.00	1.00	1.00
50	1.00	1.02	1.00
100	1.00	1.03	1.00
500	1.01	1.04	1.01

The coefficients on the factors indicating water competition in the termination county show a consistent pattern of little price response to the availability of water competition at the destination in the full period and the split periods. The lack of price response is curious, since waterway access at the destination potentially enables multimodal shipping options even where there is no effective waterway competition at the origin.

Inferences for Competition

The pricing model results show that coal rates respond to both shipment cost characteristics and market structure factors, consistent with the model of Chapter 11. Increasing railroad competition for coal shipments at the origin point modestly reduces rates, whereas increasing railroad competition at the termination point is expected to lead to larger rate reductions for coal shipments. We also observe railroad price responses to the presence of competition from water transportation, with the origin-end effects appearing stronger than the termination-end effects. The magnitudes of our estimated rate effects are similar to those found by

Winston, Dennis, and Maheshri,[14] who characterize competition for PRB coal shipments between BNSF Railway and Union Pacific as reflecting a Bertrand duopoly (i.e., a price-setting duopoly with quasi-competitive outcomes). Given the relatively low estimated coal Lerner Markup Index of 0.41 for the full sample period, the pricing model suggests that railroad competition will result in lower markups over marginal costs for coal shipments.

[14] Clifford Winston, Scott M. Dennis, and Vikram Maheshri, "Duopoly Equilibrium Over Time in the Railroad Industry," Working Paper, April 2007.

Chapter 13 Contents

LIST OF FIGURES

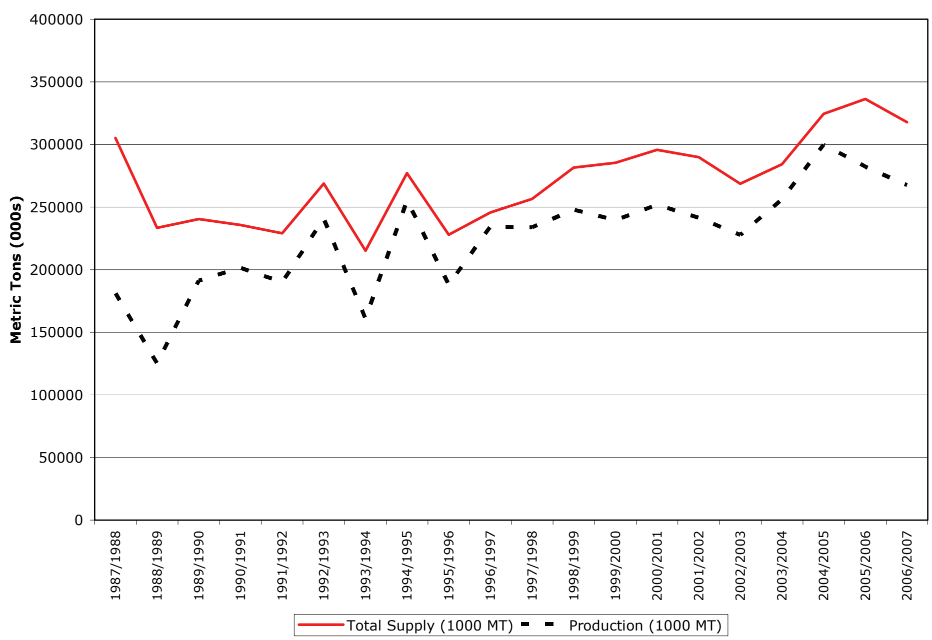
LIST OF TABLES

CHAPTER 13.
ANALYSIS OF COMPETITION: CORN AND WHEAT

13A. DESCRIPTION OF THE MARKET

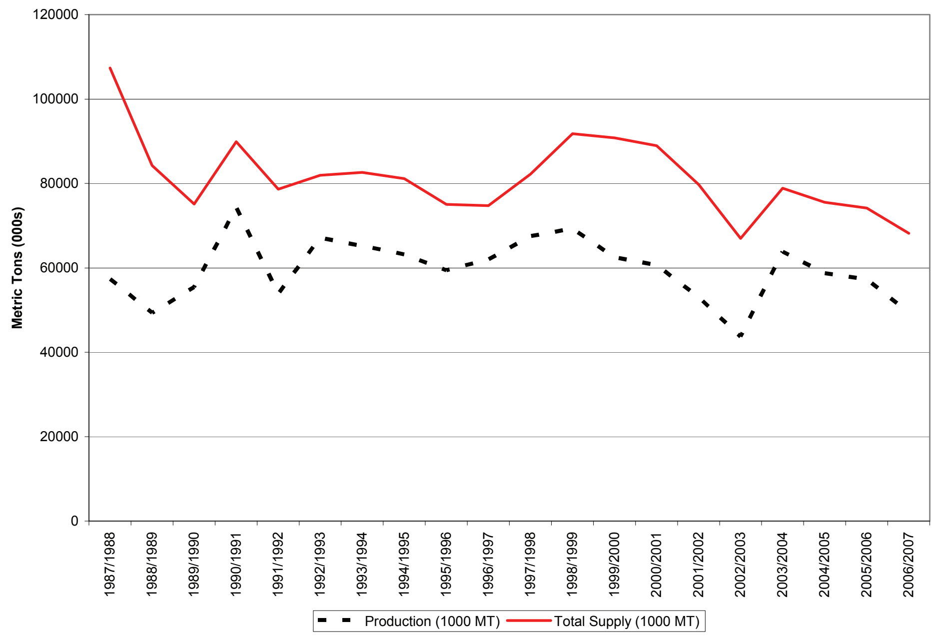
Corn and wheat are the two largest U.S. grain crops. According to the USDA, corn production for the 2006/2007 marketing year was 268 million metric tons, and total supply (including stocks and imports) was 318 million metric tons. Wheat production for 2006/2007 was 49 million metric tons (MT), and total supply was 68 million MT. Trends in production and supply are shown in Figures 13-1 and 13-2 for corn and wheat, respectively.[1]

FIGURE 13-1
U.S. CORN PRODUCTION AND SUPPLY



[1] Data for Figures 13-1 to 13-4 are from U.S. Department of Agriculture, Foreign Agricultural Service, Production, Supply and Distribution Online http://www.fas.usda.gov/psdonline/ (Accessed October 11, 2008).

FIGURE 13-2
U.S. WHEAT PRODUCTION AND SUPPLY



The U.S. corn crop is mostly consumed domestically. The major use is as animal feed. The food, seed, and industrial (FSI) use of corn has increased since the late 1980s, with recent growth attributable to the use of corn as a feedstock for ethanol production. Average annual corn exports over the 20-year period prior to the 2006/2007 marketing year (MY) are 48 million metric tons. See Figure 13-3.

Compared to corn, a larger fraction of the U.S. wheat crop is exported, though the level of corn exports is higher. In recent years, wheat exports and domestic FSI consumption have been of similar magnitudes. The use of wheat as animal feed has been relatively limited in recent years. See Figure 13-4.

FIGURE 13-3
U.S. CORN DISPOSITION[2]

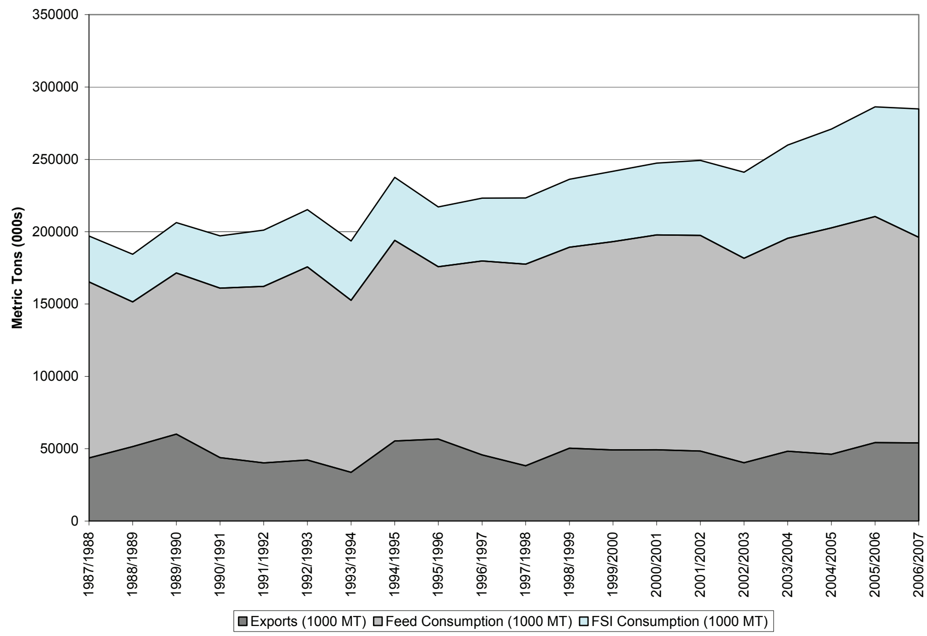
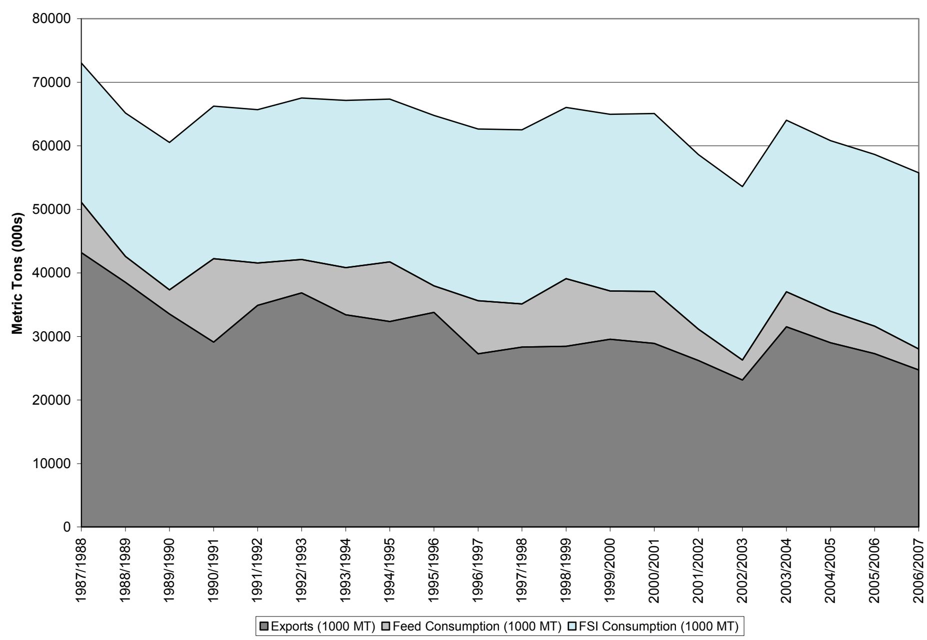


FIGURE 13-4
U.S. WHEAT DISPOSITION



[2] Note that stocks account for differences between total consumption and total supply.

In the immediate post-Staggers Act era, grain shipments were priced and service terms determined mostly according to confidential contracts. In the late 1980s, railroads introduced guaranteed forward placement of railcars using auctions to set prices, beginning with the Burlington Northern's Certificate of Transport program; similar programs were subsequently initiated by other railroads after legal challenges to the BN program were resolved. The auctions set a "differential… relative to the public tariff for the designated movement and grain."[3] Currently, grain shipments may also move at public tariff rates without a guaranteed window for railcar delivery.

Geography of Shipments

The top five corn-producing states—the "Corn Belt" states of Iowa, Illinois, Nebraska, Minnesota, and Indiana—account for approximately two-thirds of U.S. corn production.[4] The Corn Belt has relatively good access to navigable portions of the upper Mississippi, Missouri, and Ohio River systems. Accordingly, barge transportation is the predominant mode for U.S. corn shipments; 2006 rail shipments of 94 million tons (the CWS tonnage estimate) represent approximately 1/3 of combined domestic consumption and corn exports. Figure 13-5 shows the geographic distribution of 2005 CWS rail shipments of corn by origin county. Rail originations of corn are concentrated in the Midwestern Corn Belt, but there are gaps in the vicinities of navigable waterways where no (or few) rail shipments originate.[5] In examining origin-destination combinations for counties close to waterways where there were originating rail corn shipments, we found that these corn shipments were to destinations not amenable to transportation on the Mississippi River system, for example shipments to Pacific Ocean ports or to west Texas feedlots.

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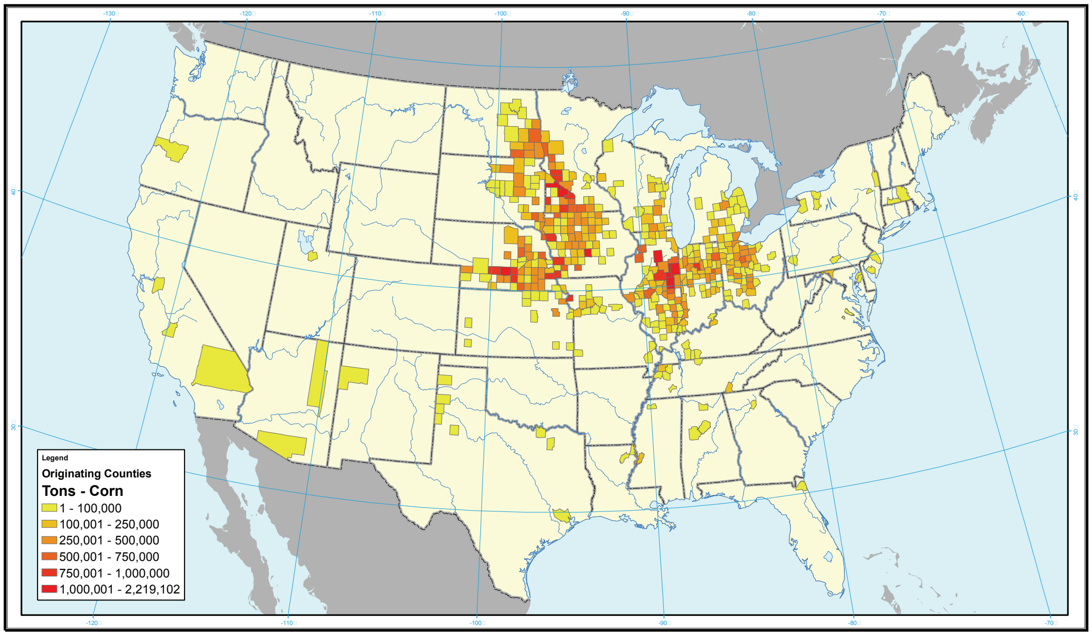
[3] William W. Wilson and Bruce L. Dahl, "Railcar Auctions for Grain Shipments: A Strategic Analysis." *Journal of Agricultural and Food Industrial Organization*, Vol. 3 (2005), Article 3.

[4] U.S. Department of Agriculture, National Agriculture Statistics Service, 2002 Census of Agriculture, Vol. 1, Chapter 2, Table 24, at http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_US_State_Level/st99_2_024_024.pdf (accessed October 11, 2008).

[5] Additionally, some counties, particularly those with small numbers of shipments, may not appear in a given year's CWS due to sampling variation.

FIGURE 13-5
TONNAGE OF RAIL SHIPMENTS OF CORN BY ORIGIN COUNTY
2005 CARLOAD WAYBILL SAMPLE



U.S. wheat production is concentrated in the northern and central plains, though significant quantities of wheat are grown in Idaho, Oregon, and Washington State. Rail accounts for approximately 60 percent of wheat shipments, and as much as 75 percent of the shipments of wheat for export.[6] Figure 13-6 shows the geographic distribution of 2005 CWS rail shipments of wheat by origin county. With the notable exception of Oregon and Washington counties close to the Columbia River system, many rail shipments of wheat originate in areas that are relatively remote from waterway facilities (see Figure 13-7) or, indeed, export points and other population centers. As a result, we would expect these insular areas' wheat shippers to exhibit "captivity" in the sense of having poor modal options to rail shipment.

[6] U.S. Department of Agriculture, Economic Research Service, *Agricultural Outlook* (March 1998), p. 2.

FIGURE 13-6
TONNAGE OF RAIL SHIPMENTS OF WHEAT BY ORIGIN COUNTY
2005 CARLOAD WAYBILL SAMPLE

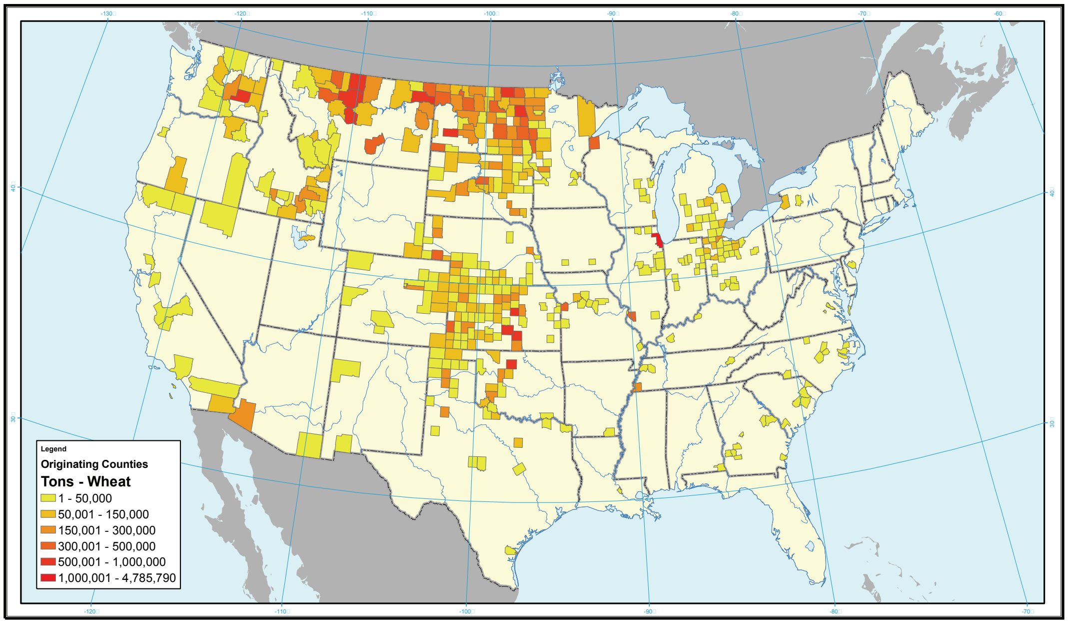
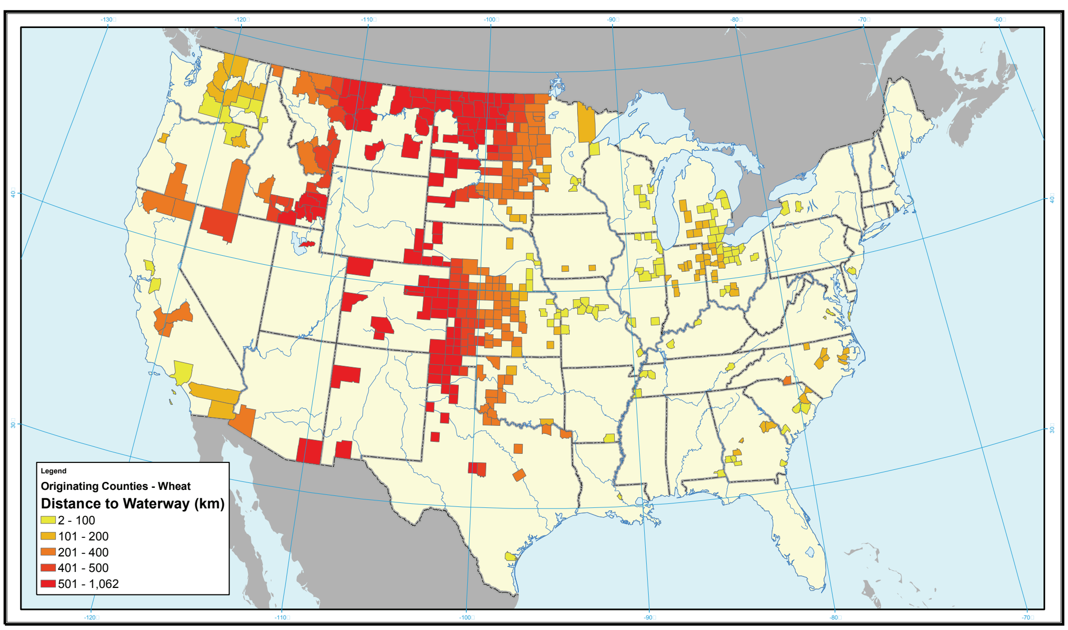


FIGURE 13-7
DISTANCE TO NEAREST WATERWAY FACILITY FOR COUNTIES WITH RAIL SHIPMENTS OF WHEAT

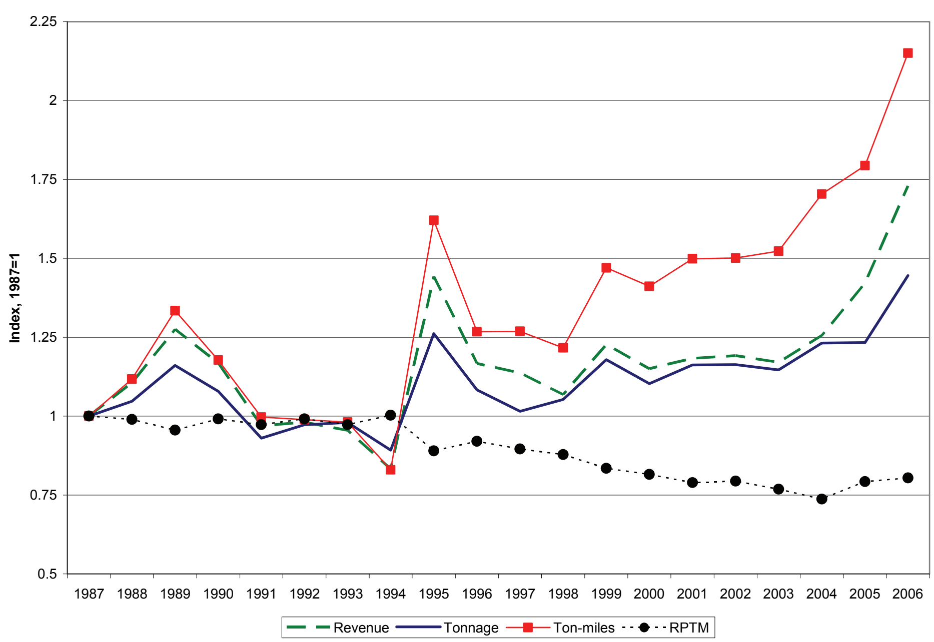


Tonnage and Revenue Trends

Corn (5-digit STCC 01132) and wheat (STCC 01137) are major components of the aggregate "farm products" commodity group (2-digit STCC 01). As shown in Table 11-1, 2006 corn waybills represent 3.8 percent of railroad revenue, 4.0 percent of tonnage, and 5.2 percent of ton-miles. For wheat, the 2006 figures are 2.2 percent of revenue, 2.2 percent of tonnage, and 2.3 percent of ton-miles. Combined, corn and wheat represent 73 percent of revenue, 77 percent of tonnage, and 75 percent of ton-miles for 2006 rail shipments of farm products.

Figure 13-8 shows the trends in real revenue, tonnage, ton-miles, and real revenue per ton-mile (RPTM) for corn shipments in the CWS from 1987 to 2006. Revenues and other dollar amounts are in constant dollars (base period 2000 quarter 1).

FIGURE 13-8
ANNUAL REAL REVENUE, TONNAGE, TON-MILES, AND REAL REVENUE PER TON-MILE
CORN SHIPMENTS, 1987-2006
CARLOAD WAYBILL SAMPLES

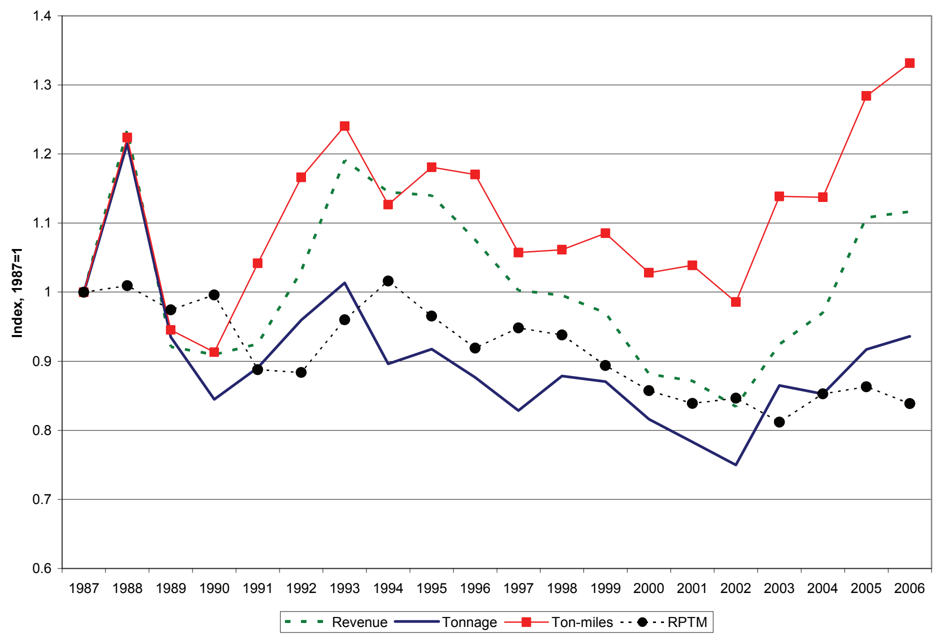


Rail tonnage for corn was relatively flat into the late 1990s, during which time corn supply was also relatively flat, though total domestic corn consumption plus exports was increasing (see Figures 13-1 and 13-3). In 1995, revenue, tonnage, and ton-miles all jumped sharply; ton-miles (via average length of haul) and revenue decreased somewhat in 1996 but still remained well above their previous trends. Revenue loosely tracked ton-miles until 1998, and then increased less rapidly than ton-miles as RPTM decreased through 2004. RPTM increased in 2005 and 2006, and revenue increased faster than tons and ton-miles in those years. Over the 2001-

2006 period of our pricing model analysis, tonnage increased 24 percent, ton-miles increased 43 percent, and real revenue increased 46 percent. Increases in average shipment size and length of haul underlie the recent trends in the variables shown in Figure 13-8 (see Figure 13-10, below).

Trends in real revenue, tonnage, ton-miles, and real RPTM for wheat shipments are provided in Figure 13-9.

FIGURE 13-9
ANNUAL REAL REVENUE, TONNAGE, TON-MILES, AND REAL REVENUE PER TON-MILE
WHEAT SHIPMENTS, 1987-2006
CARLOAD WAYBILL SAMPLES



Wheat tonnage increased over the 2001-2006 pricing analysis period, but remained below its peaks in 1988 and 1993. The previous declines in tonnage mirrored the general pattern of declining wheat supply and consumption-plus-exports (see Figures 13-2 and 13-4). Despite the decline in tonnage, increased length of haul led to overall growth in ton-miles. Revenue grew less than ton-miles, as RPTM was below its 1987 level from 1995 to 2006. Tonnage, ton-miles, and revenue increased over the 2001-2006 period of our pricing model analysis, by 20 percent, 28 percent, and 28 percent, respectively.

Other Shipment Characteristics

Figures 13-10 and 13-11 show trends in corn and wheat shipment characteristics from the CWS.

FIGURE 13-10
SELECTED CORN SHIPMENT CHARACTERISTICS
INDEXES FOR AVERAGE DISTANCE AND TONS/CAR (LEFT AXIS)
PERCENTAGES FOR UNIT TRAINS AND PRIVATE CAR OWNERSHIP (RIGHT AXIS)
1987-2006 CARLOAD WAYBILL SAMPLE

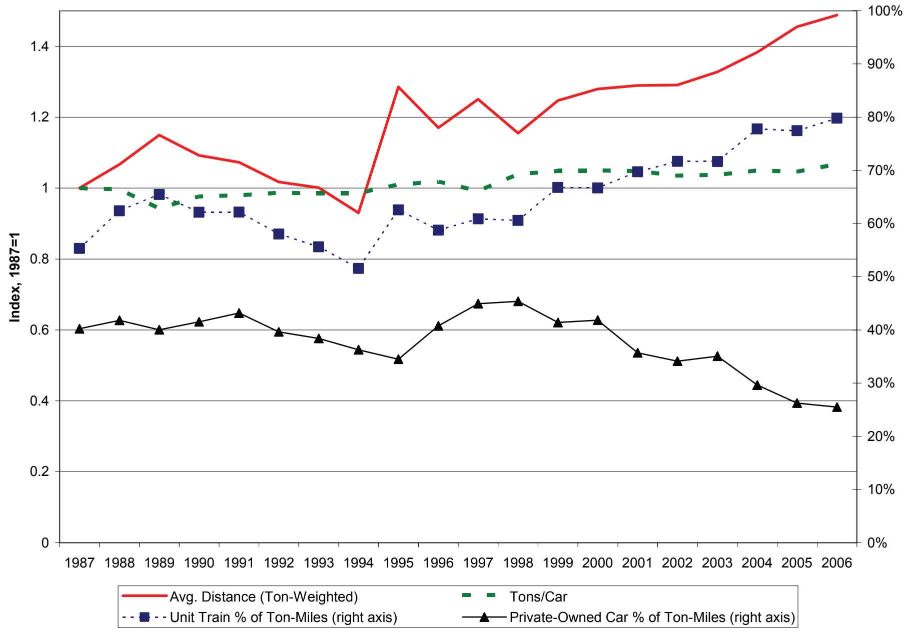
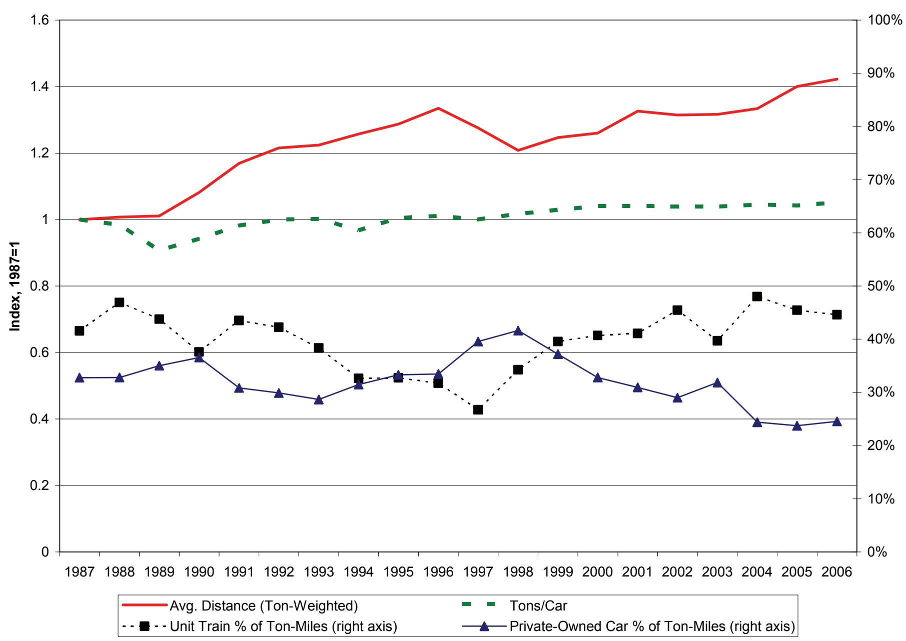


FIGURE 13-11
SELECTED WHEAT SHIPMENT CHARACTERISTICS
INDEXES FOR AVERAGE DISTANCE AND TONS/CAR (LEFT AXIS)
PERCENTAGES FOR UNIT TRAINS AND PRIVATE CAR OWNERSHIP (RIGHT AXIS)
1987-2006 CARLOAD WAYBILL SAMPLE



Average tons per corn carload increased 7 percent, from 97 to 103 tons, during the 1987-2006 period. Average shipment size grew, particularly from the mid-1990s; the fraction of ton-miles carried in unit-train shipments (defined here as 50 or more carloads) increased from approximately 60 percent in the mid-1990s to 80 percent in 2006. The average distance jumped from 1994 to 1995, then increased through the early 2000s to 1,055 miles versus 709 miles in 1987, a 49 percent increase. The fraction of ton-miles shipped in privately owned cars decreased markedly from 2000 to 2006. From 1987 to 2000, ton-miles in private cars varied from 34 to 45 percent. Since 2000, the fraction of ton-miles in private cars fell to 25 percent in 2006.

Wheat shipments exhibited a 5 percent increase in tons per car, from 98 tons to 103 tons, during the 1987-2006 time period. Compared to corn, the average wheat shipment size is considerably smaller. The average tons per wheat waybill actually declined in the mid-1990s before increasing in the 2000s. The fraction of ton-miles in shipments of 50 or more cars fell to a low of 27 percent in 1997 before rebounding in the 1998-2006 period. Average length of haul increased 42 percent from 1987 to 2006. The fraction of ton-miles shipped using private cars peaked in 1998, then generally declined over the 2001-2006 period covered by our pricing models.

We would expect the increases in tons per car and average length of haul to lower shipment costs per ton-mile for both corn and wheat, other things equal. Since the percent of shipments in private cars declined somewhat in the pricing model sample period, the car ownership mix change would tend to increase railroad costs slightly, compared to the earlier part of the sample period.

13B. Pricing Analysis[7]

Cost Factors

Table 13-1 reports coefficients for shipment cost factors in the pricing equations estimated for the full 2001-2006 period (see also Chapter 11, Table 11-4) and for equations estimated using samples split into the 2001-2003 and 2004-2006 periods.[8]

[7] See Chapter 11 for definitions of variable names appearing in the remainder of this chapter.

[8] The estimates reported in Tables 13-1 and 13-2 are from the same set of commodity-specific regressions. Thus, the R^2 statistics reported in Table 13-1 also apply to Table 13-2.

TABLE 13-1
COST FACTOR COEFFICIENTS, CORN AND WHEAT PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

	Corn			Wheat		
Variable	**2001-2006**	**2001-2003**	**2004-2006**	**2001-2006**	**2001-2003**	**2004-2006**
ln MILES	-0.680	-0.646	-0.711	-0.560	-0.570	-0.540
	(-140.8)	(-87.0)	(-117.9)	(-113.3)	(-77.5)	(-86.8)
ln TONS	-0.061	-0.059	-0.061	-0.021	-0.022	-0.026
	(-57.3)	(-36.2)	(-46.6)	(-18.4)	(-12.0)	(-18.4)
ln TONSCAR	-0.874	-0.877	-0.896	-0.918	-0.817	-0.948
	(-91.4)	(-55.3)	(-81.5)	(-68.0)	(-34.6)	(-63.7)
D_OWN	-0.094	-0.095	-0.091	-0.046	-0.045	-0.036
	(-34.0)	(-23.1)	(-25.9)	(-14.4)	(-9.6)	(-9.3)
R-squared	0.57	0.52	0.66	0.52	0.49	0.58
N	31,597	15,257	16,340	22,054	10,472	11,582

The pricing model results show that rail rates for corn and wheat are responsive to factors we would expect to reduce marginal costs per ton-mile, notably the length of haul (MILES) and car loadings (TONSCAR). We find that increasing shipment size in tons is also associated with lower rail rates for both corn and wheat. The coefficients on the car ownership indicator, D_OWN, for the full sample periods yield implicit car rental rates of $177 per carload for corn and $93 per carload for wheat, evaluated using 2006 shipment characteristics.

Over our pricing models' full sample period (2001-2006), average length of haul, tons per car, and tons per shipment all increased for both corn and wheat. However, the increases in average length of haul and shipment size were considerably larger for corn than for wheat—15 percent versus 7 percent for length of haul, and 42 percent versus 18 percent for shipment size. These changes in average shipment cost characteristics for corn rail shipments from 2001 to 2006, along with the small increase in TONSCAR, imply a 14.7 percent lower rate (RPTM), other things equal; for wheat, the shift in rail shipment cost characteristics from 2001 to 2006 implies a 5.6 percent rate decrease, other things equal.[9]

Market Structure Factors

Table 13-2 reports coefficients for market structure factors in the pricing equations estimated for the full 2001-2006 period (see also

[9] Additionally, the rate of use of railroad-owned cars increased from 2001 to 2006 for both corn and wheat; this would slightly offset the favorable shifts in other cost-related factors.

Chapter 11, Table 11-5) and for the equations estimated using samples split into the 2001-2003 and 2004-2006 periods.

TABLE 13-2
MARKET STRUCTURE FACTOR COEFFICIENTS, CORN AND WHEAT PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

	Corn			Wheat		
Variable	**2001-2006**	**2001-2003**	**2004-2006**	**2001-2006**	**2001-2003**	**2004-2006**
DLM_ORG	-0.023	-0.032	-0.018	0.029	0.009	0.053
	(-6.8)	(-6.2)	(-4.3)	(7.2)	(1.5)	(10.7)
RRCOMP_ORG	-0.018	-0.028	-0.005	-0.002	-0.012	0.006
	(-6.6)	(-6.8)	(-1.4)	(-0.6)	(-1.9)	(1.2)
DLM_TER	0.064	0.046	0.089	0.025	-0.001	0.048
	(17.0)	(8.4)	(18.1)	(4.1)	(-0.2)	(6.1)
RRCOMP_TER	0.021	-0.016	0.066	0.003	0.003	0.012
	(6.3)	(-3.4)	(15.3)	(0.9)	(0.5)	(2.5)
ln KMWATER_ORG	0.001	0.008	-0.008	0.110	0.115	0.079
	(0.7)	(2.9)	(-3.7)	(43.3)	(31.5)	(22.8)
ln KMWATER_TER	0.010	0.013	0.010	-0.000	-0.008	0.008
	(6.2)	(5.3)	(4.9)	(-0.2)	(-3.4)	(4.6)

We observe a number of statistically insignificant and marginally significant[10] effects for the market structure factors in the corn and wheat models. Notably, those include the coefficients on the reciprocal of the origin-county Herfindahl Index (RRCOMP_ORG) in the 2004-2006 sample period for corn, and for all sample periods for wheat. The coefficient on the termination-county analogue, RRCOMP_TER, is statistically insignificant in the 2001-2006 and 2001-2003 periods for wheat. In addition, we observe unexpected positive coefficients on those variables for some periods, indicating that rail rates are increasing with increases in the number of effective railroad competitors. Last, we observe relatively large and significant effects from water competition at origin on wheat's rail rates, but relatively small or counterintuitive effects from water competition at origin for corn.

To aid in interpreting these results, we translate the coefficients from Table 13-2 into shift factors indicating the estimated effects on rail rates, using the formulas described in the Pricing Analysis Section of Chapter 12. Table 13-3 shows the estimated rail rate shift effects for rail competition at origin.

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[10] While *t*-statistics exceeding 1.645 in absolute value are usually considered "significant" at standard confidence levels (90 percent or more), the prospect of observing "spurious" effects from the combination of large sample size and relatively parsimonious specifications merits caution in interpreting the significance of coefficients.

TABLE 13-3
ESTIMATED RAILROAD COMPETITION EFFECTS AT ORIGIN
CORN AND WHEAT SHIPMENTS

	Corn			Wheat		
RRCOMP_ORG	2001-2006	2001-2003	2004-2006	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.05	1.02	1.03	1.02	0.97	0.99	0.95
1.25	1.02	1.03	1.02	0.97	0.99	0.95
1.50	1.01	1.02	1.02	0.97	0.99	0.95
1.75	1.01	1.01	1.01	0.97	0.98	0.95
2.00	1.01	1.00	1.01	0.97	0.98	0.95
3.00	0.99	0.98	1.01	0.97	0.98	0.95

Our estimates indicate that corn rates vary relatively little with increases in the number of effective railroads over the range of one to three in the origin county. Interestingly, the results show that corn rates are slightly lower when there is a single serving railroad than when there are two serving railroads and one railroad has a dominant share (values of RRCOMP_ORG close to 1). Given the relatively high average estimated Lerner Markup Indexes from Table 11-6—LMI equals 0.70 for corn shipments in the full sample period—these results may reflect the effects from regulatory constraints that are binding only in the absence of other rail options for shippers. The estimated increases in corn rates with increasing RRCOMP_ORG in the 2004-2006 sample period are not statistically significant.

For wheat, we observe reductions in rail rates with RRCOMP_ORG increases, though the effects are modest and predominantly arise from the coefficient on DLM_ORG, the effect on RPTM from having a single serving railroad at the origin county; the marginal effects of increasing RRCOMP_ORG are extremely small. However, the decline in RPTM when moving from a single serving railroad at origin to some degree of railroad competition is statistically significant for the 2001-2006 and 2004-2006 sample periods.

Table 13-4 shows the estimated effects of railroad competition at the termination county. For the most part, the termination county competition effects are ambiguous as declines in RPTM from introducing railroad competition (the increase from 1 to 1.05 in RRCOMP_TER) are offset by "wrong sign" effects from RRCOMP_TER. Much of the expected effect of railroad competition at the termination county arises from the DLM_TER variable (moving from a single serving railroad to any amount of railroad competition), as the RRCOMP_TER has the "wrong sign" (sometimes insignificant) for both commodities, except for corn in the 2001-2003 period.

TABLE 13-4
ESTIMATED RAILROAD COMPETITION EFFECTS AT TERMINATION
CORN AND WHEAT SHIPMENTS

	Corn			Wheat		
RRCOMP_TER	**2001-2006**	**2001-2003**	**2004-2006**	**2001-2006**	**2001-2003**	**2004-2006**
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.05	0.94	0.95	0.92	0.98	1.00	0.95
1.25	0.94	0.95	0.93	0.98	1.00	0.96
1.50	0.95	0.95	0.95	0.98	1.00	0.96
1.75	0.95	0.94	0.96	0.98	1.00	0.96
2.00	0.96	0.94	0.98	0.98	1.00	0.96
3.00	0.98	0.93	1.04	0.98	1.01	0.98

Table 13-5 shows the estimated effects on rail rates of the proximity to water transportation at the origin county.

TABLE 13-5
ESTIMATED WATER COMPETITION EFFECTS AT ORIGIN
CORN AND WHEAT SHIPMENTS

	Corn			Wheat		
Distance to Water (miles)	**2001-2006**	**2001-2003**	**2004-2006**	**2001-2006**	**2001-2003**	**2004-2006**
1	1.00	1.00	1.00	1.05	1.06	1.04
50	1.01	1.04	0.96	1.62	1.65	1.41
100	1.01	1.04	0.96	1.75	1.79	1.49
500	1.01	1.06	0.95	2.08	2.15	1.69

Our results suggest that water transportation has small constraining effects (if any) on rail rates for corn shipments in the full and 2001-2003 periods, and a small counterintuitive effect in the 2004-2006 period. In contrast, the estimated effects on the rail rates for wheat shipments from water competition are large in all three sample periods. As we noted above, much of the Corn Belt is in relatively close proximity to navigable stretches of the upper Mississippi, Missouri, and Ohio Rivers, and the geographic distribution of corn shipments by rail features gaps close to the waterways. Thus, corn shipments with good access to waterways travel by waterways, and the rail shipments included in the CWS reflect shipment characteristics—not necessarily observed—that relax the water constraint.

For wheat, the CWS includes shipments from growers in the Great Plains, particularly in North Dakota and Montana, which are very far from the nearest waterway access points. However, we also observe rail shipments of wheat originating in Oregon and Washington State counties with relatively short distances to waterway access points on the Columbia River system. The relatively short water distances along the Columbia River would tend to make the truck/barge combination a closer competitor to rail shipments compared to long water movements along the Mississippi

River to the Gulf of Mexico. Thus, the magnitude of the estimated effect is not totally unexpected, as it is reflective of differences between very favorable and very unfavorable shipment geography.

Table 13-6 shows the estimated rail rate effects of water accessibility at the termination county.

TABLE 13-6
ESTIMATED WATER COMPETITION EFFECTS AT TERMINATION
CORN AND WHEAT SHIPMENTS

	Corn			Wheat		
Distance to Water (miles)	2001-2006	2001-2003	2004-2006	2001-2006	2001-2003	2004-2006
1	1.00	1.01	1.00	1.00	1.00	1.00
50	1.04	1.06	1.04	1.00	0.97	1.04
100	1.05	1.07	1.05	1.00	0.96	1.04
500	1.07	1.09	1.07	1.00	0.95	1.06

The estimated water competition effect at the termination point is weak overall. For corn shipments, the effect is 5 to7 percent higher rail rates at 100 miles and 7 to 9 percent higher rates at 500 miles. For wheat shipments in the full sample period, there is no material or statistically significant effect of water accessibility on rail rates at the destination; the effects are inconsistent in the split-sample periods.

Inferences for Competition

We find that rail rates for corn and wheat shipments are responsive to cost factors but relatively insensitive to variations in railroad competition. In our qualitative research, we heard shippers' views that railroads did not seem very interested in competing for their business. The relatively small effects of railroad competition on rail rates that we estimate lend some credence to the shippers' views. We observe a strong effect of the availability of water transportation at origin on rail rates for wheat shipments; we believe this is reflective of the unfavorable geography of wheat shipments from the Great Plains versus shipments from regions with better modal alternatives. Interestingly, we do not see much evidence of rail rate reductions for corn shipments from water-competition constraints. This may in part reflect that the water option for the relatively small share of corn shippers who currently use rail is less attractive than the simple distance to waterways may indicate.

Chapter 14 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 14.
ANALYSIS OF COMPETITION: CHEMICALS

14A. DESCRIPTION OF THE MARKET

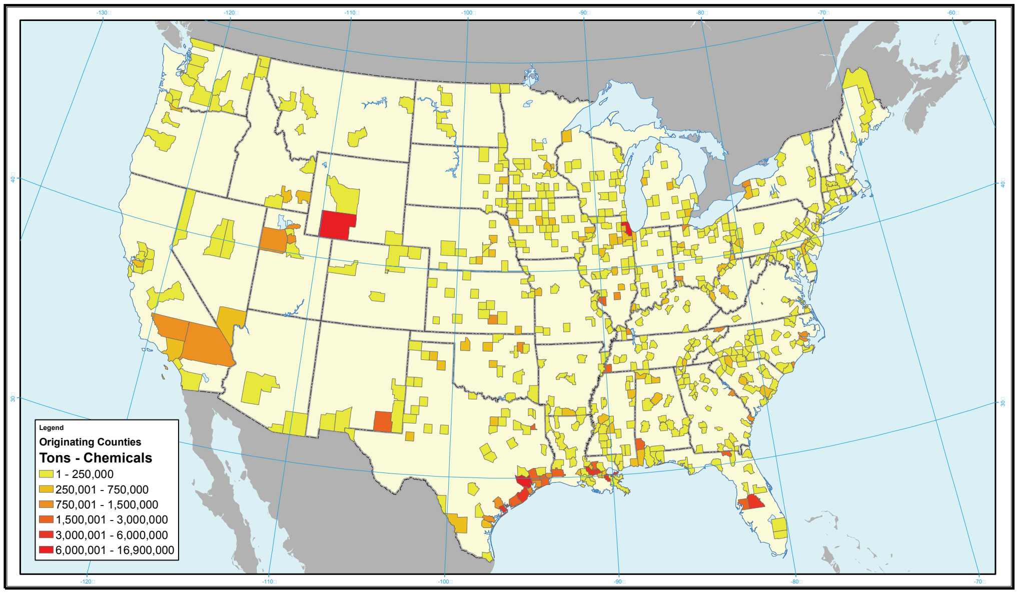
The chemicals commodity group (2-digit STCC 28) encompasses a large number of products with distinct final markets, in contrast with the relatively homogeneous coal, corn, and wheat discussed in Chapters 12 and 13. Major component commodities include organic and inorganic industrial chemicals (3-digit STCC 281, e.g., ammonia, chlorine, other industrial gases, and alcohols), plastics and synthetic fibers (3-digit STCC 282), and agricultural chemicals including fertilizers (3-digit STC 287). Many chemical shipments are in carload quantities; the CWS annual averages have ranged from 1.1 to 1.18 carloads per waybill, which is low for bulk commodity shipments.

Materials classified as non-hazardous account for a majority of the chemical shipments, however a significant fraction of railroad chemical tonnage is hazardous materials. Among the major hazardous chemicals shipped by rail are ammonia and chlorine; the former is a precursor chemical to a variety of nitrogen compounds (including fertilizers) while municipal water treatment is among the major chlorine uses. Hazardous materials are subject to specific regulations on train makeup and routing that are potentially costly to railroads. The costs and/or perceived risks of hazardous material shipments by rail may have increased in the post-9/11 security environment, and our analysis investigates premiums charged for hazardous material shipments by rail.

Geography of Shipments

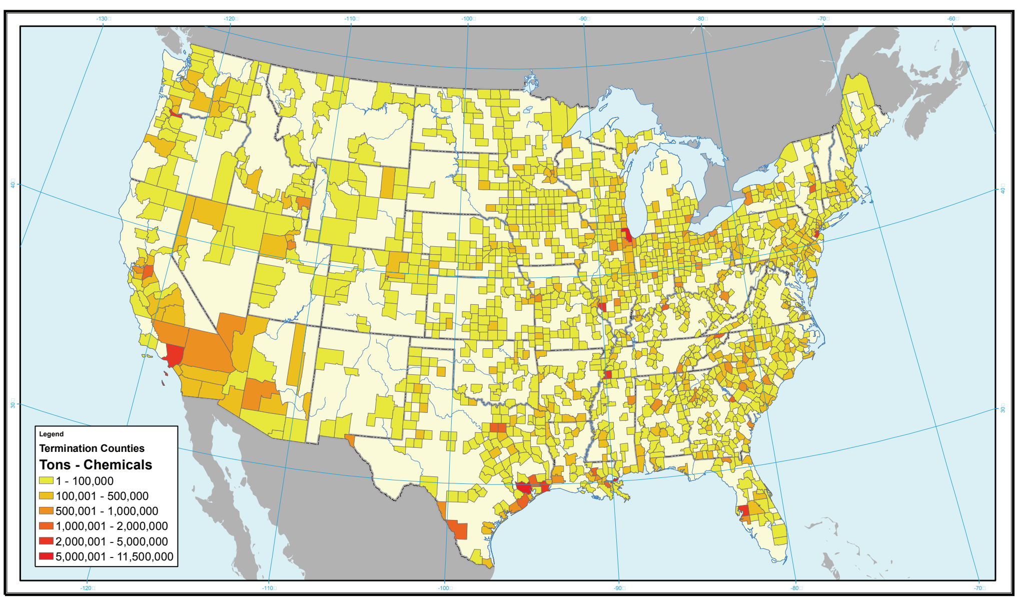
Rail originations of chemical shipments by county are shown in Figure 14-1. Major origin rail shipment concentrations include portions of the Texas and Louisiana Gulf Coasts, various other manufacturing and refining centers, and ports of entry for imported chemicals.

FIGURE 14-1
CHEMICAL SHIPMENT TONNAGE BY ORIGIN COUNTY
2005 CARLOAD WAYBILL SAMPLE



Rail destinations of chemical shipments by county are shown in Figure 14-2.

FIGURE 14-2
CHEMICAL SHIPMENT TONNAGE BY TERMINATION COUNTY
2005 CARLOAD WAYBILL SAMPLE

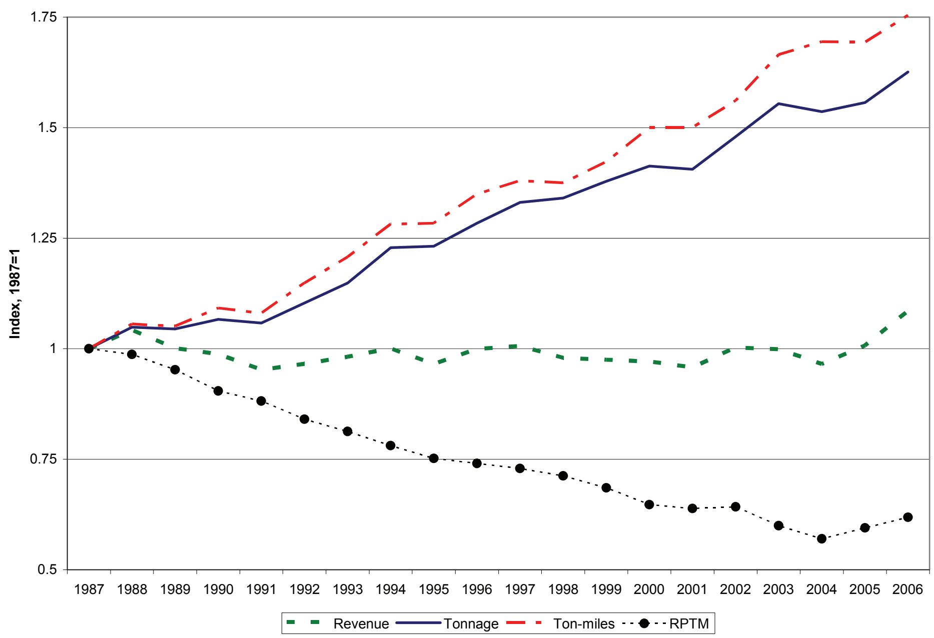


Chemical shipment destinations are very widely dispersed, reflecting in part the supply of fertilizers and pesticides to major growing regions. The low densities for chemical shipments limit the shippers' abilities to organize lower-cost, multiple-carload destination rail shipments.

Tonnage and Revenue Trends

In 2006, chemicals including hazardous materials accounted for 8.9 percent of tonnage, 9.3 percent of ton-miles, and 11.8 percent of revenue in the CWS (see Table 11-1 in Chapter 11). Figure 14-3 shows the trends in real revenue, tonnage, ton-miles, and real revenue per ton-mile for chemical shipments in the CWS from 1987 to 2006. Revenues and RPTM are in constant dollars (base period 2000 quarter 1).

FIGURE 14-3
ANNUAL REAL REVENUE, TONNAGE, TON-MILES, AND REAL REVENUE PER TON-MILE
CHEMICAL SHIPMENTS (INCLUDING HAZARDOUS MATERIALS), 1987-2006
CARLOAD WAYBILL SAMPLE

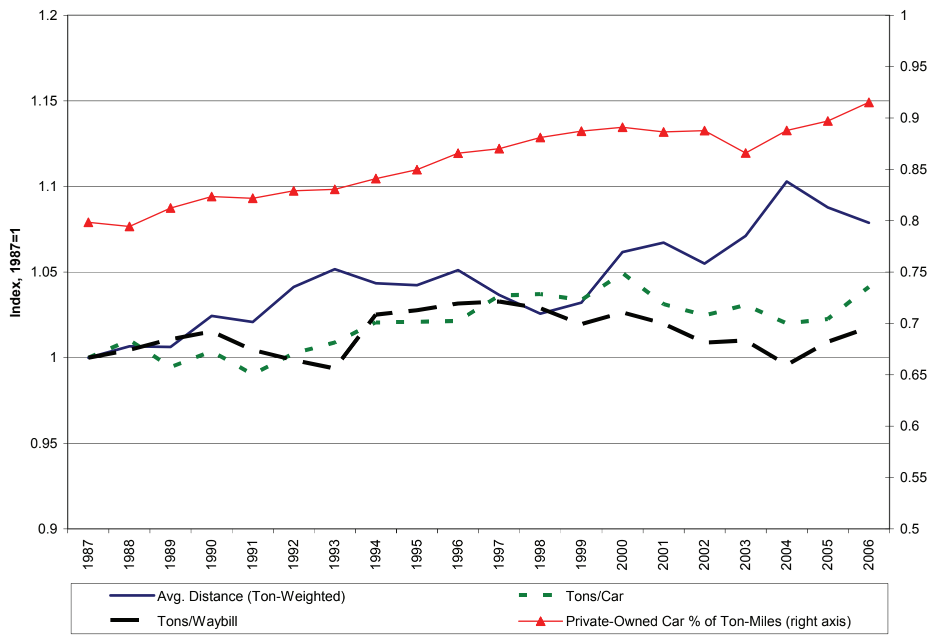


Rail tonnage for chemicals increased 63 percent over the 1987-2006 period, and 16 percent from 2001 to 2006. Average length of haul (not shown) increased modestly, factoring into the increases for ton-miles of 75 percent from 1987 to 2006, and 17 percent from 2001 to 2006. The growth in revenue lagged both tonnage and ton-mile growth over the 1987-2006 period, increasing 9 percent. However, revenue grew 14 percent from 2001 to 2006, mostly due to an increase in RPTM from 2004 to 2006. RPTM fell 43 percent between 1987 and 2004 before recovering modestly, to 62 percent of 1987 average RPTM, in 2006.

Other Shipment Characteristics

Figure 14-4 shows trends in chemical shipment characteristics from the CWS.

FIGURE 14-4
SELECTED CHEMICAL SHIPMENT CHARACTERISTICS
INDEXES FOR AVERAGE DISTANCE, TONS/CAR, AND TONS/WAYBILL (LEFT AXIS)
PERCENTAGES FOR PRIVATE CAR OWNERSHIP (RIGHT AXIS)
1987-2006 CARLOAD WAYBILL SAMPLES



Average length of haul increased 8 percent over the 20-year period, and 1 percent from 2001 to 2006. Shipment size measures—tons per car and tons per waybill—show fluctuations within 5 percent of their 1987 levels; they slightly increased over the full 1987-2006 period, but were essentially unchanged over the 2001-2006 period. Rates of privately owned car usage are high over the 20-year period, increasing from 80 percent of ton-miles in 1987 to 92 percent in 2006; private car usage rates increased 3 percent over the 2001-2006 period covered by our pricing analysis. Not shown in this figure, the percentage of chemical rail tonnage comprising hazardous materials increased from 28-30 percent for the 2000-2003 period to 35-38 percent in the 2004-2006 period.

Unlike coal, corn, and wheat, chemical shipment characteristics have not materially shifted towards lower-cost configurations, and so chemical shipments will tend to be more exposed to the "generic" cost increases of railroads. Additionally, the recent higher percentages of hazardous materials in the chemical rail shipment mix would tend to increase rail costs and rates.

14B. PRICING ANALYSIS[1]

Cost Factors

Table 14-1 reports coefficients for shipment cost factors in the pricing equations estimated for chemicals including hazardous materials (hazmats) over the full 2001-2006 period (see also Chapter 11, Table 11-4) as well as the 2001-2003 and 2004-2006 periods.[2]

TABLE 14-1
COST FACTOR COEFFICIENTS, CHEMICAL PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

Variable	2001-2006	2001-2003	2004-2006
ln MILES	-0.523	-0.521	-0.522
	(-221.7)	(-152.9)	(-162.8)
ln TONS	-0.046	-0.038	-0.052
	(-22.1)	(-12.4)	(-18.7)
ln TONSCAR	-0.177	-0.137	-0.228
	(-47.5)	(-25.2)	(-43.9)
D_OWN	0.069	0.040	0.083
	(18.0)	(7.8)	(14.5)
D_HAZARD	0.111	0.077	0.128
	(47.0)	(20.5)	(40.4)
R-squared	0.21	0.20	0.24
N	247,368	119,594	127,774

The pricing model results show that RPTM for chemicals are lower for longer hauls, larger shipment sizes, and heavier loads, as we would expect to see. The effects of length-of-haul and shipment size are relatively consistent across the sample periods. Chemical RPTM is less responsive to car loading than we estimated for coal and grains, though the estimated effect is higher in the 2004-2006 period than in the 2001-2003 or full 2001-2006 sample periods.

The coefficients on D_OWN, the private car ownership indicator variable, do not show an implicit rental payment for use of privately owned cars. We understand that railroads prefer not to own specialized cars for chemicals because they are often not fungible across shippers. That is, specialized equipment may be required for various characteristics of the chemicals, such as whether the chemicals are shipped as solids,

[1] See Chapter 11 for definitions of variable names appearing in the remainder of this chapter.

[2] The estimates reported in Tables 14-1 and 14-2 are from the same set of commodity-specific regressions. Thus, the R^2 statistics reported in Table 14-1 also apply to Table 14-2.

liquids or gases, and/or the reactivity of the chemicals with the air and with materials from which the cars are built. Additionally, mixing certain chemicals with residues from other chemicals can either damage the shipments by contamination or cause dangerous reactions. In effect, the shippers' supply of rail cars is built into the RPTM charged for chemical shipments, and it may be the case that the minority of chemical shipments able to employ railroad-owned cars have lower costs related to car types.

We also estimated pricing equations for shipments coded as non-hazardous materials, and obtained similar results for the effects of ln MILES, ln TONS, ln TONSCAR, and D_OWN on RPTM.

Our results show that the average RPTM premium for hazardous material shipments, indicated by the D_HAZARD variable,[3] increased from 7.7 percent in the 2001-2003 period to 12.8 percent in the 2004-2006 period.

As we noted above, average length of haul, tons per car, and tons per shipment have changed little over the pricing models' 2001-2006 sample period. The pricing model results predict that a chemical shipment with 2006 average characteristics would face a 2006 RPTM little changed in constant dollar terms versus the RPTM for the average 2001 chemical shipment—1.5 percent lower for the 2006 average characteristics, with essentially identical results obtaining from the full sample period and the split-sample period estimates. This small effect would be outweighed by the shift in the shipment mix towards hazardous materials and the increased hazardous materials' premium in 2006.

Market Structure Factors

Table 14-2 reports coefficients for market structure factors in the pricing equations estimated for the full 2001-2006 period (see also Chapter 11, Table 11-5) and the equations estimated using samples split into the 2001-2003 and 2004-2006 periods. The signs on the market structure factors are of the expected directions, though the effects of competition from water transportation at the originating points of chemical shipments are statistically insignificant or marginally significant. The effects are relatively consistent in sign and magnitude across time periods, though the coefficients on the variables representing railroad competition at the origin (DLM_ORG and RRCOMP_ORG) are smaller in the 2004-2006 period than the other sample periods.

To aid in interpreting these results for the market structure, we translate the coefficients from Table 14-2 into shift factors indicating the estimated effects on RPTM using the formulas described in Chapter 12.

[3] D_HAZARD is an indicator variable that equals 1 for the 2-digit hazardous material STCC 49, 0 otherwise.

TABLE 14-2
MARKET STRUCTURE FACTOR COEFFICIENTS, CHEMICAL PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

Variable	2001-2006	2001-2003	2004-2006
DLM_ORG	0.071	0.082	0.048
	(19.9)	(15.9)	(9.8)
RRCOMP_ORG	-0.040	-0.059	-0.033
	(-24.1)	(-23.5)	(-14.2)
DLM_TER	0.086	0.074	0.098
	(27.4)	(16.7)	(22.5)
RRCOMP_TER	-0.037	-0.028	-0.037
	(-21.8)	(-11.2)	(-16.2)
ln KMWATER_ORG	0.005	0.006	0.003
	(4.2)	(3.4)	(2.1)
ln KMWATER_TER	0.037	0.031	0.039
	(37.4)	(22.5)	(28.7)

Table 14-3 shows the rate shift factors for rail competition at the origin for several values of RRCOMP_ORG.

TABLE 14-3
ESTIMATED RAILROAD COMPETITION EFFECTS AT ORIGIN
CHEMICAL SHIPMENTS

RRCOMP_ORG	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00
1.05	0.93	0.92	0.95
1.25	0.92	0.91	0.95
1.50	0.91	0.89	0.94
1.75	0.90	0.88	0.93
2.00	0.89	0.87	0.92
3.00	0.86	0.82	0.89

Our estimates indicate that the RPTM for non-hazardous chemicals declines with additional railroad competition at the origin, though the effect is weaker in the 2004-2006 sample period than in the 2001-2003 and the full sample period. The effect of increasing RRCOMP_ORG from one to two is 8 percent using the 2004-2006 period, 11 percent for the full period, and 13 percent for the 2001-2003 period.

Table 14-4 shows the estimated effects of railroad competition at the termination county. The termination-county railroad competition effects on RPTM are reasonably consistent over the three sample periods, yielding 10 to13 percent reductions when RRCOMP_TER moves from one to two. The effects of introducing any competition (i.e. the shift from one railroad to RRCOMP_TER equaling 1.05) are 7-10 percent reductions in RPTM depending on the sample period. On the origin end, when

RRCOMP_ORG changes from one to 1.05, reductions in RPTM range from 5 to 8 percent across sample periods and are statistically significant in each case.

TABLE 14-4
ESTIMATED RAILROAD COMPETITION EFFECTS AT TERMINATION
CHEMICAL SHIPMENTS

RRCOMP_TER	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00
1.05	0.92	0.93	0.90
1.25	0.91	0.92	0.90
1.50	0.90	0.92	0.89
1.75	0.89	0.91	0.88
2.00	0.88	0.90	0.87
3.00	0.85	0.88	0.84

Table 14-5 shows the estimated effects of proximity to water transportation at the origin county on RPTM for chemical shipments.

TABLE 14-5
ESTIMATED WATER COMPETITION EFFECTS AT ORIGIN
CHEMICAL SHIPMENTS

Distance to Water (miles)	2001-2006	2001-2003	2004-2006
1	1.00	1.00	1.00
50	1.02	1.03	1.02
100	1.03	1.03	1.02
500	1.03	1.04	1.02

RPTM is slightly higher for chemical shipments originating at greater distances from water facilities, though the effect is small. Table 14-6 shows the estimated effects of water accessibility at the termination county. The effects of the water competition indicator at the termination point of the chemical shipments are large and relatively consistent across sample periods. Figure 14-1, above, shows that many rail shipments of chemicals originate near ports and waterways, reflecting in part the locations of major chemical manufacturing centers along the Gulf Coast, the Mississippi River (and its major tributaries), the Delaware River, and so on. With chemical manufacturing concentrated near waterways, access to water facilities at the termination point appears to be the more binding constraint on the pricing of chemical shipments by railroads.

TABLE 14-6
ESTIMATED WATER COMPETITION EFFECTS AT TERMINATION
CHEMICAL SHIPMENTS

Distance to Water (miles)	2001-2006	2001-2003	2004-2006
1	1.02	1.02	1.02
50	1.17	1.15	1.19
100	1.20	1.17	1.22
500	1.28	1.23	1.30

Inferences for Competition

The pricing model results show that RPTM for chemical shipments by rail responds to both shipment cost characteristics and railroad market structure factors, consistent with the model described in Chapter 11. However, with little change in average rail shipment characteristics over time, chemical shippers are relatively exposed to increases in the “generic” marginal costs of railroads. Additionally, hazardous chemical shippers appear to be facing higher rate premiums in the 2004-2006 sample period, likely reflecting more stringent shipment security regulations and risk premiums. We also observe robust rate responses to the presence of competition from other railroads at both origin and destination counties, and of water transportation at the destination county.

Chapter 15 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 15. ANALYSIS OF COMPETITION: INTERMODAL SHIPMENTS

15A. DESCRIPTION OF THE MARKET

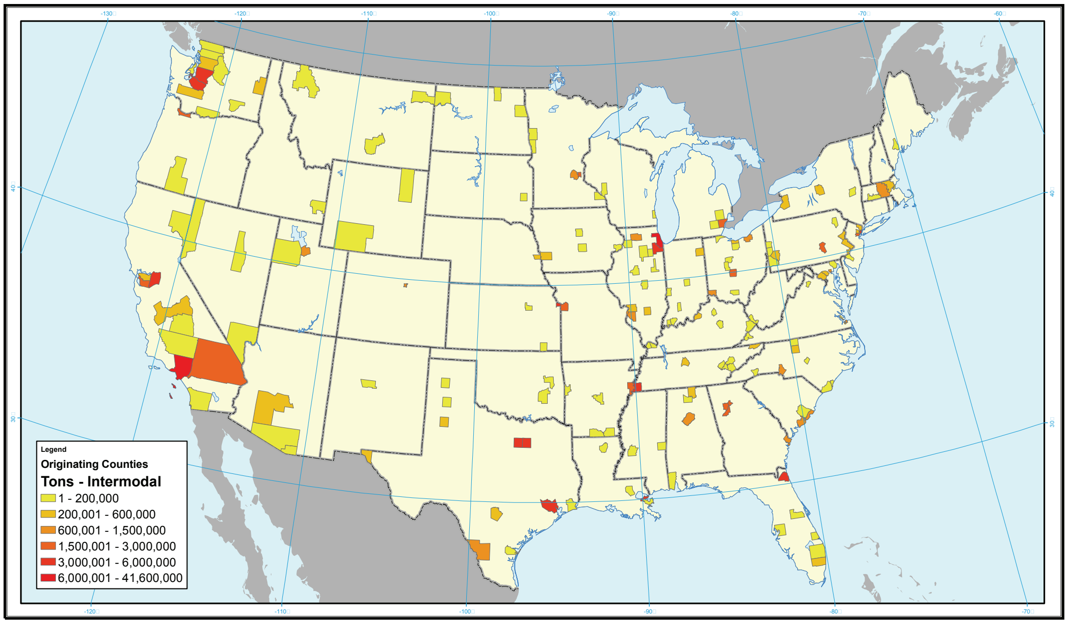
In our analysis, intermodal shipments are defined as shipments of goods loaded in standard shipping containers or in highway truck trailers that are carried on rail flat cars—respectively, container on flat car (COFC) and trailer on flat car (TOFC) movements. The final product markets for intermodal shipments are diverse. A majority of COFC and TOFC movements are recorded under 2-digit STCC 46, which designates shipments where specific commodities are unknown, not elsewhere classified, or mixed with the primary commodity group(s) unknown; our analysis also incorporates COFC and TOFC movements recorded under commodity-specific STCC codes. These shipments include containerized imported goods, the reverse flow of containerized U.S. export goods, and domestic shipments hauled partly by rail.

Railroad shipments of containers and truck trailers may compete with highway and/or water transportation alternatives. For shorter hauls, all-truck movements tend to have cost advantages over intermodal movements, despite relatively high per-mile costs for trucks, as all-truck movements avoid “drayage” costs associated with hauling the container or trailer to and from railroad terminals, as well as the costs of loading and unloading the railroad flat cars. For longer hauls, truck shipments may have more desirable service qualities despite higher costs, although railroads have developed and expanded higher-speed and scheduled services in competition with trucking. Water alternatives may include arranging oceanic shipments to ports closer to the shipments’ ultimate destinations and river barge shipments of containers, particularly for less time-sensitive shipments.

Geography of Shipments

Intermodal shipments travel between terminals generally located near ports and other population centers from which shipments are aggregated for further shipment or distributed to their final destinations. The geographic distributions of rail origins and destinations for intermodal shipments are very similar. Figure 15-1 shows the distribution of intermodal tonnage by origin county in the 2006 CWS.

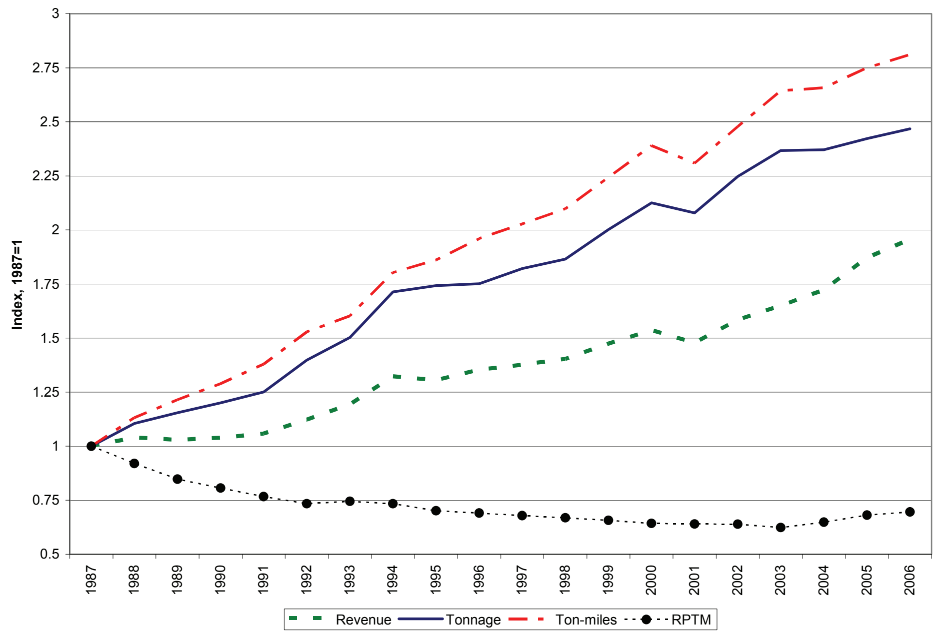
FIGURE 15-1
INTERMODAL RAIL SHIPMENTS BY ORIGIN COUNTY
2006 CARLOAD WAYBILL SAMPLE



Tonnage and Revenue Trends

Intermodal shipments are the second largest category of rail shipments in terms of revenue and ton-miles, behind coal, and the third-largest category by tonnage, after coal and chemicals. See Table 11-1. Approximately two-thirds of intermodal shipments are reported under 2-digit STCC 46; the remaining shipments are classified by commodity code. Figure 15-2 shows the trends in real revenue, tonnage, ton-miles, and real revenue per ton-mile from 1987 to 2006 according to the CWS. Revenue and RPTM are reported in constant (2000 quarter 1) dollars. Overall intermodal tonnage increased by 147 percent from 1987 to 2006, with the 2000-2001 recession corresponding to the major break in the trend of upward volumes. Ton-miles increased 181 percent on increased average length of haul. The growth rate for revenue lagged the tonnage and ton-miles growth rates, increasing 96 percent, as RPTM dropped relatively rapidly in the late 1980s and early 1990s. RPTM declined less rapidly through 2003, at which time RPTM was 62 percent of its 1987 value in real terms. RPTM then increased from 2003 to 2006, so that RPTM increased 9.4 percent over the 2001-2006 period of our pricing model analysis.

FIGURE 15-2
ANNUAL REAL REVENUE, TONNAGE, TON-MILES, AND REAL REVENUE PER TON-MILE INTERMODAL (COFC & TOFC) SHIPMENTS, 1987-2006
CARLOAD WAYBILL SAMPLE



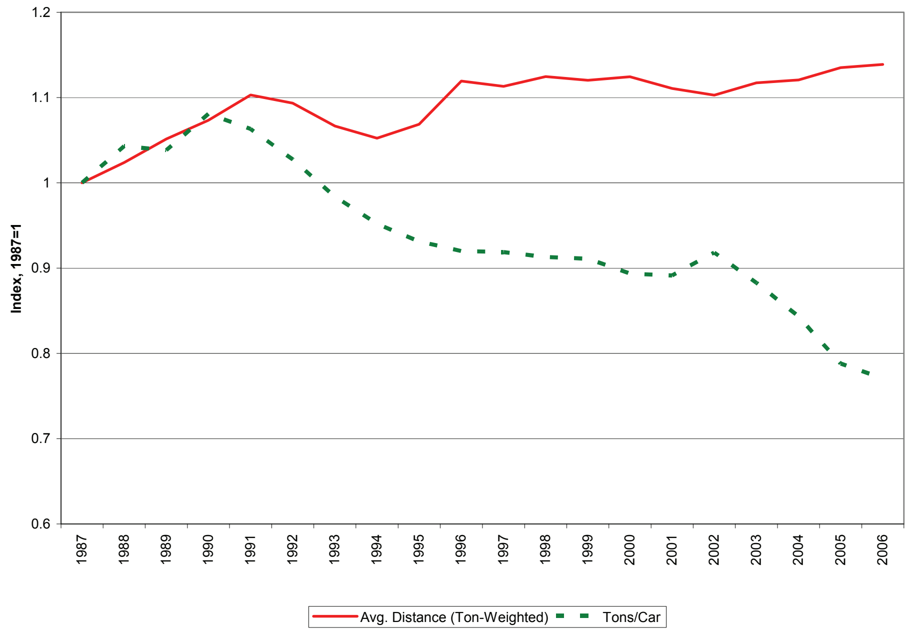
A possible contributing factor to the recent increase in RPTM is the net expansion of value-added, high-speed, and/or scheduled intermodal services by the major railroads, which we expect would be higher-priced as it is driven by retail goods. The service levels associated with those movements are not observable in the CWS, so we cannot readily control for their provision in our analysis. In the qualitative analysis phase of our study, we heard concerns expressed by railroad representatives that voluntary adoption of such higher-value services could be mistaken for rail-rate inflation.

Other Shipment Characteristics

Figure 15-3 shows trends in selected intermodal shipment characteristics from the CWS. Both tons per car and tons per waybill have declined overall, particularly from 2002 to 2006 (and from 1990 to 1995 for tons per waybill). It's possible that shipping containers moving by rail are loaded to weights at which they would exceed weight limits for trucks.[1] To the extent marginal intermodal traffic would otherwise travel over highways, the marginal loads may be lighter than average. Additionally, some products including high-valued consumer goods and parcels tend to fill containers' or trailers' cubic volumes before reaching maximum (highway) weights.

[1] Gross vehicle weight limits are generally 80,000 lb. on the Interstate Highway System.

FIGURE 15-3
SELECTED INTERMODAL (COFC &TOFC) SHIPMENT CHARACTERISTICS
INDEXES FOR AVERAGE DISTANCE AND TONS/CAR
1987-2006 CARLOAD WAYBILL SAMPLES



Intermodal shipments are billed as single-carload shipments even when shippers place multiple containers or trailers on the same train to the same destination, so we cannot observe trends in shipment size other than tons per carload. The annual averages for the tons per car measure ranged from 12.6 to 15.3 between 2001 and 2006, with a peak in 2002. Average length of haul for intermodal shipments is long—nearly 1,300 miles in 1987, and nearly 1,500 miles in 2006. Most of this increase in distance occurred between 1987 and 1996; the 2001-2006 increase was 3 percent. Additionally, the share of ton-miles in privately owned cars (with TTX cars treated as railroad-owned) increased from 61 percent in 1996 to 80 percent in 2006 (not shown). Intermodal industry statistics also show a small fraction of railroad-owned intermodal traffic, which exhibit sharp declines in railroad-owned trailer activity in 2005 and 2006.[2]

[2] See http://www.intermodal.org/statistics_files/stats11.shtml; and http://www.intermodal.org/statistics_files/stats12.shtml (accessed October 11, 2008).

15B. Pricing Analysis[3]

Cost Factors

Table 15-1 reports coefficients for shipment cost factors in the pricing equations estimated for the full 2001-2006 period (see also Chapter 11, Table 11-4) and the equations estimated using samples split into the 2001-2003 and 2004-2006 periods.[4]

Table 15-1
Cost Factor Coefficients, Intermodal Pricing Models
Full and Split Sample Periods
(t-statistics in parentheses)

Variable	2001-2006	2001-2003	2004-2006
ln MILES	-0.639	-0.583	-0.701
	(-282.32)	(-186.70)	(-216.35)
ln TONSCAR	-0.841	-0.834	-0.847
	(-1824.84)	(-1189.64)	(-1396.34)
D_OWN	0.103	0.090	0.130
	(154.20)	(84.27)	(143.43)
R-squared	0.66	0.66	0.68
N	1,817,185	811,968	1,005,217

The pricing model results show that intermodal shipment rates are lower for longer-haul shipments (higher MILES) and higher car loading (TONSCAR) in the full 2001-2006 sample period and in the 2001-2003 and 2004-2006 sample periods, consistent with our results for other commodities. The positive coefficient on D_OWN is unexpected and indicates higher rates for intermodal shipments using privately owned cars.

Tons per carload (TONSCAR) decreased 14 percent, on average, over the pricing model's 2001-2006 sample period, and the increase in length of haul (MILES) was small (3 percent). Given these characteristics, the pricing model results from the full sample period imply that the changes in the cost factors would increase the RPTM for the average 2006 shipment by 10 percent over the 2001 shipment, other things equal. The effects of observable cost factors, then, largely explain the increase in the intermodal RPTM for the 2001-2006 period (see p. 15-2, above). As we noted in Chapter 11, the unobservability of shipment size and service-

[3] See Chapter 11 for definitions of variable names appearing in the remainder of this chapter.

[4] The estimates reported in Tables 15-1 and 15-2 are from the same set of commodity-specific regressions. Thus, the R^2 statistics reported in Table 15-1 also apply to Table 15-2.

quality parameters in the CWS limits our ability to fully assess changes in cost characteristics for intermodal shipments.

Market Structure Factors

Table 15-2 reports coefficients for market structure factors in the pricing equations estimated for the full 2001-2006 period (see also Chapter 11, Table 11-5) and the equations estimated using samples split into the 2001-2003 and 2004-2006 periods.

TABLE 15-2
MARKET STRUCTURE FACTOR COEFFICIENTS, INTERMODAL PRICING MODELS
FULL AND SPLIT SAMPLE PERIODS
(t-statistics in parentheses)

Variable	2001-2006	2001-2003	2004-2006
DLM_ORG	0.011	0.023	0.004
	(6.43)	(8.75)	(1.68)
RRCOMP_ORG	0.039	0.001	0.051
	(74.75)	(0.56)	(80.75)
DLM_TER	-0.034	0.044	-0.063
	(-16.90)	(14.16)	(-23.77)
RRCOMP_TER	-0.013	-0.027	-0.005
	(-18.38)	(-25.36)	(-5.31)
ln KMWATER_ORG	0.024	0.023	0.022
	(67.71)	(45.49)	(45.22)
ln KMWATER_TER	0.045	0.046	0.044
	(130.13)	(90.05)	(91.76)

These pricing model results show a number of counterintuitive coefficient estimates for railroad competition factors. In particular, we observe positive coefficients on RRCOMP_ORG in all three sample periods (though small and statistically insignificant for the 2001-2003 period), suggesting that increased railroad competition at the origin increases RPTM, other things equal. However, we observe negative effects on RPTM from increased railroad competition at the termination county (RRCOMP_TER), as we would expect. The effects for a single railroad serving the origin county (DLM_ORG) are positive, while the effects for a single railroad serving the termination county (DLM_TER) vary in sign and magnitude across the three sample periods. The coefficients on the water competition variables are positive, as expected (increased distance to water facilities relaxes the water competition constraint on rail rates), and the termination-county effects are larger than the origin-county effects.

To aid in interpreting these results for the market structure, we calculate shift factors indicating the estimated effects of the coefficients from Table 15-2 on rates using the formulas described in Chapter 12.

Table 15-3 shows the rate-shift factors for rail competition at origin for several values of RRCOMP_ORG.

TABLE 15-3
ESTIMATED RAILROAD COMPETITION EFFECTS AT ORIGIN
INTERMODAL SHIPMENTS

RRCOMP_ORG	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00
1.05	0.99	0.98	1.00
1.50	1.01	0.98	1.02
1.75	1.02	0.98	1.04
2.00	1.03	0.98	1.05
2.50	1.05	0.98	1.08
3.00	1.07	0.98	1.10
4.00	1.11	0.98	1.16

In general, RPTM does not respond very strongly to changes in railroad competition at the origin over low values of the number of effective competitors. In the full and the 2004-2006 periods, the model predicts RPTM increases of 3 percent and 5 percent, respectively, when RRCOMP_ORG increases from 1 to 2. We note that the average value of RRCOMP_ORG is approximately 2.5. As RRCOMP_ORG increases from 2 to 3, the positive coefficients on RRCOMP_ORG in the full and the 2004-2006 sample periods are associated with further increases in RPTM.

These results may indicate that increased railroad competition for intermodal shipments is directed into costly but unmeasured service characteristics, that costs increase due to congestion in areas served by a larger number of railroads (busy ports, major points of interchange between railroads), or a combination of factors. Increases in container traffic have led to congestion issues on some major intermodal routes, and indications that capacity constraints may have played a role include major capacity expansion projects launched during our sample period for intermodal corridors such as the BNSF Southern Transcon and the UP Sunset Route.

Table 15-4 shows the estimated effects of railroad competition at the termination county. The rate effects at low values for RRCOMP_TER vary across the periods, as the sign of the coefficient on DLM_TER is positive in the 2001-2003 period, indicating higher RPTM in counties with one serving railroad, but negative in the 2001-2006 and 2004-2006 periods. However, the marginal effects of adding competitors are uniformly negative across the sample periods, so the shift factor declines for values of RRCOMP_TER greater than 1.05. The implied reductions in RPTM range from 1 to 2 percent when RRCOMP_TER increases from 2 to 3.

TABLE 15-4
ESTIMATED RAILROAD COMPETITION EFFECTS AT TERMINATION
INTERMODAL SHIPMENTS

RRCOMP_TER	2001-2006	2001-2003	2004-2006
1.00	1.00	1.00	1.00
1.05	1.03	0.96	1.06
1.50	1.03	0.94	1.06
1.75	1.02	0.94	1.06
2.00	1.02	0.93	1.06
2.50	1.01	0.92	1.06
3.00	1.01	0.91	1.05
4.00	1.00	0.88	1.05

Tables 15-5 and 15-6 show the estimated effects of proximity to water transportation on intermodal RPTM. Both the origin and termination county water competition effects are strong and consistent across the sample periods. We heard in our stakeholder interviews that container ships' destinations could be chosen to minimize rates for the subsequent rail shipment legs, effectively putting railroads serving different ports in competition with each other. We would expect a railroad's intermodal market power to be at its zenith for long-haul shipments involving (and especially between) interior cities, where highway freight is at a cost, if not a cost and service, disadvantage, and where the substitutability of water transportation is limited.

TABLE 15-5
ESTIMATED WATER COMPETITION EFFECTS AT ORIGIN
INTERMODAL SHIPMENTS

Distance to Water (miles)	2001-2006	2001-2003	2004-2006
1	1.00	1.00	1.00
50	1.10	1.09	1.09
100	1.12	1.11	1.10
500	1.16	1.15	1.14

TABLE 15-6
ESTIMATED WATER COMPETITION EFFECTS AT TERMINATION
INTERMODAL SHIPMENTS

Distance to Water (miles)	2001-2006	2001-2003	2004-2006
1	1.00	1.00	1.00
50	1.19	1.19	1.19
100	1.23	1.23	1.22
500	1.33	1.33	1.31

Inferences for Competition

We find that rail rates for intermodal shipments are responsive to observable cost shifters, with the exception of the car ownership indicator, but do not show consistent patterns of behavior with respect to railroad competition indicators. While the effect of adding railroad competition at origin has the “wrong sign” in some of the reduced-form models (particularly in the 2004-2006 sample period), we observe that the “perverse” effects are not very large in the vicinity of the sample mean for railroad concentration. However, water transportation constraints on railroad pricing appear to be strong, and the results are consistent with information from our qualitative research on shippers’ behavior in seeking out low rates by choice of port facilities.

The instability of the effects of the “market structure” factors in the pricing models mirrors underlying changes in railroads’ provision of intermodal services and the competitive environment. However, the lack of data on intermodal shipments’ cost and service characteristics limits our ability to model important factors for intermodal pricing, raising the likelihood that the unstable results stem from confounding effects of unmeasured factors on measurable effects. The 2001-2006 period covered by our pricing models was marked by changes in intermodal service offerings and capacity expansion programs on major intermodal corridors—the latter presumably responding to increasingly binding capacity constraints on those routes. However, analysis of waybill rates for intermodal shipments is limited by the lack of commodity information for most shipments as well as the absence of reliable indicators of service characteristics in the waybill data.

We expressed concern in Chapter 11 that some low-cost features of intermodal shipments are not observable in the CWS data. Thus we do not put any weight on the negative measured *level* of the intermodal LMIs. However, given the evidence of water competition constraints and the cost advantages enjoyed by all-truck movements for shorter lengths of haul, it is likely that the railroad industry’s pricing power is limited by competition from other modes.

Chapter 16 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 16.
ANALYSIS OF RAILROAD CAPACITY

INTRODUCTION

Issues concerning competition, rates, and service quality are intrinsically interrelated. In our stakeholder interviews, some expressed the opinion that railroads could manipulate their capacity to create artificial shortages, thereby enabling the railroads to increase rates to shippers. Whether railroad capacity is manipulated, capacity constraints can significantly impact railroad rates and terms of service. In instances where capacity is constrained, prices serve as a rationing mechanism that cuts demand to meet capacity supply. When excess capacity exists, rate reductions and discounts can be used to increase capacity utilization.

Through our stakeholder interviews and independent background research conducted in the qualitative research phase of this project, we determined that railroad capacity can be generally thought of as anything that affects a railroad's ability to transport volumes (in a given amount of time) over its network.[1] The physical factors that affect a railroad's ability to transport volumes generally depend on the amount of capital and labor employed by the railroad. Railroad capital includes way and structures, locomotives, railcars, signaling, and other information systems. Railroad labor consists of workers possessing various skill levels and other characteristics such as union status. The amount of capacity available from a given quantity of production inputs (i.e., productivity) will be affected by factors such as technological innovations (often embodied in capital), work rules and other regulations, railroad operating practices, and learning by doing.[2] The ability to adjust capacity depends on the ability to adjust these various types of capital and labor inputs and other attributes, with some more easily adjusted than others.

A very important influence on railroad capacity is the existence of congestion at points in the network. While congestion can occur on mainline segments that are heavily utilized, it often occurs in terminal areas, highly crowded urban areas, ports, and other transloading facilities. In fact, while other measures of capacity along a given route may indicate sufficient capacity

[1] This could be refined by looking at particular network segments or origin-destination pairs.

[2] As discussed below, in a cost function framework, capacity utilization has been defined in terms of the marginal product of capital relative to its price. When the marginal product of capital is higher than its price, then there is a capacity shortage. When the marginal product of capital is lower than its price, there is a capacity surplus. Thus capacity utilization is a function of market variables.

to meet demand, a feature common to most network industries is that congestion at terminals or other specific network locations can often become a binding constraint on the utilization of route capacity.[3] This is similar to the effects of blocking or congestion that occurs in communications or data networks when limited switch or router capacity creates a restriction in network throughput despite the existence of virtually unlimited fiber optic capacity.

We begin this chapter with a summary of comments submitted in the STB's 2007 capacity and infrastructure proceeding in order to provide an overview of industry stakeholders' opinions on important issues regarding railroad capacity and infrastructure. Next, we discuss a number of descriptive measures of railroad capacity including miles of track, terminal dwell time, rail fleet statistics, railroad expenditures, and train speed. We then turn to modeling approaches applied to evaluating railroad capacity and its utilization, transportation systems flow modeling, and econometric analysis.

16A. Summary of the STB's Ex Parte 671, Rail Capacity and Infrastructure Requirements

In April 2007, the STB held a public hearing to "examine issues related to rail traffic forecasts and infrastructure requirements."[4] In addition to the public hearing in which interested parties participated, numerous written comments were submitted to the STB. We provide a brief summary outline of these comments here to highlight key issues of concern related to railroad capacity and infrastructure. This is not meant to be an exhaustive summary of Ex Parte 671.[5] It should be noted that a number of these issues were also expressed to us in our stakeholder feedback process (see Chapter 5).

- Investment in capacity and infrastructure can be broken into three components:
    - Investment in technology to improve productivity and efficiency of current infrastructure. (Examples include wayside detectors, acoustic detector systems, track geometry cars, heavy-axle load services, software such as SmartYard® which aims to improve rail yard operational efficiency, trip planning systems, electronically controlled braking systems, etc.)

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[3] James McClellan, "Railroad Capacity Issues," in *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007, p. 32.

[4] Surface Transportation Board Notice, Ex Parte 671, Rail Capacity and Infrastructure Requirements, March 6, 2007.

[5] Surface Transportation Board, Ex Parte No. 671, complete set of filings can be found at http://www.stb.dot.gov/FILINGS/all.nsf/(Personal-216.170.165.28)?OpenView&Count=300.

  - Repairs, maintenance, and replacement of current infrastructure. (Examples include general maintenance as well as replacement of infrastructure at the end of its useful life such as a wooden bridge.)
  - Investment in new infrastructure. (Examples include new track, new signals, new locomotives, additional personnel, etc.)

- Respondents indicate that all three components of investments are needed to achieve necessary capacity.
- One rail carrier suggested that investment in maintenance/repairs and technology to improve the productivity of the current network should come before investment in new infrastructure.
- Most respondents perceived that railroad capacity currently is constrained, leading to a fragile network.
  - For example, one small disturbance in the network, such as bad weather or a derailment, causes major and persistent delays in the whole network. As a second example, some respondents indicated that due to the increased congestion of the railways, average train velocity is down compared to 20 years ago, resulting in slower turn times, etc.
  - Most respondents also believe that capacity shortages will only get worse in the coming years, as demand for rail services increases substantially due to increased energy demand (coal and corn for ethanol) and increased import of consumer goods (intermodal).
  - A few respondents suggested that capacity constraints are either intentionally maintained or manufactured by the rail carriers as an excuse to raise rates.
  - At least one respondent indicated that network tightness may be due, at least in part, to management/operational decisions.
  - Most respondents agree/acknowledge that rail carriers are investing heavily in infrastructure improvements (technology, maintenance, and new infrastructure), but that this investment will not be sufficient to meet growing demand in the future.
- The drivers of demand growth were discussed.
  - One of the major drivers of growth in demand for rail services has been strong growth in intermodal traffic/use.
  - Several respondents expressed concern that the discussion on capacity was too narrowly focused on the needs of intermodal traffic (as it is fast growing and highly profitable).
  - Another major driver of demand growth is increased energy demand, which leads to greater demand for coal and corn/ethanol.

(Though this was typically cited as being a lesser contributor to growth, both recent and future, than intermodal traffic.)

- Most respondents (railroads and shippers alike) acknowledged that railroads have been investing at high levels in infrastructure maintenance and expansion over the past several years. In measuring investment as a percentage of revenues, the railroad industry has one of the highest levels of re-investment in capital, among all U.S. industries, at about 17 percent of revenues.
    - However, one respondent indicated that much of this investment might be going toward maintenance of the current system and that increasing expenditure levels may be deceptive in that they reflect, in part, increasing land and materials costs, rather than an increase in infrastructure projects.
    - Railroads and the AAR stressed the need for long-term revenue adequacy in order to invest sufficiently in infrastructure expansion and improvements. These respondents indicated that railroads are finally approaching/reaching revenue adequacy, but that calls for rate (earnings) restrictions and re-regulation of the industry would limit the railroads' ability to invest in infrastructure. Rate increases may be necessary to allow railroads to recover their capital costs of these infrastructure investments.
    - Several railroads (and the AAR) indicated that shippers want capacity increases (and want capacity sufficient to meet peak demand, or at "just in case" levels) but are not willing to pay for it. Some of these respondents indicated that this is an unrealistic expectation.
        - One railroad also pointed out that rail carriers must balance the needs of different types of customers with differing priorities. Their investments must reflect this diversity of their customer base. Railroads stress that, as one rail carrier put it, "capacity expansion projects must generate returns sufficient to justify the investment."
    - Some shippers stated the concern that captive shippers might bear the financial burden (through increased rates) of railroad infrastructure investments that do not benefit them directly. In response to these concerns, some railroads indicated that specific network improvements benefit general network fluidity and stability, therefore benefitting all rail users, not just those using the improved or added routes.
- Shippers expressed concerns about the railroads' cost recovery methods.
    - Some shippers worried that the need for infrastructure investment may cause abuses of market power in the industry to go overlooked. One respondent stated, "It would be unfortunate if current concerns

about rail capacity and infrastructure were to increase the Board's tendency to protect the railroads from the consequences of competing in the real world."

- Shippers had concerns about cross-subsidization. Several respondents expressed concerns that captive shippers would end up paying the price for capacity expansion that would primarily benefit intermodal traffic, but would not improve their own service or improve the capacity issues that apply to their areas/routes (either entirely or at least differentially).

- Many captive shippers feel that they are already subject to differential pricing. These shippers are concerned that they may be charged still higher rates, and they indicate that current regulations make it difficult to challenge excessive rail rates. Many of these shippers, especially coal shippers, indicate that they have already invested substantially in railroad infrastructure both directly (for example, by investing in tracks and handling stations) as well as indirectly through their high rates.

- Some respondents commented on the public benefit of rail use and expansion rather than highway use and expansion. They noted the following:
  - Environmental benefit (less pollution compared to highways)
  - Safety (compared to highway/truck freight)
  - Reduced highway congestion
  - Fuel efficiency (which has public benefits through cost reductions and the environment)
  - Some respondents also indicated that the public benefits of rail use also justify the tax credit for infrastructure investment.

- Respondents made several comments concerning public-private partnerships.
  - Railroads and shippers alike generally supported the concept of public-private partnerships. Respondents stressed that public funding should be in proportion with public benefits and private funding should be in proportion with private benefits.
  - Several respondents indicated that public-private partnerships would help fund projects benefitting a number of different groups (but for which no single group would have the financial means or incentive to implement the project on its own).
  - One railroad suggested three criteria for public-private partnerships. First, they "should be used only where there is a mix of public and private benefits from a project… Second, the cost of public funding should be proportionate to the public benefits produced. Third, public funding for such projects should not provide a competitive benefit for one rail carrier over another."

- One responded pointed out that rail is the only major transportation network in the country that receives little or no government funding/subsidies. Several respondents suggested that public-private partnerships would increase government funding of rail infrastructure over highways, which would benefit the public in a number of ways.

- Many respondents suggested that the Board require better reporting of data on railroad capacity and demand (and that in doing so, the Board might consider developing standardized measures and definitions related to capacity). Some suggested an annual State of the Industry Report to Congress.

In summary, the comments elicited through the STB proceeding illustrate that capacity issues and the ability of railroads to accommodate current and future demand for their services are major concerns for both railroads and shippers. In the remainder of this chapter, we investigate railroad capacity and evaluate the extent of capacity constraints in U.S. railroad networks.

16B. Descriptive Measures of Railroad Capacity

Miles of Track

One indicator of railroad capacity is provided by the miles of track information found in the R-1 annual reports filed by the Class I railroads.[6] While the R-1 miles of track data can provide an assessment of capacity at an aggregate level, it does not provide information on a more disaggregate basis such as route- or corridor-specific data. Table 16-1 reports changes in the total miles of track and several track categories found in R-1 Schedule 700, Line 57. The track categories reported in this table are miles of road (main track (road)); miles of second main track and all other main track (second and other main); miles of passing track, crossovers, and turnouts; miles of way switching track; and miles of yard switching track. For the industry composite, changes are reported over the 1987-1999 and 1999-2006 periods. We report individual railroad data for the 1999-2006 period, which is after the conclusion of major merger activity.[7]

Focusing on individual railroads, the growth in second and other mainline track by Western railroads (BNSF, KCS, and UP) is noteworthy because this growth represents expansion of overall capacity inasmuch as

[6] R-1 Annual Reports, Schedule 700, Line 57.

[7] The data for CN contained a number of irregularities, and therefore it is not included in Table 16-1.

duplicative track on the same right of way allows bidirectional running or simultaneously running multiple trains in a single direction.

TABLE 16-1
CHANGES IN CLASS I MILES OF TRACK
1987-2006

	Total Miles of Track	Main Track (Road)	Second and Other Main	Total Main	Passing, Crossovers, Turnouts	Way Switching	Yard Switching
Industry-wide							
1987-1999	-19.9%	-17.9%	-4.0%	-16.1%	-24.2%	-32.6%	-27.2%
1999-2006	-1.7%	-1.1%	6.6%	0.1%	-20.9%	-22.8%	8.8%
Individual Railroads, 1999-2006							
BNSF	-2.8%	-4.1%	6.2%	-2.8%	-1.3%	-4.6%	-2.5%
CP	-3.3%	0.2%	0.0%	0.2%	-13.1%	-12.0%	-14.9%
CSX	-8.6%	-9.6%	0.0%	-7.8%	-64.0%	-73.0%	31.8%
KCS	13.0%	15.2%	25.0%	15.3%	7.1%	-12.9%	18.3%
NS	-1.9%	-3.0%	-0.1%	-2.4%	-1.1%	-1.4%	-0.4%
UP	-6.2%	-3.0%	18.5%	-0.1%	-30.1%	-43.1%	-0.3%

Figure 16-1 charts the 1987-2006 Class I data for total and mainline miles (including second and other mainline miles) of track for the industry. Consistent with the growth rates in Table 16-1, it can be seen that there was a decline in both total and mainline miles until the mid-1990s and both series have been relatively flat since then.

FIGURE 16-1
CLASS I MILES OF TRACK
1987-2006

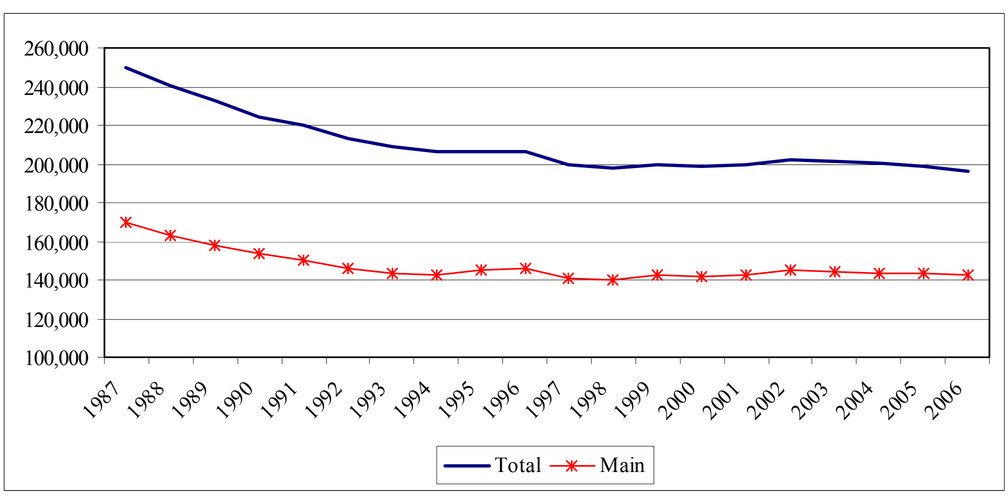
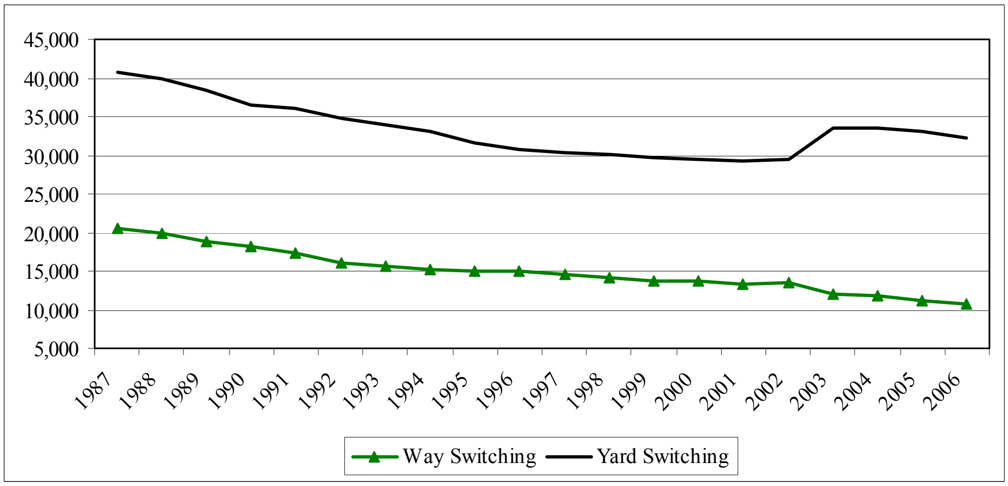


Figure 16-2 charts the Class I data for way switching and yard switching track miles from 1987-2006. Way switching miles have steadily declined over this period, while the decline in yard switching miles halted in the early 2000s, and then experienced an increase in the 2002-2003 period.

FIGURE 16-2
CLASS I MILES OF SWITCHING TRACK
1987-2006



While total Class I miles of track have declined, usage of that track has intensified as revenue ton-miles have grown continuously over the study time period. Between 1987 and 1999, Class I net ton-miles grew by 51.5 percent, compared to the 19.9 percent decline in total track miles. Between 1999 and 2006, Class I net ton-miles grew by 23.1 percent, compared to the 1.7 percent decline in total track miles.[8] The increasingly intensive use of Class I track miles is illustrated in Figure 16-3, which charts the ratio of net ton-miles to total track miles.

Track statistics for the Class I railroads do not give a complete picture of capacity as measured by miles of road or miles of track. Regional and shortline railroads own and/or operate an increasing proportion of the nation's railroad infrastructure. Overall, both total miles of road owned and miles of road operated by various railroads have fallen between 1987 and 2006. However, both have fallen more sharply for Class I railroads than for other railroads. Table 16-2 shows that, between 1987 and 2006, miles of track operated declined by 18.9 percent for Class I railroads versus increases for all other U.S. railroads. Similarly, miles of track owned declined by 26.8 percent

[8] Net ton-mile data are from R-1 Annual Reports, Schedule 755, Line 114, Column B.

for Class I railroads versus a much smaller decline for regional railroads and increases for all other U.S. railroads over this period.[9]

FIGURE 16-3
RATIO OF NET TON-MILES TO TOTAL TRACK MILES
1987-2006

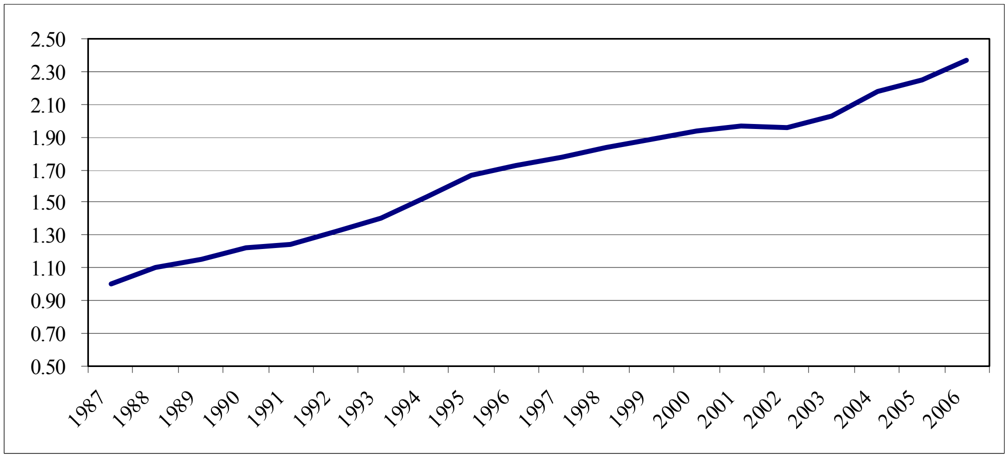


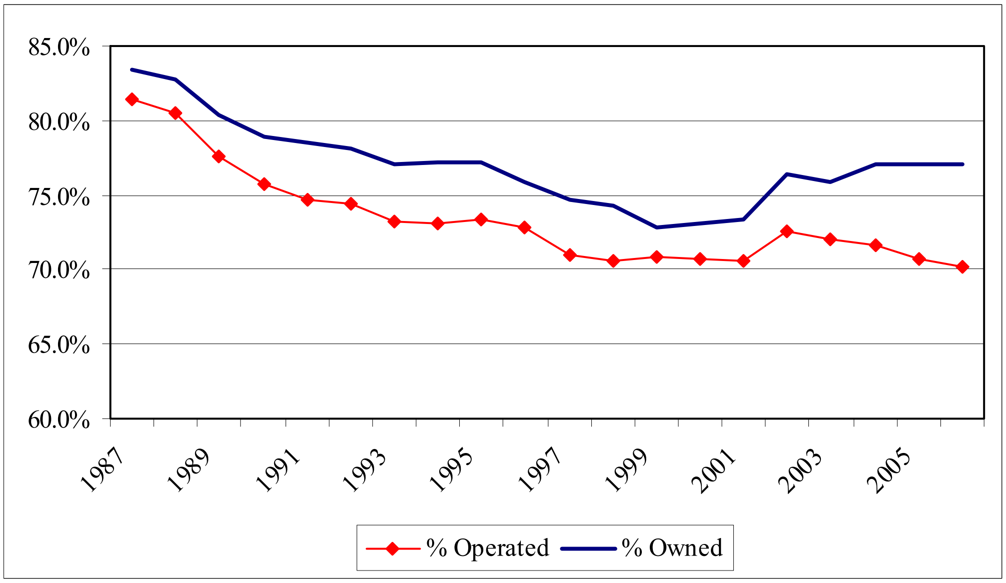
TABLE 16-2
CHANGES IN MILES OF TRACK OPERATED AND OWNED BY U.S. RAILROADS
1987-2006

	Class I	Regional	Linehaul	Switching and Terminal	Total
Miles Operated	-18.9%	30.5%	62.6%	88.1%	-5.9%
Miles Owned	-26.8%	-7.7%	23.4%	29.9%	-20.9%

The data in Table 16-2 indicate that the proportion of total miles owned and operated by Class I railroads has declined. Figure 16-4 shows that the decline has been greater for the proportion of miles operated, reflecting spinoffs of Class I-owned trackage to other operators.

[9] Railroad Ten-Year Trends, various editions, published by the Association of American Railroads, Policy and Economics Department. These values do not include Canadian railroads with U.S. operations.

FIGURE 16-4
CLASS I PROPORTION OF U.S. RAILROAD MILES OF TRACK OWNED AND OPERATED
1987-2006



Terminal Dwell Time

The time railcars spend in terminals (terminal dwell time) can be considered an indicator of numerous dimensions of railroad operations. It can be thought of as a measure of capacity, a reflection of railroad operational efficiency, a contributor to performance and customer satisfaction, and a symptom of capacity constraints or network congestion. With respect to capacity or congestion, it may be the case that there is sufficient mainline capacity, but congestion at terminals creates a slowdown in railroad performance. Or increased terminal dwell time may be symptomatic of congestion elsewhere in the network.

The Railroad Performance Measures (RPM) data consist of weekly reported data by each Class I railroad for terminal dwell time, average train speed, and cars on line.[10] The RPM terminal dwell time data can be used to

[10] Association of American Railroads, at http://www.railroadpm.org/. We analyze the average train speed data found in RPM in Chapter 17.

help identify congestion points.[11] The RPM data are available back to 1999. In October 2005, standardized definitions were adopted and, therefore, pre-October 2005 data are not directly comparable to post-October 2005 data:

> Effective October 1, 2005, the railroads began applying a new, standardized definitional framework to produce the performance data reported on this Web site, eliminating the differences resulting from the calculation methodology. Where possible, data back to January 1, 2005, have been restated on the new basis.[12]

Because of the definitional changes, we present the RPM data for two time periods: January 1999 through September 2005 (Period 1), and October 2005 through December 2007 (Period 2). Furthermore, direct comparisons among railroads are not necessarily meaningful:

> Despite the use of a common methodology, one railroad's performance metrics cannot meaningfully be compared to another railroad's, due to differences including, but not limited to, those associated with network terrain and design characteristics, traffic mix, traffic volume, length of haul, extent of passenger operations, and operational practices — as well as external factors such as weather and port operations which can impact carriers differently.[13]

Table 16-3 presents the average terminal dwell time, its standard deviation, and its coefficient of variation by year, 1999 through 2007, for each Class I railroad. As mentioned above, because of definitional changes the data in Period 2 is not directly comparable to the dwell time data for Period 1. Furthermore, the 2005 values reported are for January 2005 through September

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[11] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

> Terminal Dwell is the average time a car resides at the specified terminal location expressed in hours. The measurement begins with a customer release, received interchange, or train arrival event and ends with a customer placement (actual or constructive), delivered or offered in interchange, or train departure event. Cars that move through a terminal on a run-through train are excluded, as are stored, bad ordered, and maintenance of way cars.

However, the RPM dwell time data is limited in a number of respects. For example, it does not indicate the source of dwell time changes (e.g., shipper or railroad actions), nor does it distinguish cars that are being reclassified for continuation of their trip to their ultimate destination from cars that have reached their destination.

[12] Association of American Railroads, at http://www.railroadpm.org/.

[13] Association of American Railroads, at http://www.railroadpm.org/.

2005. However, except for BNSF, an inspection of the coefficients of variation[14] does indicate that the standard deviation of dwell times was generally lower in Period 2. Because of the shortness of Period 2 and the behavior of the Period 1 data, our analysis focuses on the Period 1 dwell time data.

TABLE 16-3
TERMINAL DWELL TIME BY YEAR
1999-2007

Average	BNSF	CN	CP	CSX	KCS	NS	UP
1999	24.87	22.27	25.86	36.19	24.49	32.12	32.96
2000	25.54	17.53	26.28	33.33	23.83	30.03	32.34
2001	26.37	13.47	26.49	29.19	24.25	27.82	31.17
2002	26.73	12.13	26.34	27.81	26.23	24.90	29.45
2003	29.18	12.90	28.81	30.17	24.03	25.99	31.02
2004	29.77	16.10	33.84	35.23	25.76	26.41	35.13
2005*	24.06	13.35	26.99	29.75	24.30	23.35	28.43
2006	23.92	11.99	20.78	25.14	22.92	22.42	27.21
2007	24.28	12.47	22.33	23.30	23.12	21.83	25.18

Std Dev	BNSF	CN	CP	CSX	KCS	NS	UP
1999	1.68	5.84	2.27	4.71	2.30	4.26	3.01
2000	2.01	3.59	2.88	4.73	2.80	2.80	2.48
2001	1.30	1.97	2.24	3.39	3.11	2.58	2.31
2002	1.87	0.83	2.43	3.29	4.09	2.28	2.72
2003	1.20	1.74	2.38	1.94	1.95	1.98	2.37
2004	1.54	1.62	3.97	3.65	2.48	2.49	2.33
2005*	1.11	1.09	3.85	2.35	1.73	1.51	1.57
2006	0.97	0.61	1.42	1.37	2.48	1.71	1.71
2007	0.96	1.58	2.52	1.82	1.80	1.61	1.33

CV	BNSF	CN	CP	CSX	KCS	NS	UP
1999	6.8%	26.2%	8.8%	13.0%	9.4%	13.3%	9.1%
2000	7.9%	20.5%	11.0%	14.2%	11.7%	9.3%	7.7%
2001	4.9%	14.6%	8.4%	11.6%	12.8%	9.3%	7.4%
2002	7.0%	6.8%	9.2%	11.8%	15.6%	9.1%	9.2%
2003	4.1%	13.5%	8.3%	6.4%	8.1%	7.6%	7.6%
2004	5.2%	10.1%	11.7%	10.4%	9.6%	9.4%	6.6%
2005*	4.6%	8.2%	14.3%	7.9%	7.1%	6.5%	5.5%
2006	4.0%	5.1%	6.8%	5.5%	10.8%	7.6%	6.3%
2007	3.9%	12.7%	11.3%	7.8%	7.8%	7.4%	5.3%

(*Statistics for 2005 only cover the months of January through September.)

[14] The coefficient of variation is defined as the ratio of the standard deviation to the average, expressed as a percent.

Analysis of Period 1 Terminal Dwell Time

Figures 16-5 through 16-11 chart the weekly Period 1 terminal dwell time data for each railroad (solid line), as well as the three-month moving averages (3MMA, dashed line).[15] While each railroad has a somewhat unique pattern, one thing that does stand out is a general increase in terminal dwell time in the 2003-2004 period, followed by a decline in 2005. Note that, particularly in the weekly series, there are regular spikes in dwell time that are indicative of seasonal factors.

Figure 16-5 shows that BNSF had an upward trend in its overall terminal dwell time that peaked in August 2004. BNSF's terminal dwell time declined significantly thereafter, reaching a trough in June 2005.

FIGURE 16-5
BNSF TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)

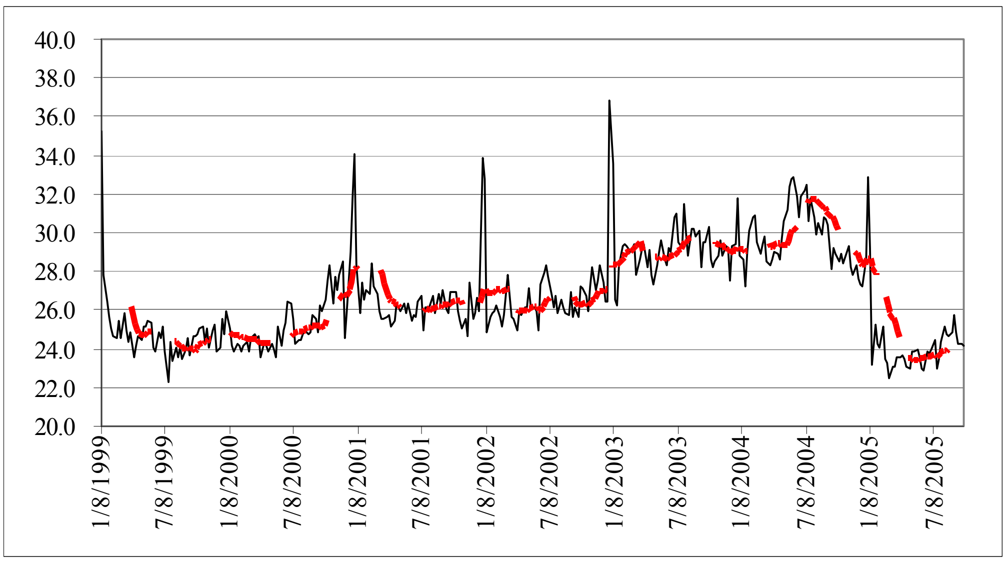


Figure 16-6 shows that CN's overall terminal dwell time reached a trough in September 2000, peaked in January 2001 and had an extended trough through 2003. It had a mild peak in September 2004 and generally declined thereafter.

[15] Appendix 16-A contains Period 2 charts for each railroad.

FIGURE 16-6
CN TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)

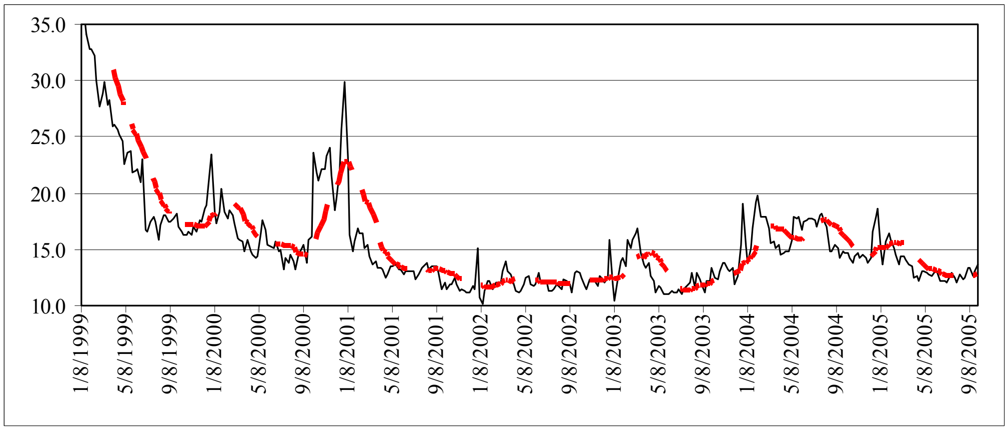


Figure 16-7 shows that CP's overall terminal dwell time was relatively stable through approximately September 2003 and then began to increase. It reached a peak at the end of 2004 and declined significantly thereafter, reaching a trough in the summer of 2005.

FIGURE 16-7
CP TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)

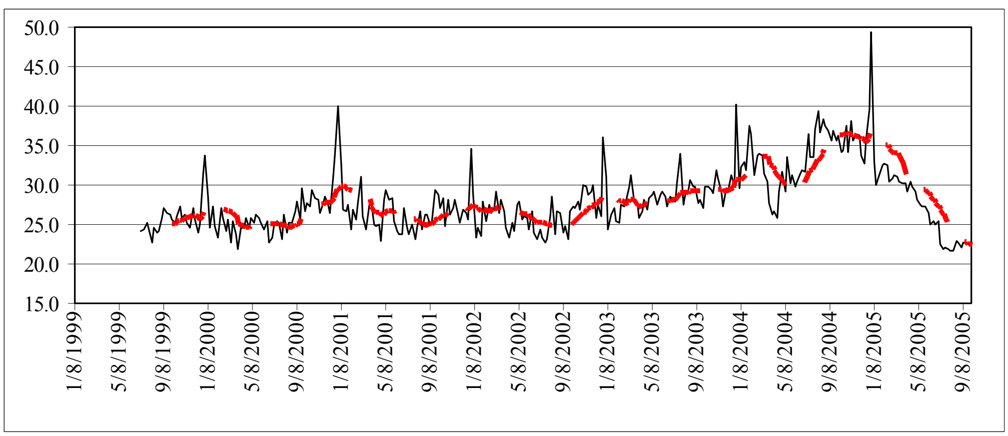


Figure 16-8 shows that CSX's overall terminal dwell time declined from its January 2000 peak and had a long trough from about April 2001 through January 2003. It subsequently increased and reached a peak in July 2004. It began declining at the beginning of 2005, and reached a trough in the summer of 2005.

FIGURE 16-8
CSX TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)

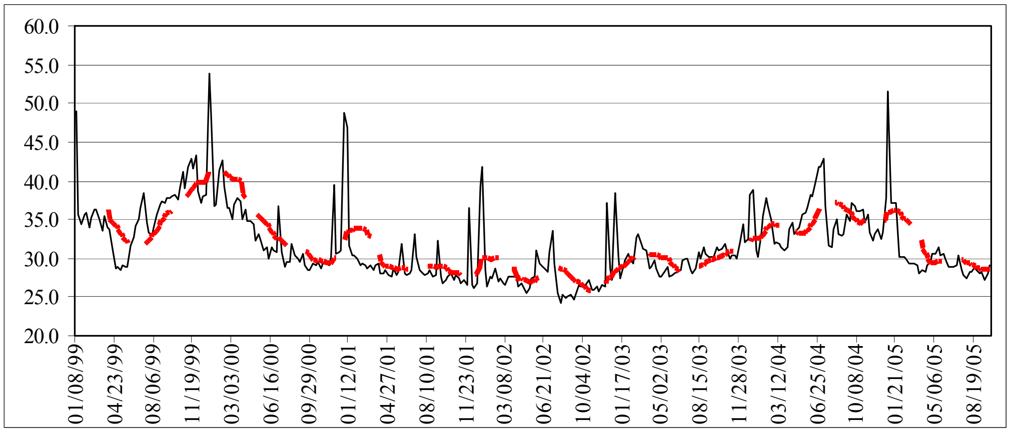


Figure 16-9 shows multiple peaks and troughs in KCS's overall terminal dwell time during Period 1. It had an extended trough from early 2003 through the summer of 2004. It peaked at the end of 2004 and quickly reached a trough in early 2005. It appears to have begun increasing again in August 2005.

FIGURE 16-9
KCS TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)

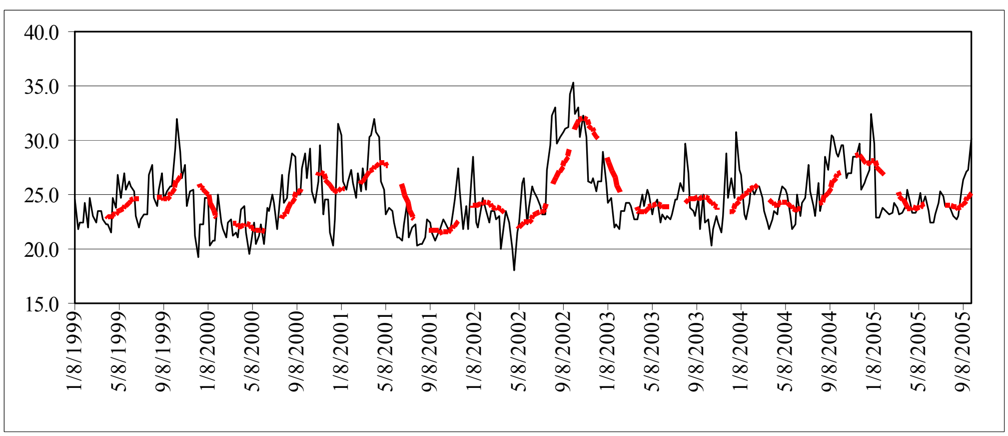


Figure 16-10 shows a generally declining trend in NS's terminal dwell time (with multiple peaks and troughs) until the summer of 2002. Thereafter, the trend appears to be generally flat with some peaks and troughs. The last peak occurred in January 2005 with a decline beginning in the spring of 2005.

FIGURE 16-10
NS TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)

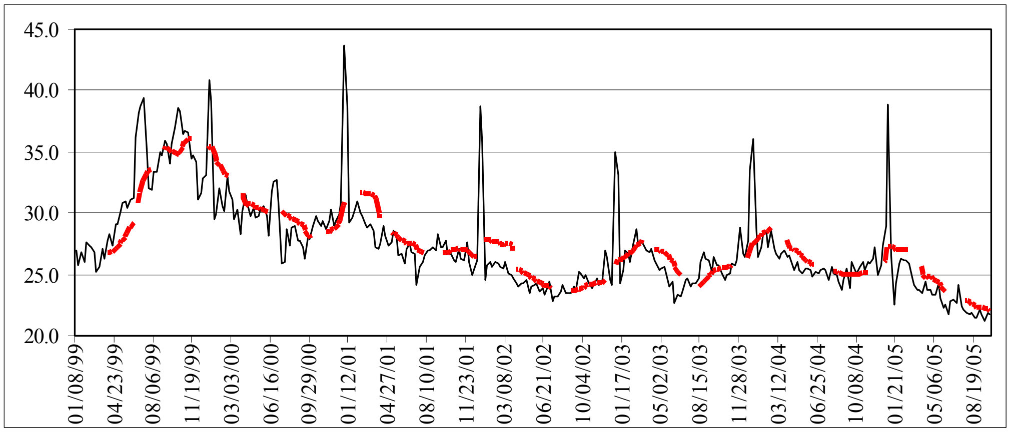
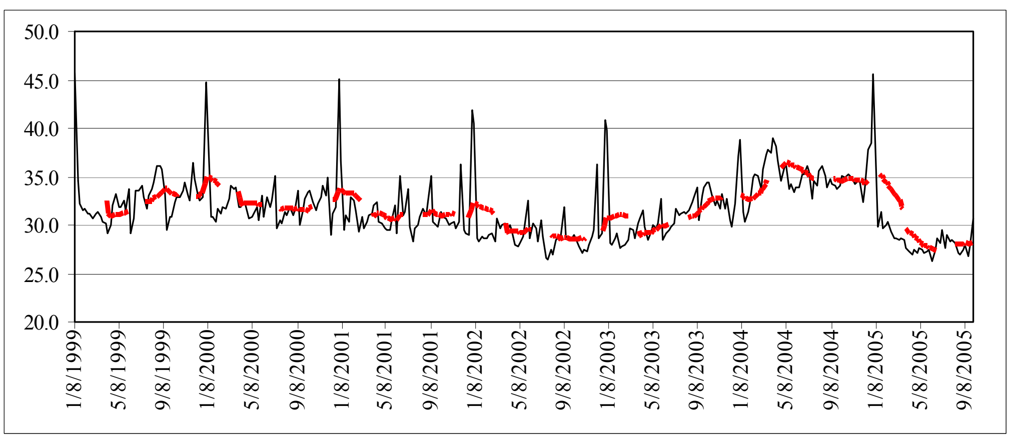


Figure 16-11 shows that UP's overall terminal dwell time generally declined between early 2000 and the end of 2002. It began increasing in April 2003 and reached a peak in May 2004. It remained in this peak range until January 2005, after which it declined significantly until reaching a trough in May 2005.

FIGURE 16-11
UP TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005 (WEEKLY AND 3MMA)



In summary, although each railroad has its own unique pattern, one common theme is a general increase in terminal dwell time in the 2003-2004 time period, followed by sizeable declines in early 2005. Moreover, the patterns of the large Western railroads (BNSF and UP) exhibit similarities during the 2003-2005 period, increasing through mid-to late-2004 and generally declining before bottoming out in mid-2005. Regarding the large Eastern railroads, CSX has a similar pattern in the 2003-2005 period. While NS does decline throughout 2005, its pattern prior to that is more of a series of peaks and troughs. We investigate the patterns of these four major Class I railroads more fully with an examination of terminal dwell times for the individual terminals of these railroads.

Analysis of Period 1 Terminal Dwell Times for Individual Terminals – January 1999 to September 2005

Tables 16-4 through 16-7 show average terminal dwell times by terminal for BNSF, CSX, NS, and UP for the January 1999 through September 2005 time period. Each table is sorted by average terminal dwell time in descending order. Standard deviations, coefficients of variation, and maximum dwell times are also displayed.

Table 16-4 shows that the BNSF terminals having the highest average dwell times over the entire period are Northtown, Barstow, Lincoln, and Argentine. These terminals also have the highest dwell times during the 2003-2004 period when dwell times generally increased for Class I railroads. These four terminals have relatively high standard deviations (Northtown has the highest), although Memphis and Fort Worth also have high standard deviations (as does Houston relative to its average). Charts for these four terminals can be found in Appendix 16-B.

TABLE 16-4
BNSF TERMINAL DWELL TIME
1/8/1999-9/30/2005

Terminal	Avg	St Dev	CV	03-04 Avg	Max
Northtown (MPS/STP), MN	32.48	5.53	17.0%	37.56	58.00
Barstow, CA	31.61	4.58	14.5%	36.59	48.00
Lincoln, NE	30.53	4.31	14.1%	33.26	48.00
Kansas City (Argentine), KS	29.27	3.50	12.0%	32.39	41.00
Denver, CO	27.52	3.36	12.2%	28.47	38.00
Galesburg, IL	27.00	3.53	13.1%	29.35	61.00
Ft. Worth, TX	26.78	4.10	15.3%	27.88	40.00
All BNSF Terminals	26.75	2.51	9.4%	29.48	36.82
Pasco, WA	24.14	3.59	14.9%	26.02	39.50
Memphis, TN	23.29	4.93	21.2%	26.25	40.00
Houston, TX	17.06	3.19	18.7%	18.29	41.00

Table 16-5 shows that the CSX terminals having the highest average dwell times over the entire period are Baltimore, Montgomery, Indianapolis, and Toledo. These terminals also have the highest averages over the 2003-2004 period. Charts for these four terminals can be found in Appendix 16-B. While Toledo has the highest standard deviation, a number of CSX terminals have high standard deviations relative to their averages including Selkirk, Russell, Cincinnati, Buffalo, Corbin, and Chicago.

TABLE 16-5
CSX TERMINAL DWELL TIME
1/8/1999-9/30/2005

Terminal	Avg	St Dev	CV	03-04 Avg	Max
Baltimore, MD	37.24	6.71	18.0%	37.20	62.40
Montgomery, AL	37.19	6.77	18.2%	41.37	67.20
Indianapolis, IN	36.69	7.28	19.8%	36.36	74.00
Toledo, OH	36.61	9.70	26.5%	38.12	85.00
Louisville, KY	34.25	6.20	18.1%	34.10	57.40
Nashville, TN	33.83	6.60	19.5%	32.60	60.30
Waycross, GA	33.77	7.05	20.9%	33.15	62.80
Selkirk, NY	33.42	8.56	25.6%	33.59	67.40
Russell, KY	33.15	7.30	22.0%	31.96	64.60
All CSX Terminals	31.75	4.71	14.8%	32.72	53.86
Cincinnati, OH	31.69	6.77	21.4%	33.47	60.80
Hamlet, NC	31.56	4.95	15.7%	32.42	54.60
Buffalo, NY	29.98	6.12	20.4%	29.11	68.30
Corbin, KY	24.01	5.49	22.9%	25.17	47.30
Chicago, IL	21.38	5.28	24.7%	21.19	74.00

Table 16-6 shows that the NS terminals having the highest average dwell times over the entire period are Roanoke, Conway, Elkhart, and Knoxville.

TABLE 16-6
NS TERMINAL DWELL TIME
1/8/1999-9/30/2005

Terminal	Avg	St Dev	CV	03-04 Avg	Max
Roanoke, VA	34.41	7.90	23.0%	30.04	57.20
Conway, PA	31.96	6.95	21.8%	28.38	60.00
Elkhart, IN	29.91	5.63	18.8%	28.35	59.70
Knoxville, TN	29.82	5.28	17.7%	28.01	52.10
Chattanooga, TN	28.81	4.81	16.7%	26.52	46.80
Linwood, NC	28.53	4.61	16.2%	26.44	46.40
Allentown, PA	28.50	4.84	17.0%	26.72	48.60
Columbus, OH	28.38	5.45	19.2%	27.29	54.80
Bellevue, OH	28.15	5.83	20.7%	26.33	51.90
Birmingham, AL	28.03	5.79	20.7%	26.32	52.10
Macon, GA	27.95	4.73	16.9%	26.80	46.60
All NS Terminals	27.38	3.86	14.1%	26.20	43.66
Decatur, IL	26.10	3.62	13.9%	26.19	45.60
Sheffield, AL	23.92	4.70	19.7%	23.65	54.40
New Orleans, LA	15.40	3.88	25.2%	16.05	32.30

These terminals also have the highest averages over the 2003-2004 period. Charts for these four terminals can be found in Appendix 16-B. Roanoke and Conway have the highest standard deviations, and Elkhart and Knoxville also have relatively high standard deviations. Other NS terminals that have high standard deviations relative to their averages were Bellevue, Birmingham, and New Orleans.[16]

Table 16-7 shows that the UP terminals having the highest average dwell times over the entire period are Houston-Settegast, West Colton, Houston-Englewood, Kansas City, and Fort Worth. Four of these terminals also have the highest averages over the 2003-2004 period, with Hinkle having a higher dwell time than Kansas City in that sub-period. Charts for the five terminals with the highest average dwell times over the entire period can be found in Appendix 16-B. Both Houston terminals and West Colton have the highest standard deviations. Hinkle also has a high standard deviation relative its average.

TABLE 16-7
UP TERMINAL DWELL TIME
1/8/1999-9/30/2005

Terminals	Avg	St Dev	CV	03-04 Avg	Max
Houston - Settegast, TX	37.44	6.79	18.1%	40.95	61.00
West Colton, CA	36.66	7.98	21.8%	37.22	73.70
Houston - Englewood, TX	35.70	6.92	19.4%	36.30	66.40
Kansas City - Neff, MO	34.45	4.92	14.3%	33.49	55.20
Fort Worth - Centennial, TX	34.42	5.32	15.4%	36.52	60.80
Chicago - Proviso, IL	32.09	4.80	15.0%	32.68	68.90
All UP Terminals	31.62	3.19	10.1%	33.09	45.82
Hinkle, OR	31.53	6.38	20.2%	34.93	63.40
Roseville, CA	31.51	4.87	15.4%	31.10	51.40
Pine Bluff, AR	29.84	4.43	14.8%	30.31	56.90
North Platte - West, NE	29.74	5.35	18.0%	30.19	55.40
North Little Rock, AR	28.49	2.99	10.5%	29.34	51.20
Livonia, LA	27.81	5.51	19.8%	29.74	57.40
North Platte - East, NE	27.79	4.10	14.8%	27.43	50.00

In summary, each railroad exhibits a wide range of dwell times across its different terminals. Terminals also differed considerably in the variability of their dwell times, suggesting that those terminals with the longest dwell times and largest variability might be affected by capacity constraints. Average dwell times in the 2003-2004 period were generally higher than the entire Period 1 averages for the Western railroads (BNSF and UP), but this relationship was more mixed for the Eastern railroads (CSX and NS).

[16] Although not fully captured in Table 16-6, NS personnel told us that Hurricane Katrina (August 2005) had a significant effect on NS facilities in New Orleans, including the ability to interchange traffic there with other carriers. We were also told that Birmingham has witnessed disproportional traffic growth relative to its capacity.

Rail Fleet Statistics

Another indicator of railroad capacity is the number of rail cars that are available on the networks. It is also useful to look at trends in the ownership of freight cars to determine the source of any increase in car capacity. The RPM includes data on the number of Class I cars on line and the percentage of cars on line that are privately owned.[17] In addition, the AAR maintains data on rail fleets of both Class I railroads and other railroads.

RPM Cars on Line

Table 16-8 shows the percentage change in the average number of cars on line, by Class I railroad and by year.[18] As was the case with terminal dwell time, standardized definitions were adopted for this measure in October of 2005, and the statistics after 2005 are not directly comparable to the statistics through 2005. What is noteworthy about the percentage changes is that the 2004 increase is coincident with the general increase in terminal dwell time in 2003-04.

TABLE 16-8
PERCENTAGE CHANGES IN AVERAGE NUMBER OF CARS ON LINE

	BNSF	CN	CP	CSX	KCS	NS	UP	Total
2000	-0.8%	13.5%	-4.8%	9.9%	-6.5%	7.7%	0.8%	3.8%
2001	-0.3%	-5.1%	-3.1%	-7.0%	-1.3%	-8.1%	2.1%	-3.0%
2002	-5.7%	-7.8%	-4.8%	-4.4%	-1.2%	-6.6%	-2.2%	-4.7%
2003	-0.1%	0.9%	-6.6%	0.1%	-9.4%	-0.6%	-0.8%	-0.8%
2004	3.6%	14.3%	3.4%	1.5%	-1.1%	0.2%	4.2%	3.6%
2005*	4.2%	-1.4%	1.3%	0.4%	8.0%	4.2%	-1.4%	1.2%
2007	2.5%	6.3%	1.3%	-1.2%	5.1%	-0.4%	-3.6%	0.0%

*Statistics for 2005 only cover the months of January through September.

Table 16-9 shows the percentage of cars on line that are privately owned, as reported in the RPM. These statistics show a shift of car ownership from railroads to private parties, as the percent of cars on line that are privately owned has generally been increasing from 48 percent in 1999 to 52 percent in 2005 (and almost 53 percent in 2007 if we also look at Period 2.) While results

[17] "Privately owned" generally refers to ownership by shippers, third-party leasing companies, or TTX.

[18] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

> Cars On Line is the average of the daily on-line inventory of freight cars. Articulated cars are counted as a single unit. Cars on private tracks (e.g., at a customer's facility) are counted on the last railroad on which they were located. Maintenance of way cars are excluded.

vary somewhat by railroad, the Table 16-9 indicates that much of the new railroad car capacity is being provided by private parties.

TABLE 16-9
PERCENT PRIVATELY OWNED CARS ON LINE
1999-2007

	BNSF	CN	CP	CSX	KCS	NS	UP	Total
1999	51.1%	38.1%	36.2%	48.4%	54.1%	39.1%	58.0%	48.4%
2000	51.4%	43.9%	37.2%	47.8%	54.9%	41.1%	57.5%	48.9%
2001	51.8%	45.1%	40.8%	48.0%	53.2%	41.7%	59.6%	50.2%
2002	51.8%	47.3%	43.2%	48.3%	55.2%	38.8%	60.6%	50.5%
2003	52.6%	48.0%	41.3%	49.5%	54.0%	39.1%	60.8%	51.0%
2004	53.0%	45.1%	41.1%	50.4%	55.6%	40.5%	61.3%	51.4%
2005*	53.8%	46.1%	42.5%	50.5%	56.1%	41.5%	62.4%	52.1%
2006	55.1%	46.5%	40.5%	52.0%	55.8%	44.4%	56.3%	51.2%
2007	56.8%	46.3%	41.5%	54.4%	56.4%	45.8%	58.0%	52.7%

*Statistics for 2005 only cover the months of January through September.

Table 16-10 shows the percent of all railroad system cars that are on line, for the system as a whole as well as individual Class I railroads. The percent of cars on line that are system cars has declined from almost 38 percent in 1999 to about 33 percent in 2005.[19] (This statistic is also approximately 33 percent in Period 2.) The same trend is found for individual railroads.

TABLE 16-10
PERCENT SYSTEM CARS ON LINE
1999-2007

	BNSF	CN	CP	CSX	KCS	NS	UP	Total
1999	38.3%	45.6%	50.5%	34.5%	29.9%	44.4%	30.5%	37.6%
2000	37.9%	40.5%	48.4%	34.1%	30.1%	42.9%	31.0%	36.9%
2001	37.8%	40.3%	46.1%	35.6%	30.6%	44.0%	29.1%	36.6%
2002	37.9%	37.0%	46.5%	35.7%	29.0%	44.3%	27.6%	35.9%
2003	36.4%	35.6%	46.9%	33.1%	31.2%	42.6%	26.6%	34.4%
2004	36.2%	38.6%	47.2%	31.2%	27.9%	40.5%	24.7%	33.3%
2005*	35.7%	40.4%	45.8%	30.7%	26.2%	39.3%	24.5%	33.0%
2006	32.6%	43.4%	45.2%	30.6%	23.1%	38.0%	26.2%	33.1%
2007	32.6%	43.9%	43.6%	29.5%	23.0%	37.8%	25.0%	32.6%

*Statistics for 2005 only cover the months of January through September.

[19] Total cars on line = system + private + foreign.

AAR Rail Fleet Data[20]

We obtained rail fleet data from the AAR's Policy and Economics Department. Selected tables from the AAR are reproduced here. Table 16-11 presents freight car acquisition data by Class I railroads and others (including non-Class I railroads, shippers, leasing companies, and TTX) from 1981 through 2007. It can be seen that the proportion acquired by others has increased by about 10 percentage points between the early 1980s and currently, from an average of about 77 percent to about 87 percent.

TABLE 16-11
FREIGHT CAR ACQUISITIONS
1981-2007

Year	Total	Class I Railroads	Others	% Class I Railroads	% Others
Averages					
1981-85	18,651	5,549	13,101	23.0%	77.0%
1986-90	21,871	2,794	19,078	11.2%	88.8%
1991-95	39,070	4,882	34,188	11.4%	88.6%
1996-00	62,794	10,728	52,067	15.7%	84.3%
2001-05	39,928	5,850	34,078	12.6%	87.4%
2001-07	48,218	6,647	41,571	12.5%	87.5%

Table 16-12 presents selected car fleet statistics for selected years between 1976 and 1992 and continuously from 1992 through 2007. The car fleet has declined from 1.7 million cars in 1976 to almost 1.4 million cars in 2007. However, the average capacity has increased from 73.8 tons in 1976 to 102.8 tons in 2007. The number of new cars has increased in recent years from relatively low levels in the early 2000s. Average age has increased from 14.6 years in 1976 to 22.5 years in 2007.

Table 16-13 reports Class I locomotive statistics from 1992 through 2007 (preliminary). Units in service and average horsepower have both increased, resulting in aggregate horsepower increasing from 49.5 million in 1992 to 84.9 million in 2007. The number of units plateaued between the late-1990s and 2003, and then began to increase in 2004.

[20] Data were obtained from AAR's Policy and Economics Department.

TABLE 16-12
SELECTED CAR FLEET STATISTICS
1976-2007

Year	Total Cars (millions)	New Cars (thousands)	Avg. Age (years)	Avg. Capacity (tons)
1976	1.70	53.6	14.6	73.8
1980	1.71	86.7	14.9	78.5
1984	1.49	12.4	16.3	84.1
1988	1.24	22.5	17.7	87.4
1992	1.17	25.8	19.2	90.6
1993	1.17	35.2	19.5	91.3
1994	1.19	48.8	19.7	92.0
1995	1.22	60.9	19.9	92.9
1996	1.24	57.9	19.9	95.6
1997	1.27	50.4	20.0	96.5
1998	1.32	75.7	19.8	97.2
1999	1.37	74.2	20.1	98.2
2000	1.38	55.8	20.4	98.7
2001	1.31	34.3	20.9	99.1
2002	1.30	17.7	21.2	99.7
2003	1.28	32.2	21.9	100.1
2004	1.29	46.9	22.3	100.5
2005	1.31	68.6	22.3	101.2
2006	1.35	74.7	22.5	102.0
2007	1.39	63.2	22.5	102.8

TABLE 16-13
CLASS I LOCOMOTIVE STATISTICS
1992-2007

Year	Units In Service	Aggregate Horsepower (millions)	Purchased & Leased New	Rebuilt Acquired	HP/Unit	% New
1992	18,004	49.5	321	139	2,749.4	1.8%
1993	18,161	50.4	504	203	2,775.2	2.8%
1994	18,505	52.4	821	393	2,831.7	4.4%
1995	18,812	55.1	928	201	2,929.0	4.9%
1996	19,269	57.5	761	60	2,984.1	3.9%
1997	19,684	60.2	743	68	3,058.3	3.8%
1998	20,261	63.3	889	172	3,124.2	4.4%
1999	20,256	64.8	709	156	3,199.1	3.5%
2000	20,028	65.3	640	81	3,260.4	3.2%
2001	19,745	64.7	710	45	3,276.8	3.6%
2002	20,506	69.3	745	33	3,379.5	3.6%
2003	20,774	70.9	587	34	3,412.9	2.8%
2004	22,015	76.1	1121	5	3,456.7	5.1%
2005	22,779	79.0	827	84	3,468.1	3.6%
2006	23,732	82.7	922	158	3,484.7	3.9%
2007*	24,143	84.9	902	167	3,516.5	3.7%

*Preliminary values are reported for 2007.

Other Measures of Railroad Capacity and Capacity Changes—R-1 Data

The R-1 Annual Report data filed by the Class I railroads provide a number of capacity indicators. Table 16-14 reports equipment expenditures by type,[21] aggregated across all Class I railroads reporting in a particular year. The data are in nominal terms, but when deflated by the GDP price index, the same general pattern emerges, as seen in Table 16-15. Both real and nominal series show mostly negative growth in the 1997-2002 period and increases in the most recent 2002-2006 period, although the latest increases are generally below the average growth rates in the 1992-1997 period.

TABLE 16-14
CHANGES IN CLASS I ANNUAL EXPENDITURES (NOMINAL)

	Road	Locomotive	Cars	Total Equip	Grand Total
1988	13.9%	87.5%	24.7%	44.7%	14.4%
1989	-4.7%	14.9%	43.5%	13.1%	8.5%
1990	4.1%	-12.9%	-31.7%	-16.2%	-7.3%
1991	-11.0%	13.6%	-11.2%	7.0%	-4.3%
1992	14.4%	-43.0%	13.0%	-20.0%	6.8%
1993	2.1%	51.3%	55.3%	45.8%	20.2%
1994	12.0%	19.4%	30.2%	22.7%	11.2%
1995	14.7%	32.5%	33.5%	30.1%	12.7%
1996	6.6%	5.8%	-28.7%	-6.2%	13.6%
1997	5.5%	12.7%	-29.7%	-2.6%	2.8%
1998	16.8%	0.5%	22.9%	7.9%	8.8%
1999	-9.2%	-12.1%	1.2%	-6.1%	-17.2%
2000	2.3%	-60.8%	2.5%	-37.0%	-15.8%
2001	-2.8%	-13.5%	-98.4%	-39.8%	-3.4%
2002	4.9%	13.7%	-65.5%	0.8%	9.2%
2003	-1.8%	31.4%	6.9%	24.1%	6.6%
2004	8.0%	-19.1%	32.5%	0.1%	5.8%
2005	8.2%	-32.1%	9.2%	-23.7%	10.8%
2006	26.4%	32.2%	50.2%	36.0%	14.3%
Averages					
1987-1992	3.4%	12.0%	7.7%	5.7%	3.6%
1992-1997	8.2%	24.3%	12.1%	18.0%	12.1%
1997-2002	2.4%	-14.4%	-27.5%	-14.9%	-3.7%
2002-2006	10.2%	3.1%	24.7%	9.1%	9.4%

[21] R-1 data from Schedule 330, Column E. Line numbers for expenditure categories and included in Tables 16-14 and 16-15 are Road (Line 30), Locomotives (Line 31), Freight Cars (Line 32), Total Equipment (Line 39), and Grand Total (Line 43).

TABLE 16-15
CHANGES IN CLASS I ANNUAL EXPENDITURES (REAL)

	Road	Locomotive	Cars	Total Equip	Grand Total
1988	10.5%	84.1%	21.4%	41.4%	11.0%
1989	-8.4%	11.1%	39.7%	9.3%	4.8%
1990	0.3%	-16.7%	-35.5%	-20.0%	-11.2%
1991	-14.4%	10.2%	-14.6%	3.6%	-7.8%
1992	12.1%	-45.3%	10.8%	-22.3%	4.5%
1993	-0.1%	49.0%	53.0%	43.5%	17.9%
1994	9.9%	17.3%	28.1%	20.6%	9.1%
1995	12.7%	30.5%	31.5%	28.1%	10.7%
1996	4.7%	3.9%	-30.6%	-8.1%	11.7%
1997	3.9%	11.0%	-31.4%	-4.2%	1.2%
1998	15.7%	-0.6%	21.8%	6.7%	7.7%
1999	-10.7%	-13.5%	-0.2%	-7.5%	-18.7%
2000	0.1%	-63.0%	0.3%	-39.2%	-17.9%
2001	-5.2%	-15.9%	-100.8%	-42.1%	-5.8%
2002	3.2%	12.0%	-67.3%	-0.9%	7.5%
2003	-3.9%	29.3%	4.8%	22.0%	4.5%
2004	5.2%	-22.0%	29.6%	-2.7%	2.9%
2005	5.0%	-35.3%	6.0%	-26.9%	7.6%
2006	23.3%	29.1%	47.1%	32.9%	11.2%
Averages					
1987-1992	0.0%	8.7%	4.4%	2.4%	0.3%
1992-1997	6.2%	22.3%	10.1%	16.0%	10.1%
1997-2002	0.6%	-16.2%	-29.2%	-16.6%	-5.4%
2002-2006	7.4%	0.3%	21.9%	6.3%	6.6%

Summary of Descriptive Measures of Rail Capacity

Post-Staggers declines in Class I miles of track have stabilized in recent years and track continues to be used more intensively, as net ton-miles per mile of track continue to increase.[22] The general increase in terminal dwell times during the mid-2000s indicates greater congestion at points in the railroad networks. However, this general increase is small relative to the wide range of dwell times and the variability in dwell times across different terminals. Those terminals with the longest dwell times and greatest variability might have been affected by capacity constraints. Railcar and locomotive data suggest fluctuations over time, with flat-to-declining values in the early- to mid-2000s. Recent years have seen an increase in spending as well as in the number of units. Combined with a relatively weak economy, all of this indicates that any capacity tightness that may have existed at the beginning of this decade has likely loosened in recent years.

[22] As indicated above, some but not all of the decline in Class I miles of track has been offset by increases in regional and shortline track miles.

Transportation Systems Flow Modeling of Railroad Capacity

In September of 2007, Cambridge Systematics published a study sponsored by the Association of American Railroads on railroad infrastructure needs.[23] This study concluded that infrastructure investment of $148 billion (in 2007 dollars) would be needed to keep pace with economic growth in the United States and the U.S. Department of Transportation's forecasts for railroad transportation demand. This study has been widely cited as demonstrating the need for investment incentives in the railroad industry.

The methodology that Cambridge Systematics employed in its study included: (1) establishing a network model of railroad transportation in which the primary rail freight corridors are identified and modeled, (2) determining current and future railroad traffic over the different corridors of the network, (3) estimating the capacity of each corridor on the railroad network using the Oak Ridge National Laboratory, (4) comparing future railroad traffic to current infrastructure capacity and noting where capacity shortages will arise, (5) determining the additional capacity needs and the infrastructure improvements required to meet those capacity needs, and (6) estimating the cost of the infrastructure improvements.

To determine current and future railroad traffic over the network, Cambridge Systematics relied on the U.S. Department of Transportation Freight Analysis Framework Model (Version 2.2). The Freight Analysis Framework forecasts commodity flows among 131 regions in the United States and seven foreign trade regions. Benchmark base-year flows are developed using the 2002 Commodity Flow Survey along with supplementary databases, such as the Carload Waybill Sample. Forecasts from the benchmark values are based on a number of econometric models developed by the consulting firm Global Insight. Forecasted changes in regional economic output over time and the input-output structure of the U.S. economy are used to adjust benchmark commodity flows over the railroad network. For example, output growth in Phoenix, Arizona, will lead to increases in demand for different commodities based upon the economic sectors in which the growth occurs. The required increases in commodities will be met by increases in commodity flows over that part of the network that serves Phoenix. The demand forecasts do not incorporate possible shifts in transportation between different modes (rail, truck, or barge) and they do not incorporate possible shifts in plant locations due to transportation network availability and cost. Given the recent increases in oil prices, assuming no changes in modal mix or plant locations over the next thirty years is consequential and may limit the usefulness of the model.

The corridor network model was based on the Oak Ridge National Laboratory Center for Transportation Analysis's Rail Network (Version 5-5). Capacity was estimated over this network based on the number of tracks, the

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[23] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007.

types of control systems in place, and the mix of train types using each corridor. Using railroad capacity tables, Cambridge Systematics estimated the practical maximum number of trains per day that could use each corridor.

Cambridge Systematics classified different corridors by their ratio of volume to capacity. Corridors were assigned to one of four levels of service categories. Corridors that are below capacity have low to moderate train flows with sufficient capacity to accommodate maintenance and recover from incidents. Corridors near capacity have heavy train flows with moderate capacity to accommodate maintenance and recover from incidents. Corridors at capacity have very heavy train flow with very limited capacity to accommodate maintenance and recover from incidents. Corridors above capacity have conditions for service breakdown. Table 16-16 shows the percentage distribution for the present classification of corridor mileage and the projected classification of corridor mileage in 2035 under the assumptions implicit in the model.

TABLE 16-16
DISTRIBUTION OF CORRIDOR MILEAGE BY LEVELS OF SERVICE

Level of Service	Current Percent of Corridor Mileage[24]	Percent of Corridor Mileage in 2035 without any Infrastructure Improvements[25]
Below Capacity	88%	45%
Near Capacity	9%	10%
At Capacity	3%	15%
Above Capacity	<1%	30%

This table shows that currently the railroad infrastructure capacity is large enough to handle virtually all rail transportation demand. Less than one percent of system mileage is over capacity, while three percent is at capacity. (According to Figure 4.4 in the Cambridge Systematics report, corridors that are currently above capacity can be found near Kansas City and near the Mississippi-Tennessee border.) Approximately 88 percent of system mileage is substantially below capacity. The table also indicates that if no infrastructure improvements are made over the next thirty years, 30 percent of system mileage will be over capacity and another 15 percent will be at capacity. Only 44 percent of system mileage will be significantly below capacity.

To summarize, the Cambridge Systematics study shows few current problems with available freight railroad infrastructure capacity. It also shows that thirty years into the future, using the forecasting assumptions implicit in

[24] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 4.4.

[25] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 5.1.

the Freight Analysis Framework model, there will be significant capacity problems unless significant investments are made in infrastructure. Forecasting capacity needs thirty years into the future is at best a difficult project, and the conclusions of the Cambridge Systematics study are sensitive to the economic projections that drive freight commodity flow forecasts, future decisions about plant locations, availability of other transportation modes, and changes in business operations. While the results of the study may be illustrative, they cannot provide a precise forecast of capacity needs far into the future. For example, given the recent increases in oil prices, one would expect changes in the modal mix and business locational choices.

16C. ECONOMETRIC ANALYSIS OF RAILROAD CAPACITY

There have been various attempts to determine trends in capacity utilization using econometric models. In 1993, Friedlaender and her associates published a paper on railroad costs and capital adjustments.[26] In that paper Friedlaender, et al. employed a short-run variable cost function to represent railroad costs. Variable costs (in this case the costs associated with labor, fuel, equipment, and materials and supplies) are modeled as a function of ton-miles of traffic, the percentage of traffic that was composed of agricultural products, the percentage of traffic that was composed of coal, the average length of haul, the number of track miles, and the quantity of way and structures capital. The quantity of way and structures was developed based on a perpetual inventory method applied to historical values of investment. The quantity of way and structures capital was treated as a quasi-fixed factor in the model, which means that it could only be adjusted to its optimum level over significantly long time periods.

The mathematical representation of the variable cost function is

$$C^V = C^V\left(Y, N, W^V, X^F\right)$$

where Y is a vector representing total ton-miles and its commodity composition, N is the miles of track, W^V is a vector representing the prices of the variable inputs, and X^F represents the quantity of way and structures capital. Differentiating the variable cost function with respect to the quasi-fixed input produces its value of marginal product: $\partial C^V / \partial X^F$. One can compare the quasi-fixed factor's value of marginal product with it market price[27] to determine whether there is a shortage of capacity, an excess of capacity, or an optimal level of capacity:

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[26] Ann F. Friedlaender, Ernst R. Berndt, Judy Shaw-Er Wang Chiang, Mark Showalter, and Christopher A. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-Regulated Environment," *Journal of Transport Economics and Policy*, May 1993, pp. 131-152.

[27] For convenience, we will refer to the comparison of the quasi-fixed factor's value of marginal product with its market price as the "capacity equation."

$$-\partial C^V / \partial X^F > W^F : \quad \text{capacity shortage}$$

$$-\partial C^V / \partial X^F < W^F : \quad \text{excess capacity}$$

$$-\partial C^V / \partial X^F = W^F : \quad \text{optimal capacity}$$

Friedlaender, et al. estimated this model using data on Class I railroads between the years 1974 and 1986. They found that, with the exception of the Denver Rio Grande and Grand Trunk Western railroads, Class I railroads had significant levels of excess capacity. They also found that this was true throughout the time period they estimated their model, leading them to the conclusion that there might have been substantial barriers to the optimal adjustment of capital.

More recently, Bitzan and Keeler used a slightly different approach to look at the issue of capacity and reached somewhat different conclusions.[28] In particular, they looked at trends in rail traffic density, i.e., changes in rail output over the rail network. Their measure of traffic density was revenue ton-miles per route mile. Bitzan and Keeler found regulatory liberalization allowed railroads to substantially increase their traffic density, and that this increase in traffic density had reduced operating costs by 10 to 22 percent by 2002. Bitzan and Keeler also noted that there still were substantial amounts of low density route mileage, and their analysis led them to conclude that regulatory policies designed to maintain this low density route mileage were counterproductive.

Results from Our Cost Function Estimation

As discussed in more detail in Chapter 9, we econometrically estimate a variable cost function that is very similar in structure to the one used by Friedlaender and her associates. In particular, our model can be used to determine whether in the aggregate there is a shortage or excess of way and structures capital. Table 16-17 reproduces the industry summary results presented in Chapter 9, Table 9-13.

[28] John D. Bitzan and Theodore Keeler, “Economies of Density and Regulatory Change in the U.S. Railroad Freight Industry,” *Journal of Law and Economics*, February 2007, pp. 157-179.

TABLE 16-17
INDUSTRY AVERAGE WAY AND STRUCTURES CAPITAL EMPLOYMENT

	1987	1995	2000	2006
Shadow Price of Capital	0.039	0.044	0.047	0.067
Imputed Price of Capital	0.062	0.098	0.116	0.163
Ratio: Shadow/Imputed	0.630	0.461	0.469	0.410

The results reported in this table show that overall, the Class I railroads still have an excess amount of way and structures capital.[29] In fact, the table shows the ratio of shadow price to imputed price decreasing over time, which implies that the amount of excess capital has been increasing. The first two rows of this table explain this result. While the variable cost savings that result from employing more capital has increased over time, the cost of that additional capital has increased at a more rapid rate. Thus these results suggest that the findings of Friedlaender and her associates still hold. The results in Table 16-17 are also consistent with the conclusion of Bitzan and Keeler that the railroad industry still has a considerable amount of excess capacity on its system, and the Cambridge Systematics study that concludes there presently is more than adequate capacity on most of the railroad network.

It is important to note, however, that these results apply to the aggregate network of each railroad. These studies do not imply that there are no capacity shortages or choke points on individual segments of a railroad's network that have significant effects on performance. As a recent study by the Rand Corporation has pointed out, in order to determine capacity needs at particular points of the network, much more detailed information on the network is required than what is currently publicly available.[30] Burton developed a promising approach to evaluate the need for and cost of additional railroad capacity at particular points of the railroad network.[31] His approach is based on a statistical analysis of railroad traffic levels on particular route segments and the characteristics of those route segments. Using a cross-section of route segments, he developed an econometric model that can be used to predict the available capacity on different network segments based on observed traffic data. His model also determines the least cost approach to increasing railroad capacity where needed.

CONCLUSION

A number of approaches conclude that, in the aggregate, there is not a shortage of railroad capacity. The transportation systems flow approach

[29] The shadow price of capital represents the savings in variable costs from employing additional capital. The imputed price of capital represents the cost of obtaining that capital.

[30] Brian A. Weatherford, Henry H. Willis, and David S. Ortiz, *Infrastructure, Safety, and Environment: A Review of Capacity and Performance Data*, Rand Corporation, 2008, p. xii.

[31] Mark L. Burton, "Measuring the Cost of Incremental Railroad Capacity: A GIS Approach," at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf.

indicates that rail corridors are generally not constrained. The econometric approach indicates that, in the aggregate, excess way and structures capacity exists. The descriptive approach indicates that Class I total track mileage has stabilized over the last ten years, and that usage of track has become more intense as ton-miles per mile of track has grown continuously.

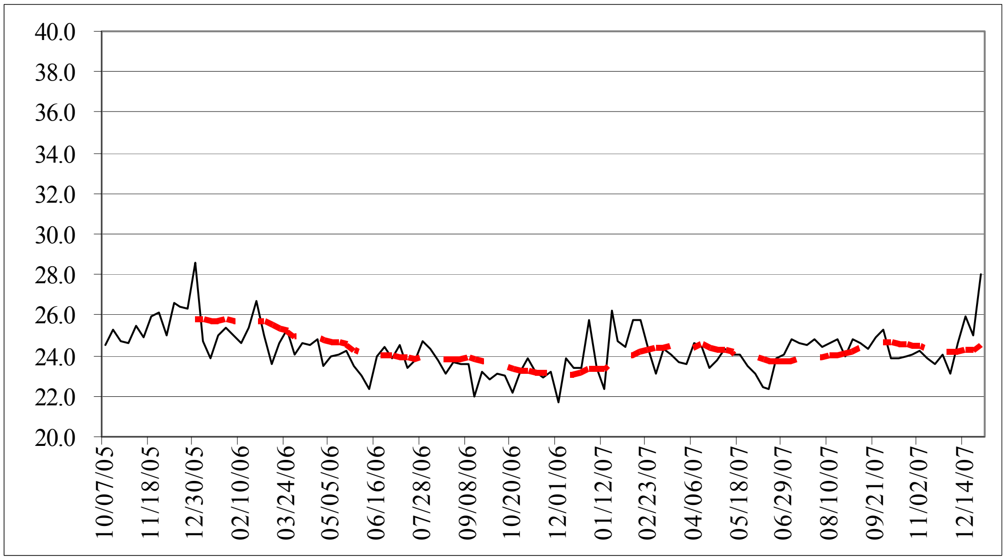
However, similar to localized congestion in other types of networks that causes reductions in output and service levels despite virtually unconstrained capacity throughout the network, congestion at various points or corridors in railroad networks appears to be the major culprit in capacity-related performance issues over the last ten years. While other measures of capacity along a given route may indicate sufficient capacity to meet demand, congestion at terminals or other specific network locations can often become a binding constraint on the utilization of route capacity or network-wide capacity.

Regarding terminal dwell time, the RPM data indicate that, while each railroad has a somewhat unique pattern, one thing that does stand out is a general increase in terminal dwell time in the 2003-04 period, followed by a decline in 2005. Moreover, individual terminals differed considerably in the variability of their dwell times, suggesting that those terminal with the longest dwell times and largest variability might be affected by capacity constraints. Other descriptive measures indicate that the late 1990s and early 2000s witnessed declines in the railcar fleet, offset by railcar capacity increases and increases in locomotive units and horsepower. Declines in spending across most equipment categories also occurred during this period, but in recent years most categories have registered increases.

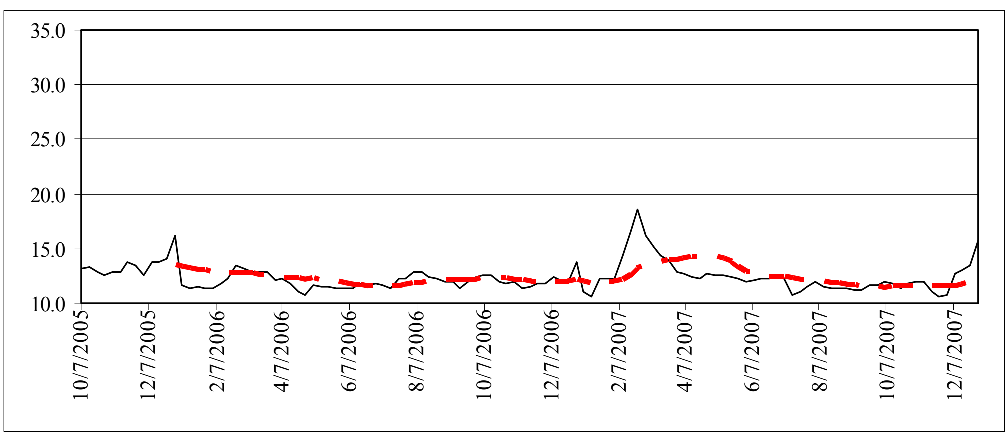
Finally, the Cambridge Systematics study concludes that while there currently is no shortage of railroad capacity, there will be significant capacity problems unless significant investments are made in infrastructure. However, forecasting capacity needs thirty years into the future is at best a difficult project, and the conclusions of the Cambridge Systematics study are sensitive to the economic projections that drive freight commodity flow forecasts, future decisions about plant locations, availability of other transportation modes, and changes in business operations. While the results of the study may be illustrative, they cannot provide a precise forecast of capacity needs far into the future. Therefore, one must treat the conclusions of the Cambridge Systematics study as tentative, at best.

APPENDIX 16-A
CLASS I AVERAGE TERMINAL DWELL TIMES, OCTOBER 2005–DECEMBER 2007

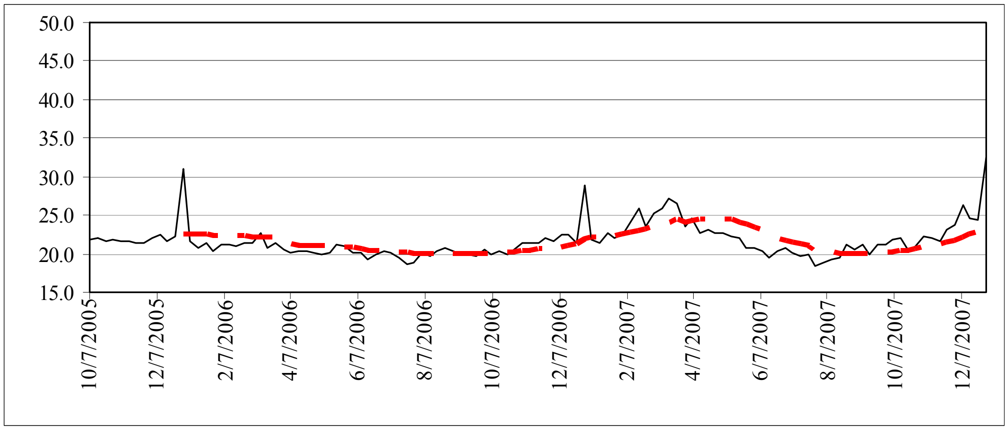
BNSF TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)



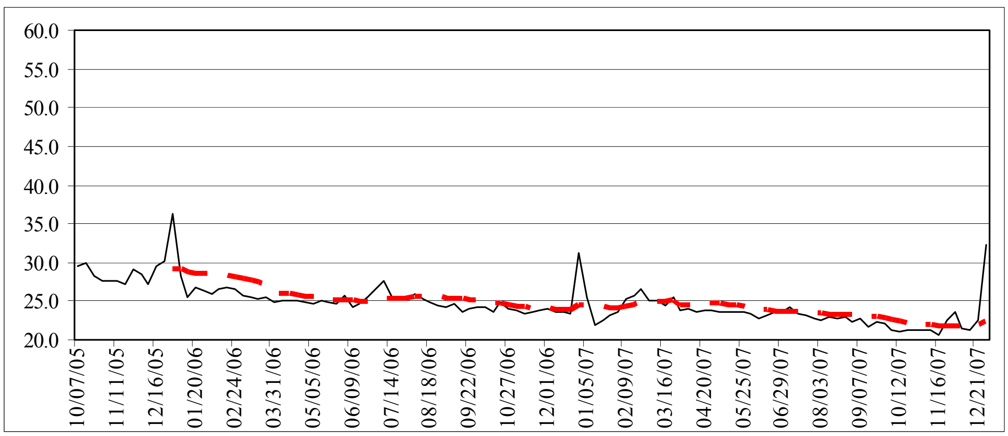
CN TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)



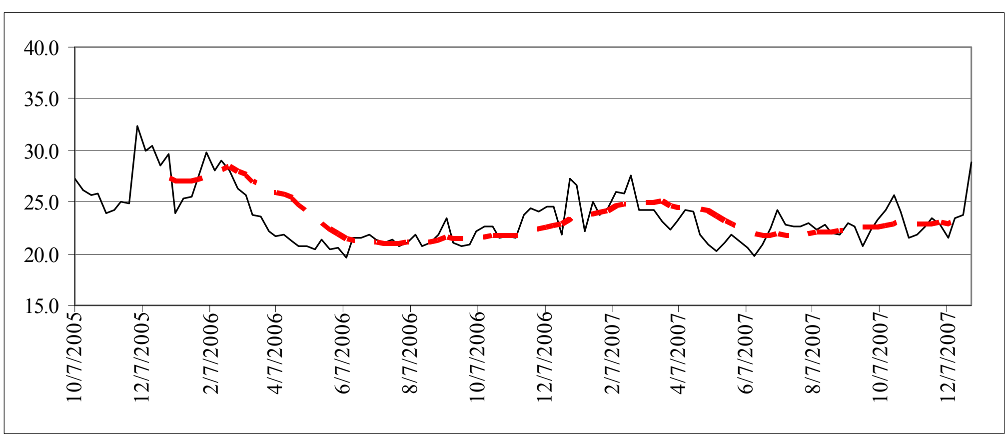
CP TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)



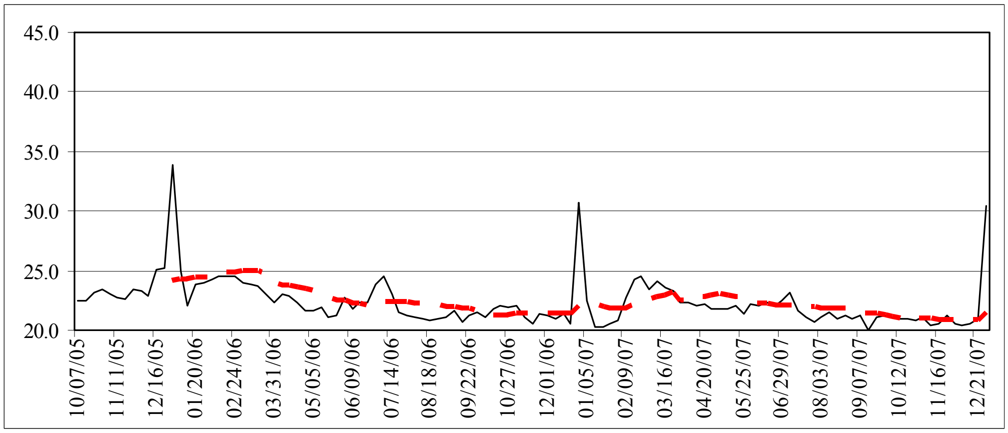
CSX TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)



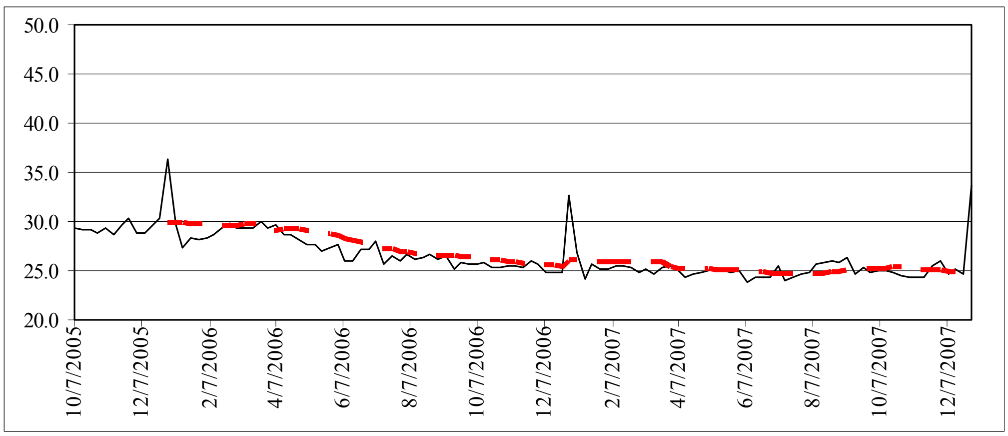
KCS TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)



NS TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)

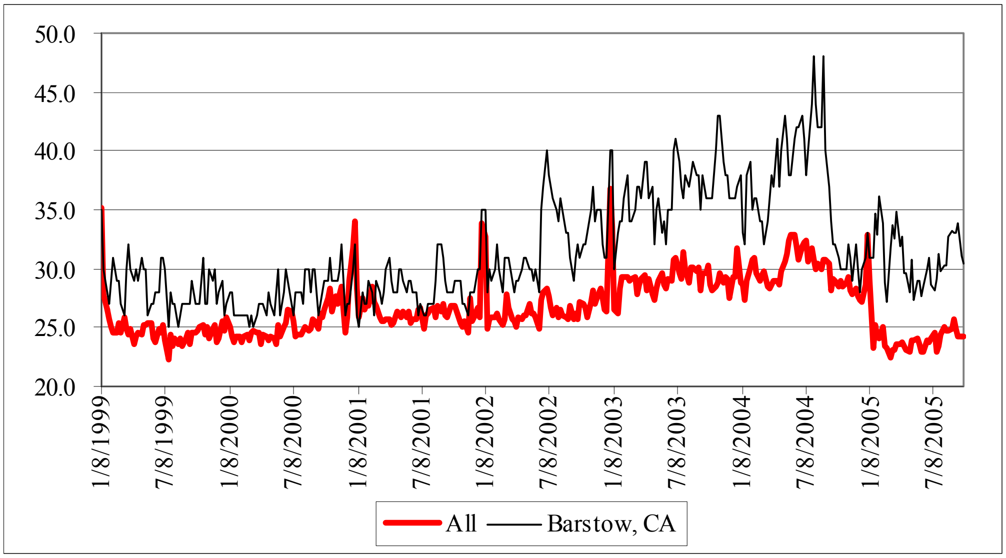


UP TERMINAL DWELL TIME
OCTOBER 2005–DECEMBER 2007 (WEEKLY AND 3MMA)

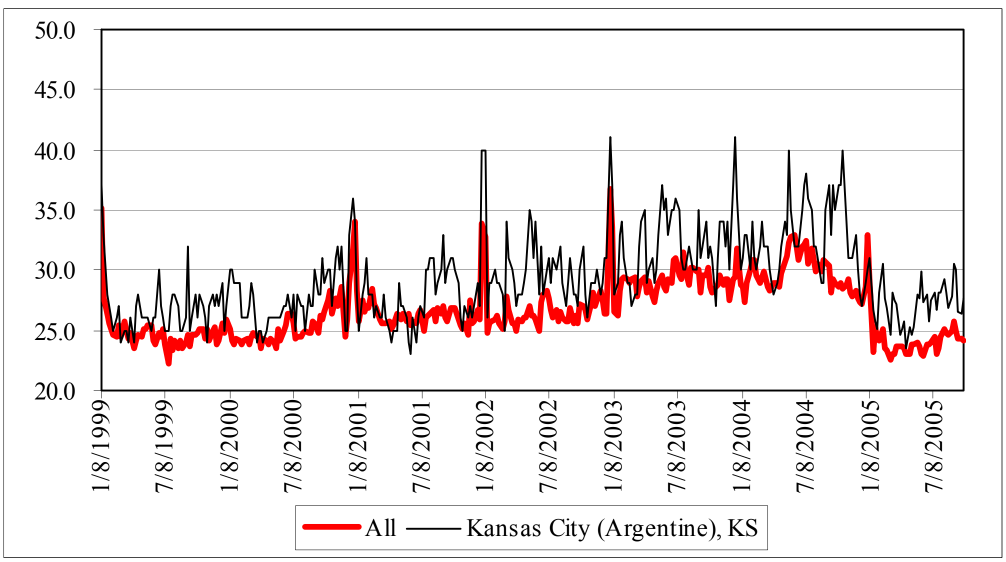


APPENDIX 16-B
SELECT TERMINAL DWELL TIMES, JANUARY 1999–SEPTEMBER 2005

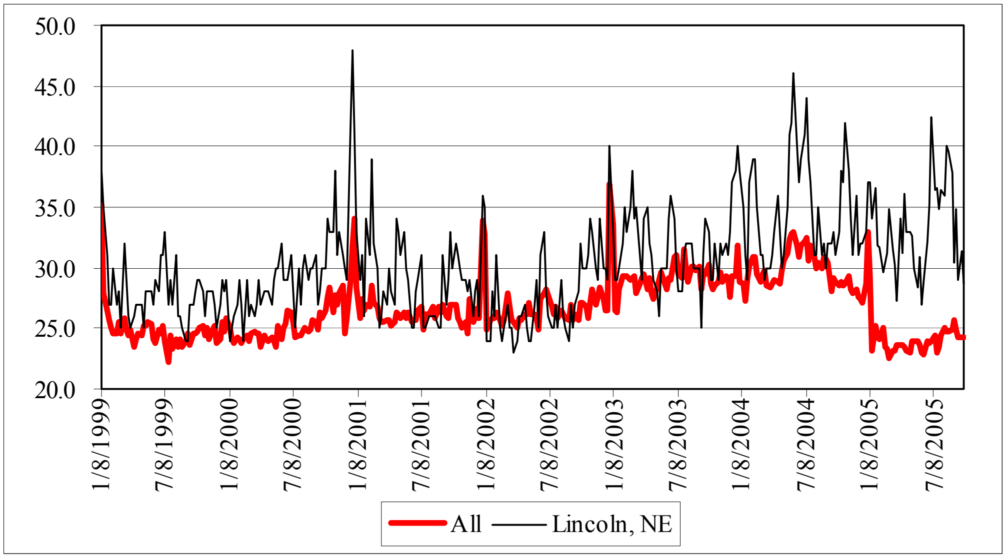
BNSF BARSTOW TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



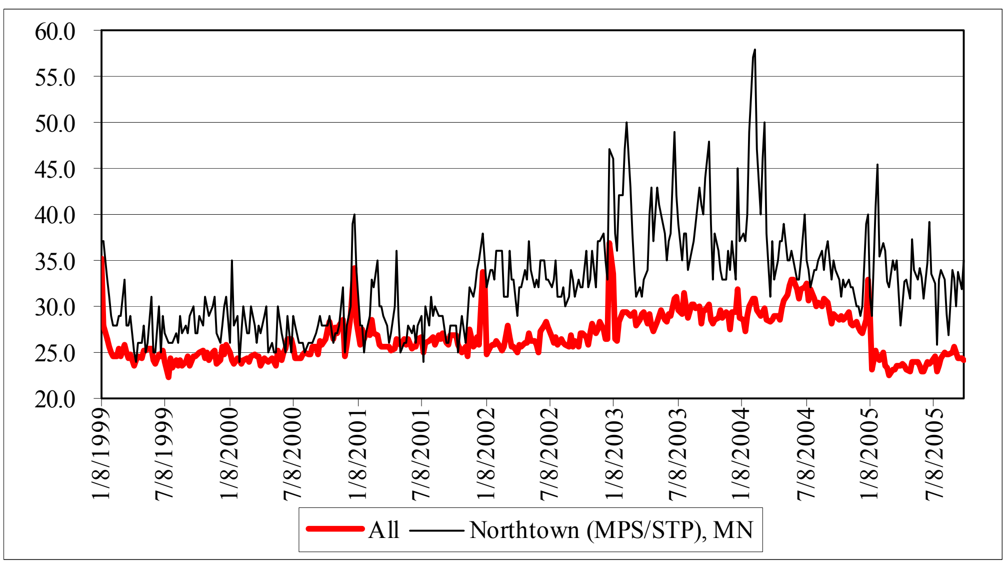
BNSF ARGENTINE TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



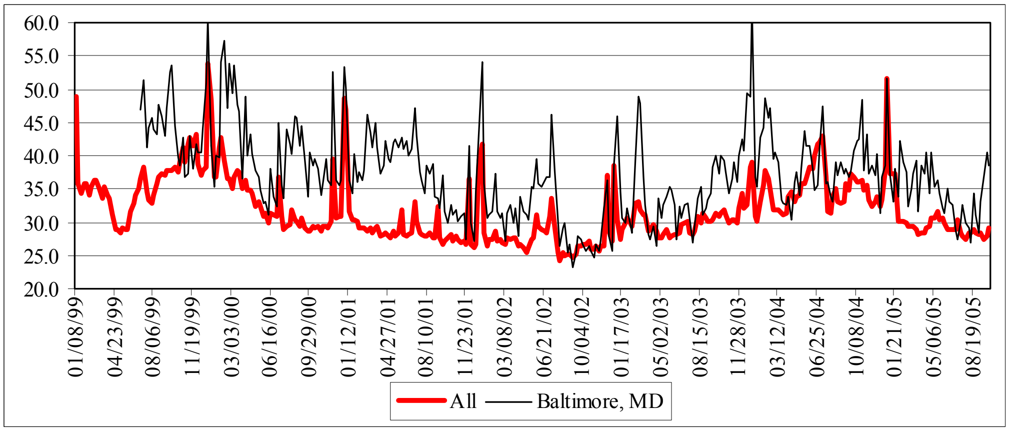
BNSF LINCOLN TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



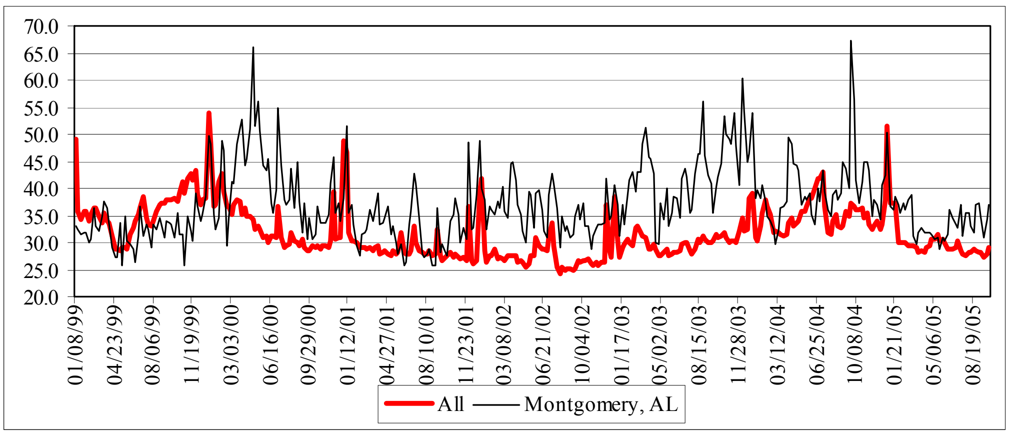
BNSF NORTHTOWN TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



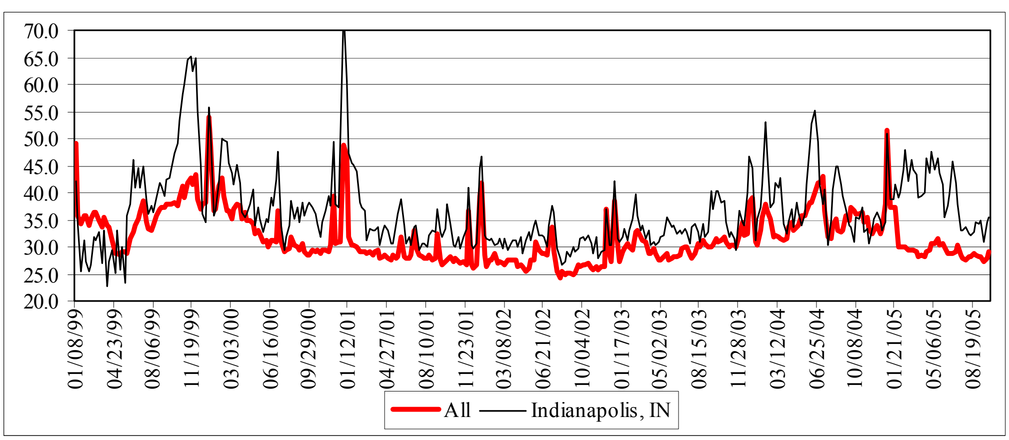
CSX BALTIMORE TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



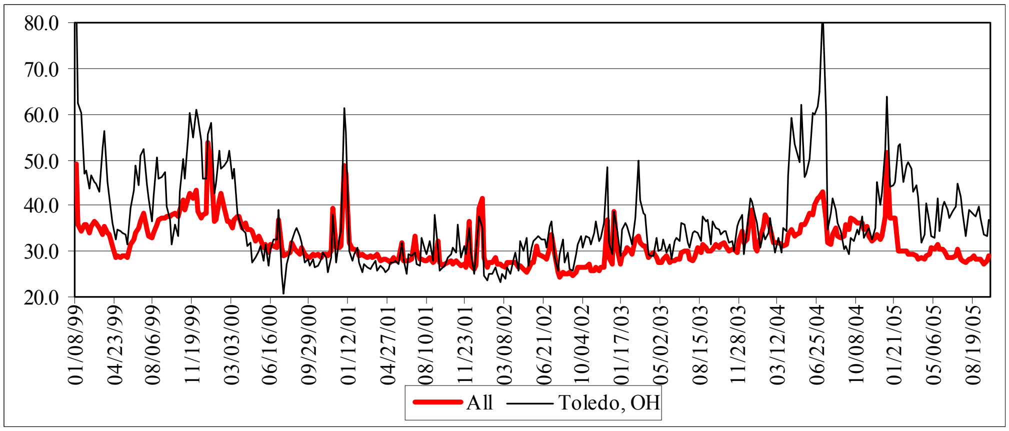
CSX MONTGOMERY TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



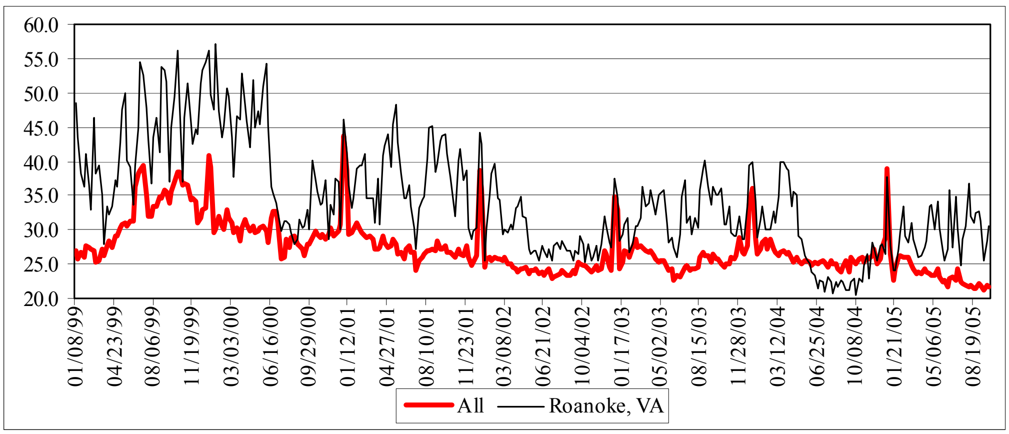
CSX INDIANAPOLIS TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



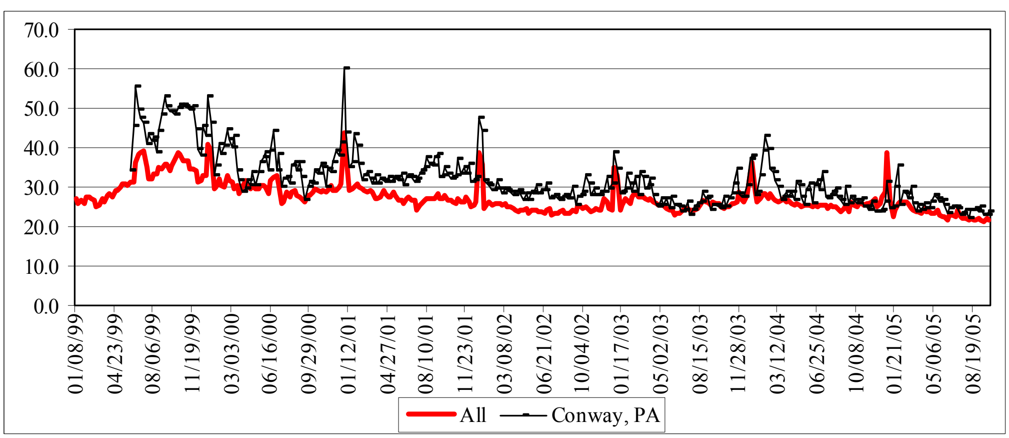
CSX TOLEDO TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



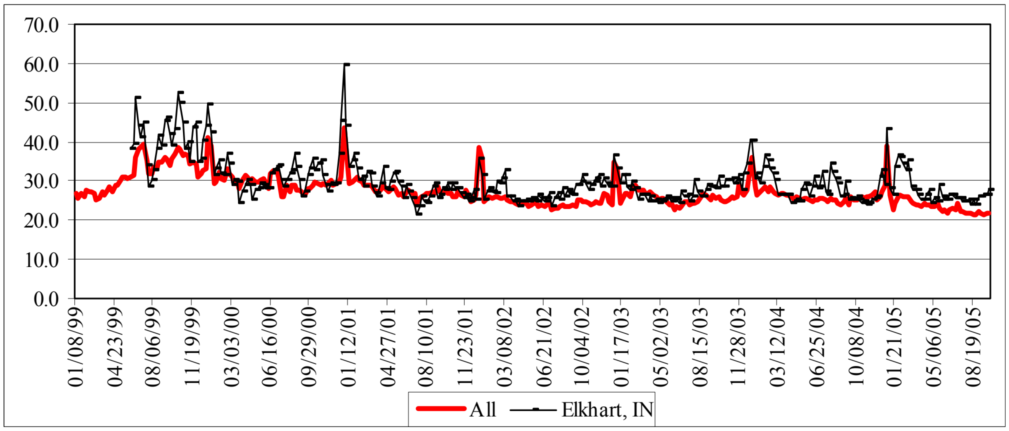
NS ROANOKE TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



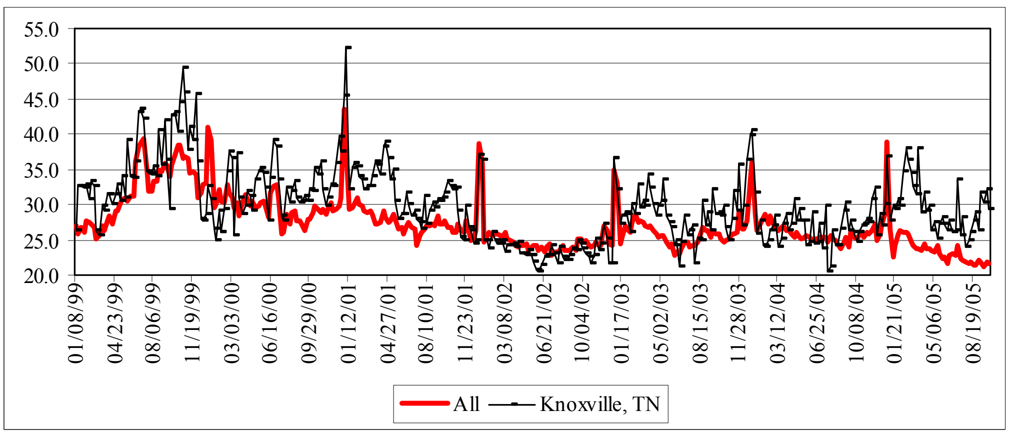
NS CONWAY TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



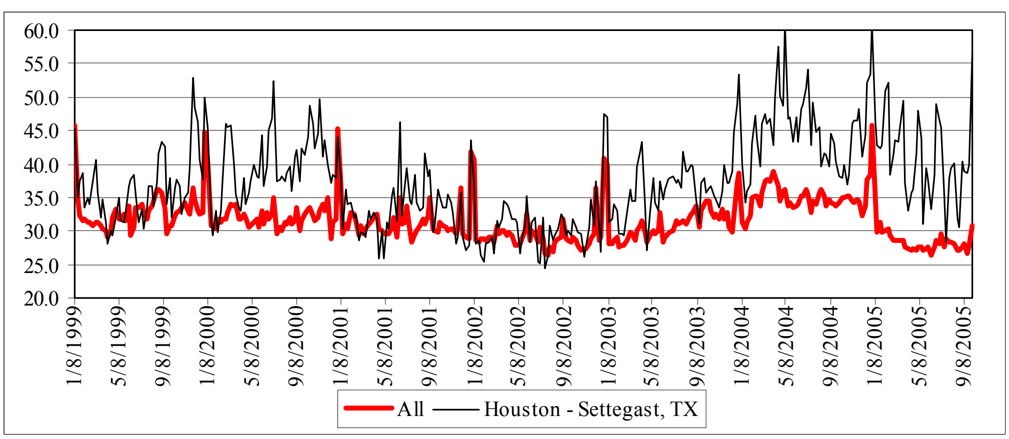
NS Elkhart Terminal Dwell Time
January 1999–September 2005



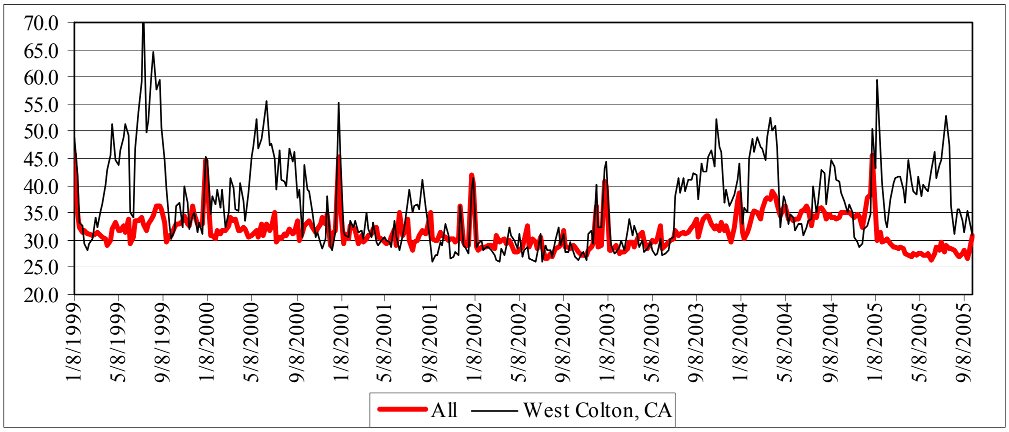
NS Knoxville Terminal Dwell Time
January 1999–September 2005



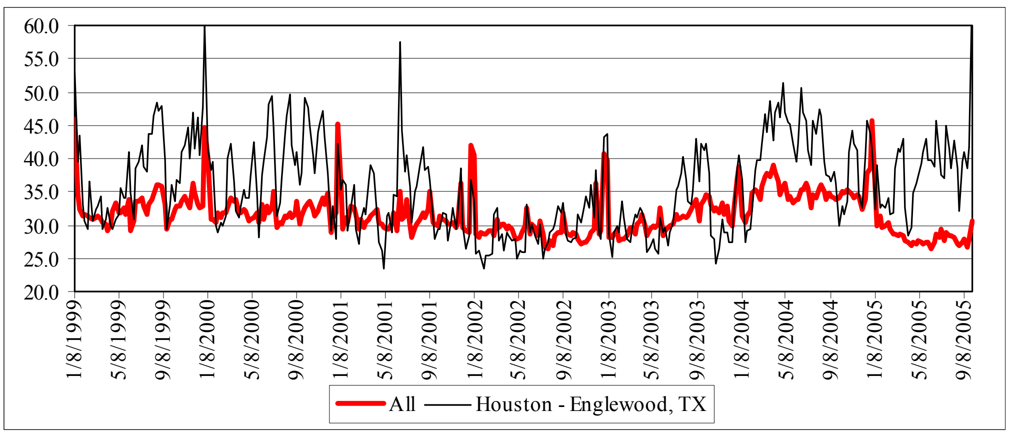
UP Houston-Settegast Terminal Dwell Time
January 1999–September 2005



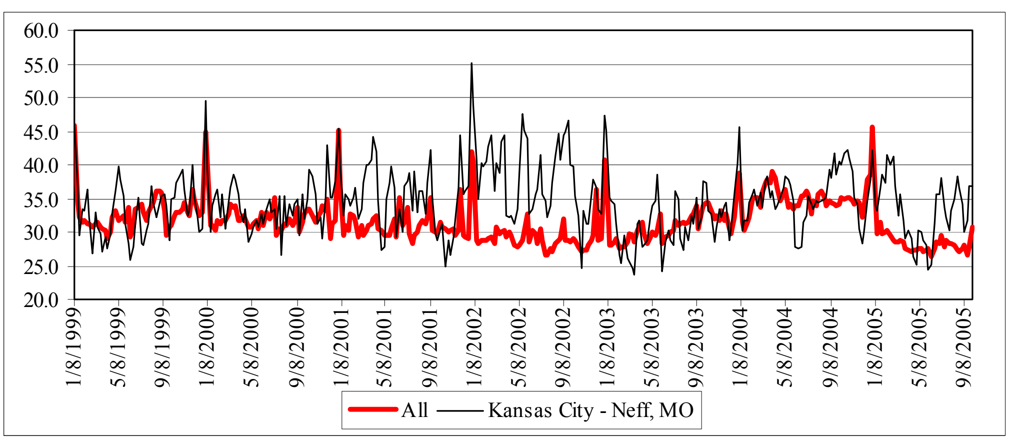
UP West Colton Terminal Dwell Time
January 1999–September 2005



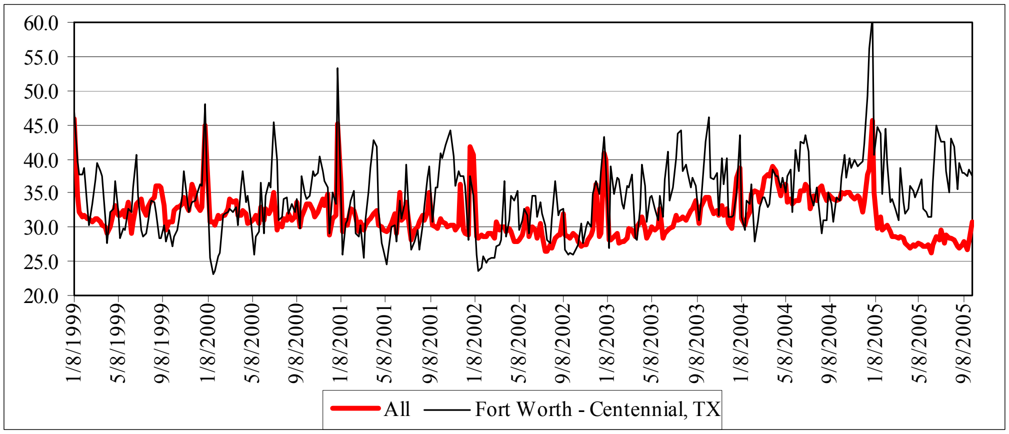
UP Houston-Englewood Terminal Dwell Time
January 1999–September 2005



UP Kansas City Terminal Dwell Time
January 1999–September 2005



UP FORTH WORTH TERMINAL DWELL TIME
JANUARY 1999–SEPTEMBER 2005



Chapter 17 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 17. SERVICE QUALITY

INTRODUCTION

In our qualitative research, respondents expressed concerns regarding service quality that included captive shippers receiving poorer service quality, and service quality declining as capacity became tighter. “Poor service” was defined in various ways, including failure to meet all service commitments, delivery variability, and unresponsiveness to shipper requests.

The primary dataset we are aware of for examining service quality issues is the weekly Railroad Performance Measures (RPM) that the Class I railroads provide to the AAR.[1] We have complete panel data for the Class I railroads from 1999 (when reporting began) through 2007. The RPM data are available on a weekly basis. The elements compiled in the RPM data that are most closely related to service quality and operating performance are average train speed and average terminal dwell time. Average train speed is defined as follows in the RPM:

> Train Speed measures the line-haul movement between terminals. The average speed is calculated by dividing train-miles by total hours operated, excluding yard and local trains, passenger trains, maintenance of way trains, and terminal time.[2]

As discussed in Chapter 16, terminal dwell time is defined as follows:

> Terminal Dwell is the average time a car resides at the specified terminal location expressed in hours. The measurement begins with a customer release, received interchange, or train arrival event and ends with a customer placement (actual or constructive), delivered or offered in interchange, or train departure event. Cars that move through a terminal on a run-

[1] Association of American Railroads, at http://www.railroadpm.org/.

[2] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

> through train are excluded, as are stored, bad ordered, and maintenance of way cars.[3]

The major limitation of the RPM data is that it is at a highly aggregate level, which does not allow us to adequately address service quality issues that may be specific to certain routes, commodities, or shippers. For example, these data do not allow us to test hypotheses about the relationship between shipper captivity and service quality. We asked members of our advisory panel if they were aware of any other data that would allow a more thorough examination of service quality issues. One panel member responded that railroads as well as many shippers record and keep data on service metrics such as cycle times. While such information is likely confidential, it was suggested that the STB may need to require the reporting of this type of data—possibly by route or by commodity—to better identify and rectify service quality issues.[4]

17A. Train Speed and Terminal Dwell Time

Train speed is an indicator of how well the network is performing. It is a measure of service quality as well as an indicator of network capacity and operational efficiency. The RPM data contain weekly data on train speed for the reporting Class I railroads. As mentioned in Chapter 16, because of definitional changes implemented in October 2005, data prior to October 2005 are not directly comparable to data after October 2005:

> Effective October 1, 2005, the railroads began applying a new, standardized definitional framework to produce the performance data reported on this Web site, eliminating the differences resulting from the calculation methodology. Where possible, data back to January 1, 2005, have been restated on the new basis.[5]

Therefore, we divide the data into two distinct periods. Furthermore, it must be cautioned that, because of the unique characteristics of each railroad, comparisons across railroads are not meaningful:

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[3] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

[4] The STB has available on its website complaint statistics by type of complaint and by commodity group going back to 2005. However, because of the aggregate nature of these statistics and the short time frame over which they are available, they are not useful for our purposes here.

[5] Association of American Railroads, at http://www.railroadpm.org/.

> Despite the use of a common methodology, one railroad's performance metrics cannot meaningfully be compared to another railroad's, due to differences including, but not limited to, those associated with network terrain and design characteristics, traffic mix, traffic volume, length of haul, extent of passenger operations, and operational practices — as well as external factors such as weather and port operations which can impact carriers differently.[6]

The RPM data report overall train speed for each railroad as well as for the following types of trains: intermodal, manifest, multilevel, coal unit, and grain unit. We use the weekly data on train speed to construct annual averages of train speed, which we call "annual train speed," for each railroad and train type.

Before discussing individual railroad details by train type, Table 17-1 presents changes in overall annual train speed for each of the Class I railroads. This table reports these annual changes by year for 2000 (i.e., the change between 1999 and 2000) through 2005 and also 2007, as well as the average of the annual changes for the 1999-2005 period.[7]

TABLE 17-1
CHANGES IN OVERALL ANNUAL TRAIN SPEED BY RAILROAD

	BNSF	CN	CP	CSX	KCS	NS	UP
2000	4.6%	-0.2%	2.0%	5.0%	8.0%	9.9%	1.8%
2001	-4.6%	1.7%	-2.7%	13.4%	0.7%	9.5%	-2.2%
2002	4.4%	10.3%	3.3%	4.2%	-2.4%	5.0%	2.2%
2003	-3.7%	-5.0%	-5.0%	-6.2%	7.3%	-0.6%	-5.9%
2004	-7.4%	-7.6%	-2.2%	-3.9%	0.2%	-1.9%	-9.4%
2005*	2.4%	3.3%	-12.7%	-4.6%	-11.4%	-3.5%	-0.7%
2007	2.0%	-6.0%	-6.4%	4.5%	0.0%	-0.2%	1.7%
Average 1999-2005*	-0.8%	0.3%	-3.0%	1.1%	0.2%	2.9%	-2.5%

*Statistics for 2005 only cover the months of January through September.

Below, we present tables for each railroad that show changes in annual train speed for all trains and by train type, as well as changes in the overall annual terminal dwell time. We also present two charts for each

[6] Association of American Railroads, at http://www.railroadpm.org/.

[7] For example, the values reported for 2000 reflect the change in annual train speeds between 1999 and 2000. Due to the redefinition of the RPM data in October 2005, we are unable to report changes for 2006.

railroad with quarterly average train speed by train type for 1Q99-3Q05 (Period 1) and 4Q05-4Q07 (Period 2).[8]

Burlington Northern Santa Fe

Table 17-2 shows that over the 1999-2005 period, BNSF's average annual train speeds declined marginally, with the largest declines occurring for intermodal and multilevel—the two fastest categories. Large declines generally occurred in 2003 and 2004 across all categories, coincident with increases in average terminal dwell time and major construction projects. Average BNSF dwell time increased every year but 2005, with a relatively large increase in 2003. All train categories exhibited increases in average speed during Period 2, with the greatest increase occurring for coal units, followed by intermodal.

TABLE 17-2
CHANGES IN BNSF AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

BNSF	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
2000	4.6%	-0.3%	1.2%	-2.2%	10.0%	5.6%	2.6%
2001	-4.6%	-0.8%	-1.5%	0.0%	-9.5%	-1.6%	3.2%
2002	4.4%	1.9%	5.4%	-1.9%	8.5%	5.8%	1.4%
2003	-3.7%	-6.3%	-5.6%	-3.3%	-1.9%	-4.5%	9.2%
2004	-7.4%	-5.3%	-6.3%	-8.5%	-7.5%	-5.1%	2.1%
2005*	2.4%	1.7%	6.4%	4.1%	3.5%	4.8%	-19.3%
2007	2.0%	4.5%	1.9%	1.8%	6.0%	2.3%	1.5%
Average 1999-2005*	-0.8%	-1.6%	-0.2%	-2.0%	0.3%	0.7%	-0.6%

*Statistics for 2005 only cover the months of January through September.

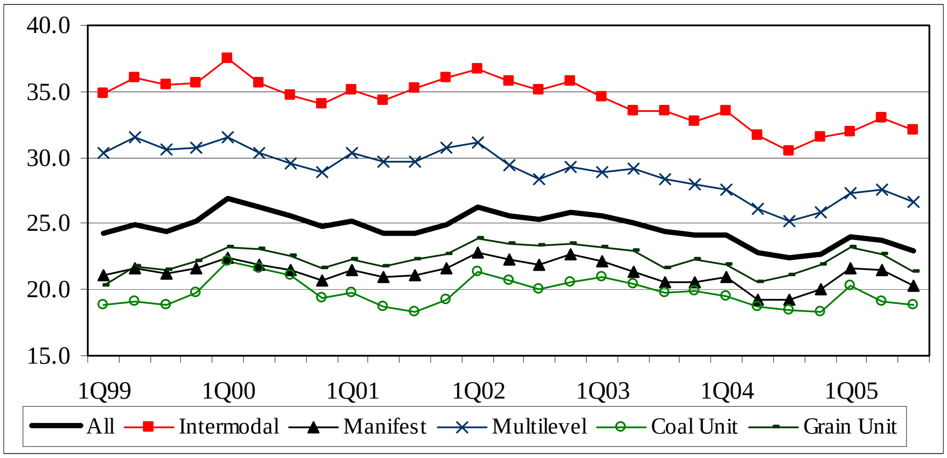
Figure 17-1 shows the general decline in BNSF's average train speeds in Period 1, led by the declines in intermodal and multilevel. All categories bottomed out in 2004, with 3Q04 being the lowest for most categories.

Figure 17-2 shows the general increase in BNSF's average speeds across categories during Period 2, led by coal units. The Period 2 pattern is also less volatile than the Period 1 pattern.

[8] Tables containing 2005 growth rates are based on data for January through September 2005.

FIGURE 17-1
BNSF AVERAGE TRAIN SPEEDS

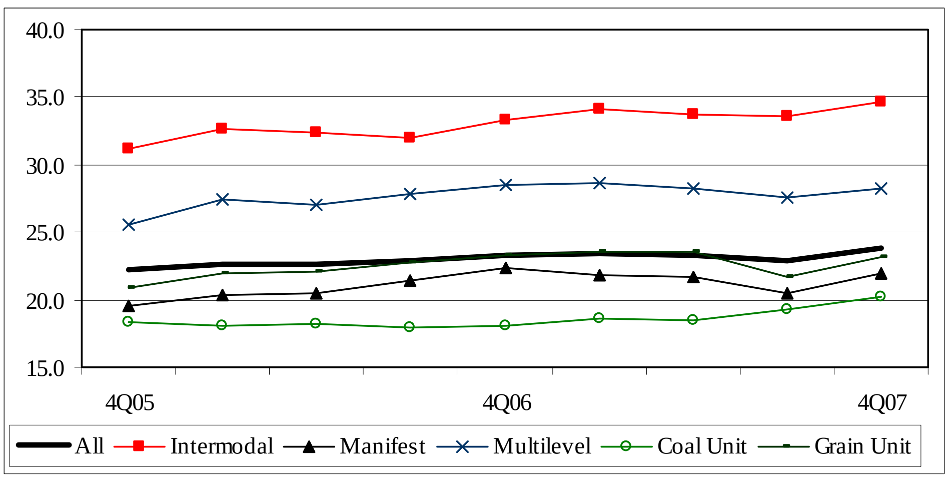
(miles per hour)
1Q99-3Q05



BNSF 1Q99-3Q05	**All**	**Inter-modal**	**Manifest**	**Multi-level**	**Coal Unit**	**Grain Unit**
Max	26.8	37.3	22.8	31.7	22.1	23.8
Min	22.4	30.5	19.2	25.2	18.3	20.3

FIGURE 17-2
BNSF AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



BNSF 4Q05-4Q07	**All**	**Inter-modal**	**Manifest**	**Multi-level**	**Coal Unit**	**Grain Unit**
Max	23.8	34.7	22.3	28.6	20.2	23.6
Min	22.3	31.2	19.5	25.6	18.0	20.9

Canadian National

Table 17-3 shows that CN's average train speeds increased slightly in Period 1 and had a relatively large decline in Period 2. Looking at annual changes, CN's average train speeds were somewhat volatile in Period 1, with the largest declines generally occurring in 2003 and 2004, coincident with increases in terminal dwell time. CN's average dwell time increased significantly in 2004, following a smaller increase in 2003. All other years in Period 1 witnessed decreases in CN's average terminal dwell time. The decrease in overall average train speed in Period 2 coincided with an increase in the average terminal dwell time.

TABLE 17-3
CHANGES IN CN AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

CN	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
2000	-0.2%	-3.7%	-1.6%	6.0%	-5.1%	-1.1%	-22.2%
2001	1.7%	3.2%	-2.9%	4.9%	9.5%	-10.3%	-23.2%
2002	10.3%	5.7%	13.4%	7.6%	17.4%	17.8%	-9.9%
2003	-5.0%	-1.6%	-4.8%	-2.0%	-7.9%	-12.2%	6.3%
2004	-7.6%	-5.4%	-5.0%	-5.7%	-28.4%	-4.0%	25.0%
2005*	3.3%	0.4%	3.3%	-0.3%	19.9%	15.6%	-16.9%
2007	-6.0%	-8.5%	-6.1%	-13.6%	5.7%	-3.4%	4.0%
Average 1999-2005*	0.3%	-0.3%	0.2%	1.7%	-0.6%	0.3%	-8.3%

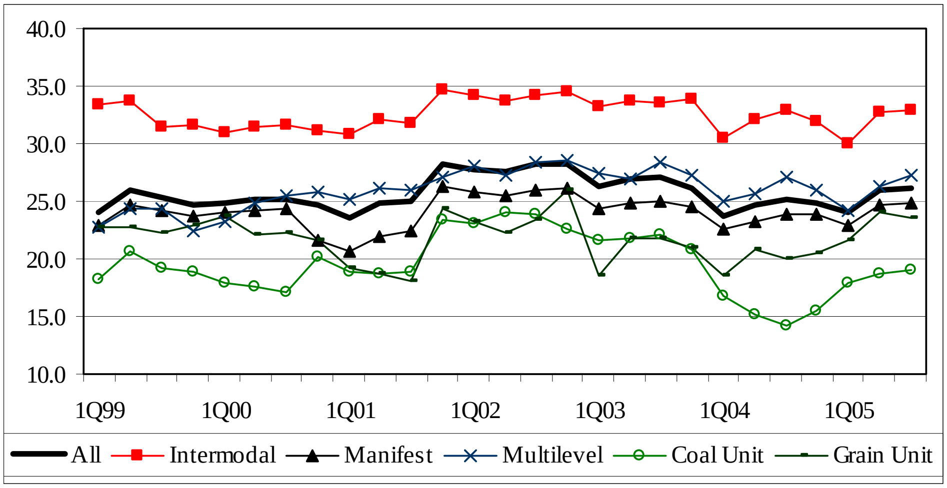
*Statistics for 2005 only cover the months of January through September.

Figure 17-3 shows that annual CN average speeds during Period 1 reached a low point during 2004. Particularly noticeable is the 28.4 percent decline for coal units in 2004, which bottomed out in 3Q04.

Figure 17-4 shows the general decline in CN average train speeds during Period 2. Bucking the trend, however, is the 5.7 percent increase for coal units, partially reversing the significant decline in 2004.

FIGURE 17-3
CN AVERAGE TRAIN SPEEDS

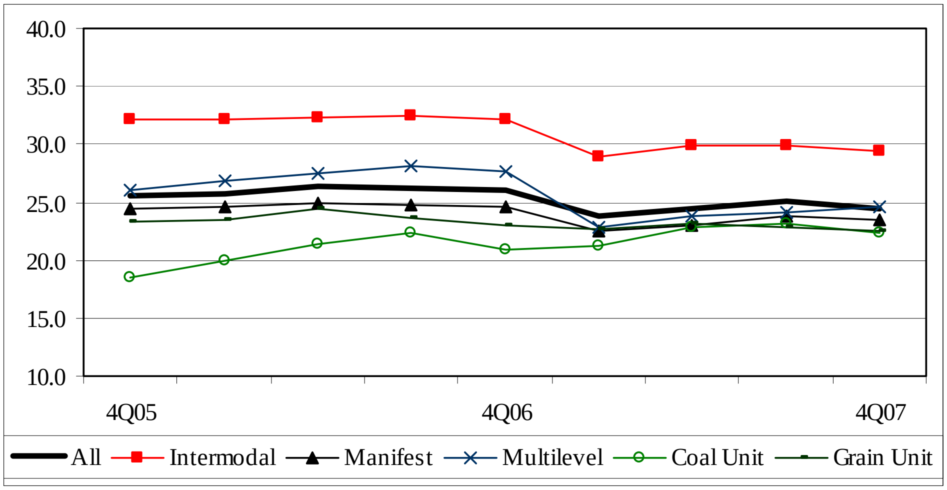
(miles per hour)
1Q99-3Q05



CN 1Q99-3Q05	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	28.3	34.7	26.2	28.6	24.1	25.9
Min	23.5	30.1	20.7	22.4	14.2	18.1

FIGURE 17-4
CN AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



CN 4Q05-4Q07	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	26.3	32.5	24.9	28.2	23.1	24.5
Min	23.8	28.9	22.6	22.8	18.4	22.6

Canadian Pacific

Table 17-4 shows a decline in average speeds in both Periods 1 and 2 across all categories for CP. In Period 1, the largest declines occurred in manifest, intermodal, and grain units. In Period 2, coal units had, by far, the largest decline. Large increases in CP's average terminal dwell time occurred in 2003, 2004, and 2007.

TABLE 17-4
CHANGES IN CP AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

CP	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
2000	2.0%	3.3%	-2.5%	-2.5%	3.3%	5.7%	1.9%
2001	-2.7%	-7.0%	-2.7%	2.3%	3.4%	-3.7%	0.8%
2002	3.3%	0.2%	1.7%	-0.3%	-2.5%	-5.1%	-0.6%
2003	-5.0%	-6.1%	-9.6%	-9.0%	-4.4%	-6.4%	9.4%
2004	-2.2%	-4.0%	-1.9%	-0.5%	0.0%	-3.0%	17.3%
2005*	-12.7%	-5.4%	-11.7%	2.1%	-8.4%	-6.3%	-19.4%
2007	-6.4%	-5.2%	-5.5%	-4.0%	-10.1%	-5.4%	7.5%
Average 1999-2005*	-3.0%	-3.3%	-4.6%	-1.4%	-1.5%	-3.2%	0.9%

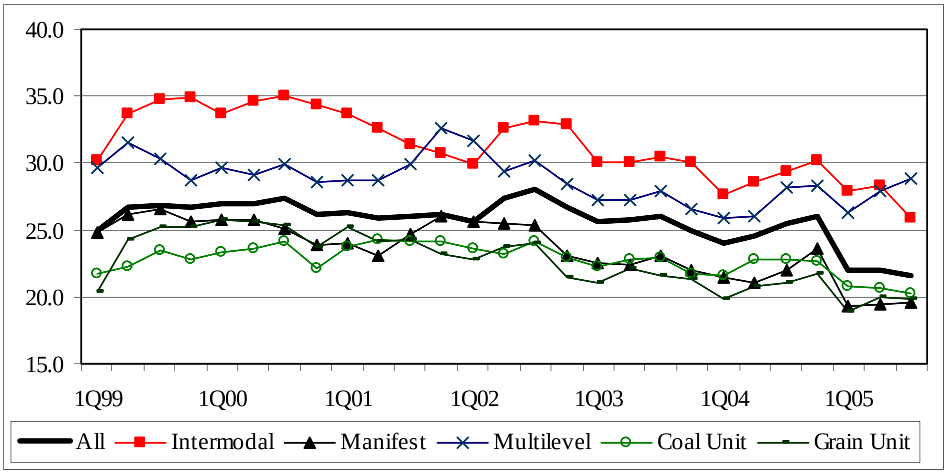
*Statistics for 2005 only cover the months of January through September.

Figure 17-5 illustrates the downward trend across all categories in CP's average speeds during Period 1.

Figure 17-6 shows that, after an initial increase, CP's average speeds decline across all categories during Period 2.

FIGURE 17-5
CP AVERAGE TRAIN SPEEDS

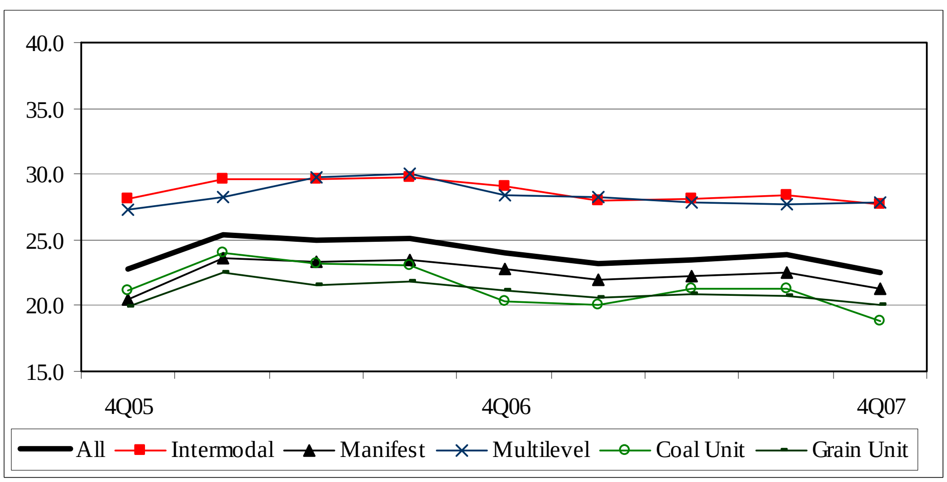
(miles per hour)
1Q99-3Q05



CP 1Q99-3Q05	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	28.1	35.1	26.5	32.6	24.2	25.7
Min	21.6	25.9	19.3	25.9	20.3	18.9

FIGURE 17-6
CP AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



CP 4Q05-4Q07	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	25.3	29.8	23.5	30.0	24.1	22.4
Min	22.5	27.7	20.5	27.3	18.9	19.9

CSX

Table 17-5 shows CSX average speeds during Period 1 increased modestly for all categories, except for a slight decline for intermodal. The declines in 2003 and 2004 were coincident with sizeable increases in average terminal dwell time. Average CSX terminal dwell time decreased in all other years. CSX's Period 2 average speeds increased across all categories, led by coal units.

TABLE 17-5
CHANGES IN CSX AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

CSX	All	Inter - modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
2000	5.0%	0.7%	6.9%	5.5%	-1.6%	4.3%	-7.7%
2001	13.4%	6.9%	16.9%	18.8%	11.5%	14.4%	-12.4%
2002	4.2%	1.0%	3.0%	2.3%	6.5%	2.0%	-4.7%
2003	-6.2%	-3.2%	-8.3%	-7.2%	-6.3%	-6.1%	8.5%
2004	-3.9%	-3.4%	-5.1%	-6.1%	-2.4%	-2.6%	16.7%
2005*	-4.6%	-2.2%	-4.8%	-3.1%	-3.3%	-4.0%	-15.3%
2007	4.5%	4.8%	2.8%	2.8%	9.0%	4.9%	-7.3%
Average 1999-2005*	1.1%	-0.1%	1.1%	1.3%	0.5%	1.1%	-3.1%

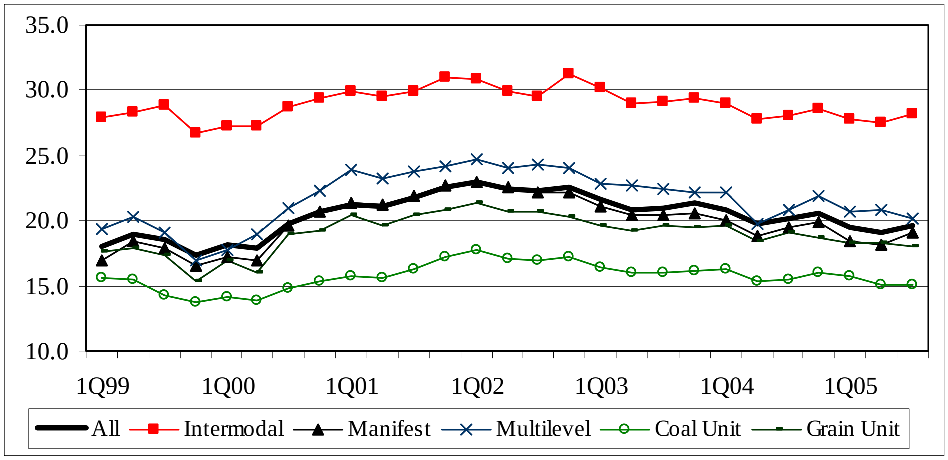
*Statistics for 2005 only cover the months of January through September.

Figure 17-7 shows that CSX's average speeds generally increased between 2000 and 2002, then declined into 2004.

Figure 17-8 shows the Period 2 increase in CSX's average speeds across all categories.

FIGURE 17-7
CSX AVERAGE TRAIN SPEED

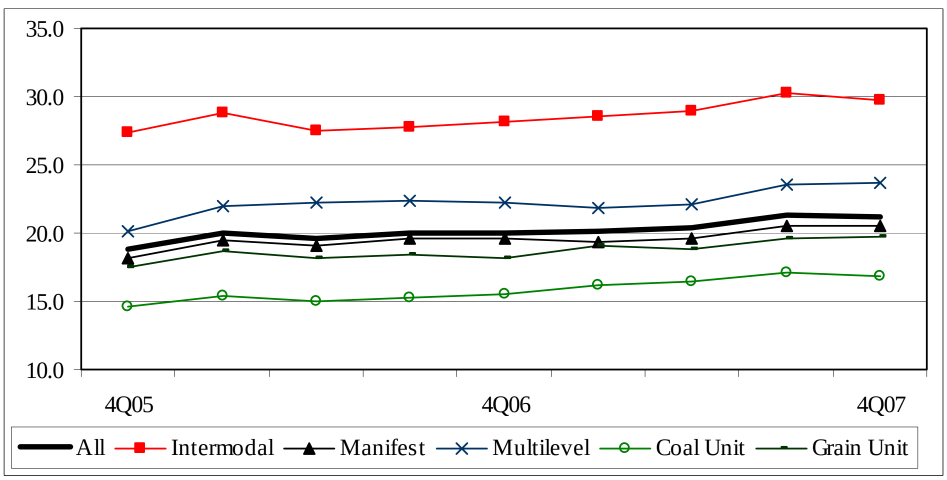
(miles per hour)
1Q99-3Q05



CSX 1Q99-3Q05	**All**	**Inter-modal**	**Manifest**	**Multi-level**	**Coal Unit**	**Grain Unit**
Max	23.0	31.2	22.9	24.7	17.7	21.4
Min	17.4	26.7	16.6	16.9	13.8	15.3

FIGURE 17-8
CSX AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



CSX 4Q05-4Q07	**All**	**Inter-modal**	**Manifest**	**Multi-level**	**Coal Unit**	**Grain Unit**
Max	21.4	30.2	20.5	23.7	17.1	19.7
Min	18.8	27.3	18.2	20.1	14.6	17.5

Kansas City Southern

Table 17-6 shows that KCS had a slight increase in its overall average speed in Period 1, with mixed results for the individual train types.[9] Coal units had the largest increase, and intermodal and manifest had slight declines. Large increases in KCS average terminal dwell time occurred in 2002 and 2004. In Period 2, there was no overall change in KCS's average train speed, but coal units had a sizable decline offsetting the increases for the other train types.

TABLE 17-6
CHANGES IN KCS AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

KCS	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
2000	8.0%	2.1%	7.9%	2.0%	21.5%	27.4%	-2.5%
2001	0.7%	-0.8%	2.1%	-0.8%	0.2%	0.2%	1.8%
2002	-2.4%	-1.7%	-1.6%	-1.7%	-3.2%	-1.0%	8.2%
2003	7.3%	6.4%	9.6%	6.4%	3.9%	-1.0%	-8.4%
2004	0.2%	1.1%	-1.0%	1.1%	4.8%	3.4%	7.0%
2005*	-11.4%	-8.7%	-11.8%	-8.7%	-8.3%	-10.5%	-5.6%
2007	0.0%	2.3%	1.7%	2.3%	-8.7%	0.7%	0.9%
Average 1999-2005*	0.2%	-0.4%	0.6%	-0.4%	2.8%	2.5%	-0.1%

*Statistics for 2005 only cover the months of January through September.

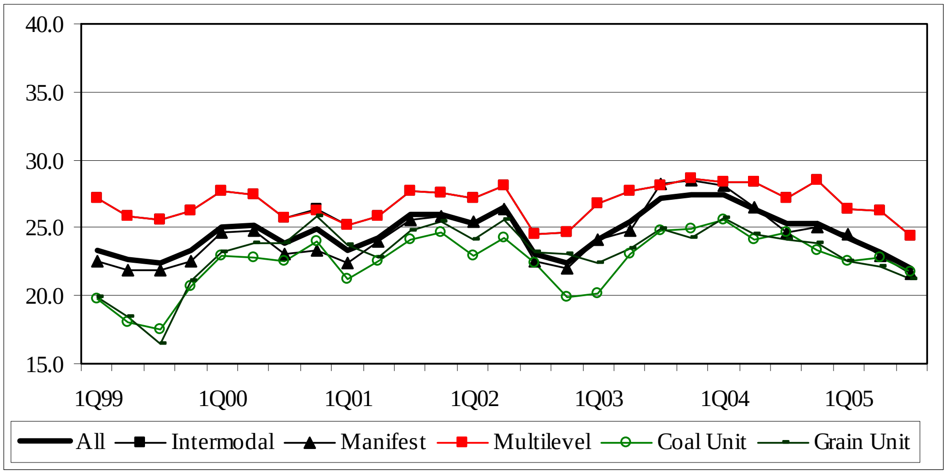
Figure 17-9 illustrates KCS's average speeds during Period 1. It can be seen that the average growth rates in Table 17-6 mask significant volatility during the period. After bottoming out in late 2002, average speeds in most categories increased in most quarters in 2003, but then declined throughout 2005.

Figure 17-10 shows an initial increase in KCS average speeds in Period 2 for all categories except intermodal/multilevel, followed by a flat-to-declining pattern.

[9] The original RPM data for KCS is identical for intermodal and multilevel. We note this and report the results as found in the original RPM data.

FIGURE 17-9
KCS AVERAGE TRAIN SPEEDS

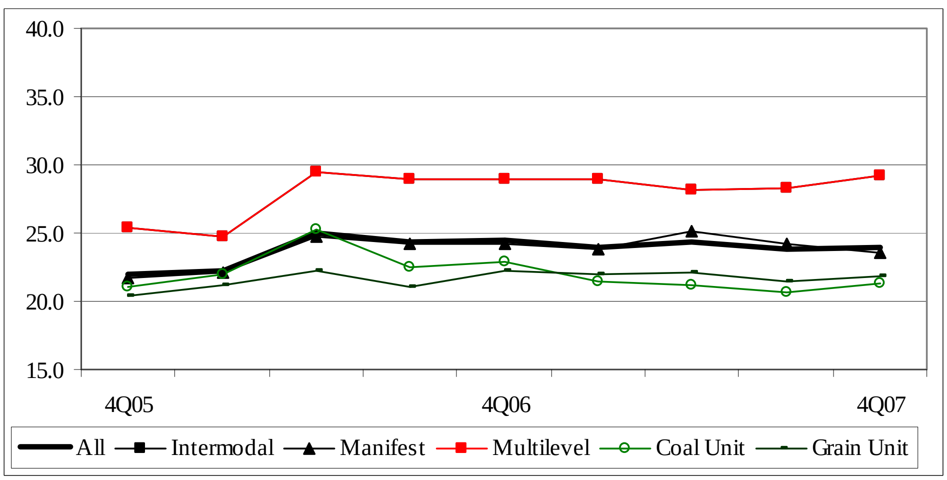
(miles per hour)
1Q99-3Q05



KCS 1Q99-3Q05	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	27.4	28.6	28.5	28.6	25.5	25.9
Min	22.0	24.4	21.6	24.4	17.5	16.5

FIGURE 17-10
KCS AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



KCS 4Q05-4Q07	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	25.0	29.5	25.2	29.5	25.2	22.2
Min	22.0	24.7	21.7	24.7	20.6	20.4

Norfolk Southern

Table 17-7 shows that NS's average speeds increased in all categories in Period 1, with manifest and grain units having the largest increases. NS's average terminal dwell time increased in 2003 and 2004, and declined in all other years. The overall Period 2 average declined slightly, with multilevel having the largest decline while coal units and intermodal posted increases.

TABLE 17-7
CHANGES IN NS AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

NS	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
1999							
2000	9.9%	4.4%	12.8%	-1.3%	4.2%	8.8%	-6.0%
2001	9.5%	8.8%	12.3%	14.4%	3.7%	10.4%	-7.4%
2002	5.0%	0.4%	5.6%	6.6%	3.7%	2.5%	-10.5%
2003	-0.6%	-0.9%	0.3%	0.3%	-4.8%	0.1%	4.4%
2004	-1.9%	-1.4%	-2.9%	-4.4%	-0.7%	-2.0%	1.6%
2005*	-3.5%	-3.3%	-4.2%	-3.0%	-1.2%	-4.1%	-11.3%
2007	-0.2%	1.0%	-1.5%	-3.4%	3.7%	-1.6%	-2.6%
Average 1999-2005*	2.9%	1.2%	3.8%	1.9%	0.8%	2.5%	-5.0%

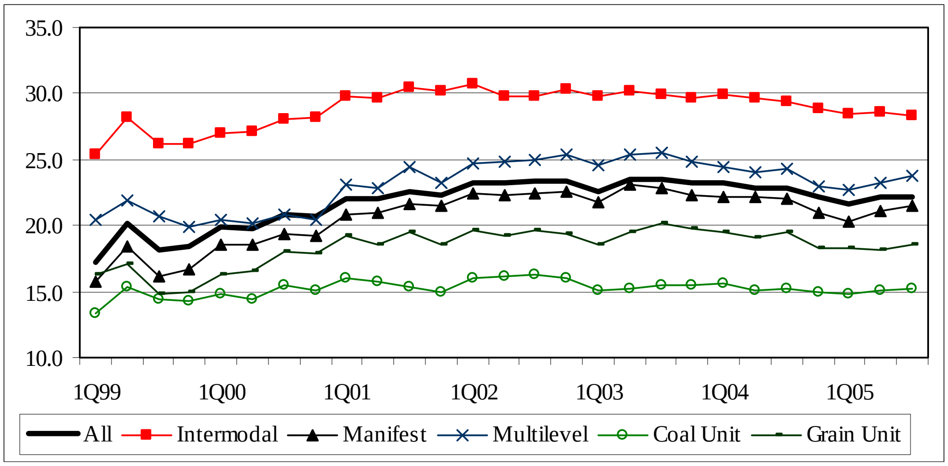
*Statistics for 2005 only cover the months of January through September.

Figure 17-11 shows that NS's average speeds increased from 1999 through about the beginning of 2002. Average speeds then remained about the same (except for coal units) until they declined slightly in 2004.

Figure 17-12 shows a relatively flat pattern for NS during Period 2, with coal units exhibiting a slight increase over the period.

FIGURE 17-11
NS AVERAGE TRAIN SPEEDS

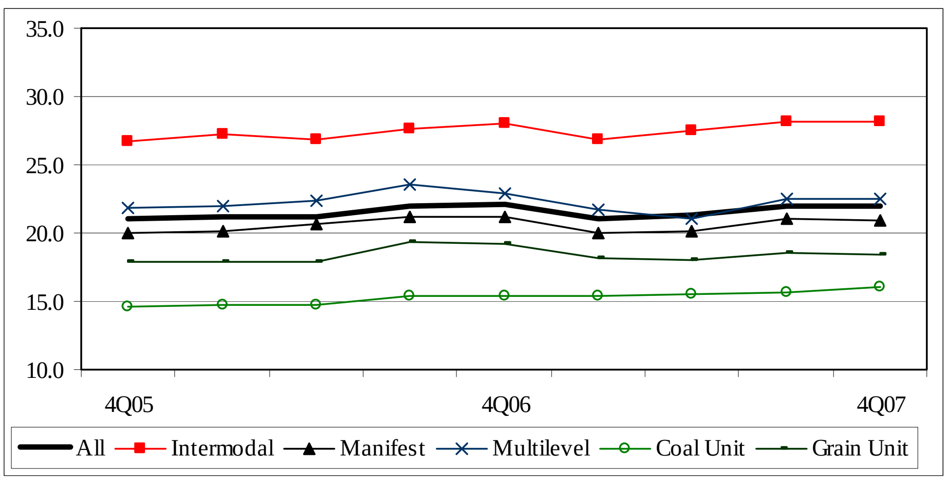
(miles per hour)
1Q99-3Q05



NS 1Q99-3Q05	**All**	**Inter-modal**	**Manifest**	**Multi-level**	**Coal Unit**	**Grain Unit**
Max	23.5	30.7	23.1	25.6	16.3	20.1
Min	17.3	25.4	15.7	19.9	13.4	14.9

FIGURE 17-12
NS AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



NS 4Q05-4Q07	**All**	**Inter-modal**	**Manifest**	**Multi-level**	**Coal Unit**	**Grain Unit**
Max	22.1	28.2	21.2	23.6	16.0	19.3
Min	21.0	26.7	19.9	21.1	14.6	17.8

Union Pacific

Table 17-8 shows that UP's average speeds declined across all categories in Period 1, with intermodal and multilevel declining the most. Large decreases in annual speed occurred in 2003 and 2004, coincident with increases in average terminal dwell time. UP's average terminal dwell time decreased in all other years. Average speeds increased during Period 2, led by intermodal and manifest.

TABLE 17-8
CHANGES IN UP AVERAGE ANNUAL TRAIN SPEEDS AND DWELL TIME

UP	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit	Dwell Time
2000	1.8%	2.1%	-2.6%	-1.8%	9.9%	1.2%	-1.8%
2001	-2.2%	-0.1%	0.1%	-1.2%	-4.7%	-5.3%	-3.6%
2002	2.2%	-1.7%	1.9%	1.3%	6.6%	2.2%	-5.5%
2003	-5.9%	-4.3%	-6.8%	-7.1%	-6.0%	-5.1%	5.3%
2004	-9.4%	-12.4%	-9.9%	-10.4%	-3.9%	-9.7%	13.2%
2005*	-0.7%	-5.4%	3.4%	0.6%	-4.0%	1.9%	-18.9%
2007	1.7%	3.6%	2.8%	1.2%	-1.9%	0.2%	-7.4%
Average 1999-2005*	-2.5%	-3.7%	-2.4%	-3.2%	-0.6%	-2.6%	-2.4%

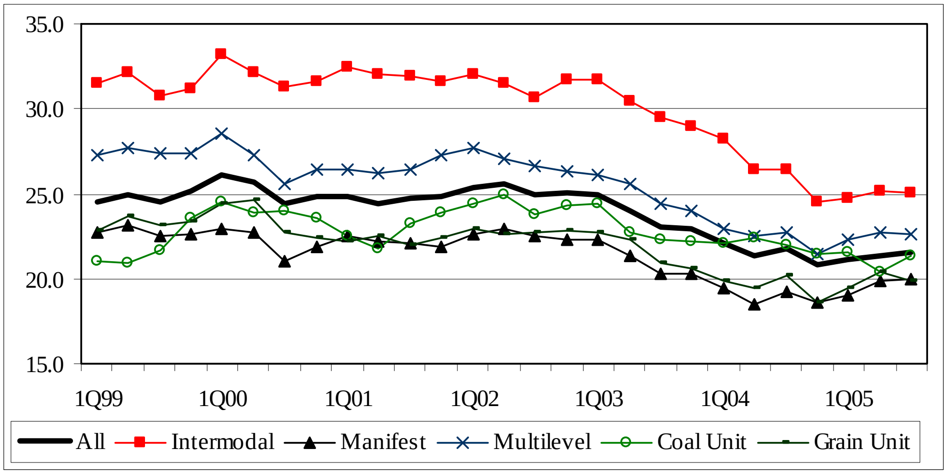
*Statistics for 2005 only cover the months of January through September.

Figure 17-3 illustrates the general downward trend in UP's average speeds during Period 1, with sharp decreases during 2003.

Figure 17-14 shows the increases in UP's average speeds during Period 2, led by the increases in intermodal.

FIGURE 17-13
UP AVERAGE TRAIN SPEEDS

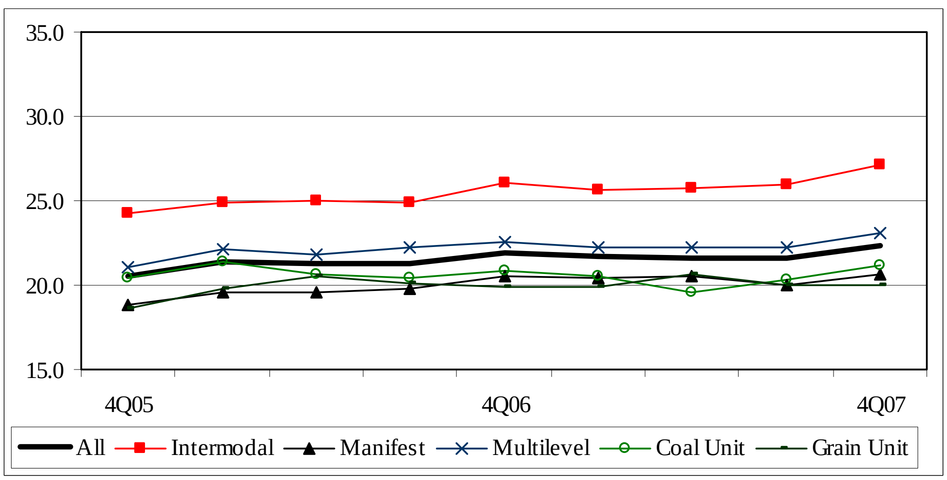
(miles per hour)
1Q99-3Q05



UP 1Q99-3Q05	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	26.1	33.2	23.1	28.6	24.9	24.6
Min	20.8	24.5	18.5	21.5	20.4	18.6

FIGURE 17-14
UP AVERAGE TRAIN SPEEDS

(miles per hour)
4Q05-4Q07



UP 4Q05-4Q07	All	Inter-modal	Manifest	Multi-level	Coal Unit	Grain Unit
Max	22.3	27.2	20.6	23.1	21.3	20.7
Min	20.6	24.3	18.8	21.1	19.5	18.7

Summary

Subject to the caveat regarding comparability across railroads, the following general observations emerge from our analysis of train speeds (and terminal dwell time) based on the RPM data examined above:

- Average train speed for the large Western railroads (BNSF and UP) declined, while average train speed for the large Eastern railroads (CSX and NS) increased between January 1999 and September 2005.
- In 2003 and 2004, there were widespread declines in average train speed across railroads (except for KCS) and increases in average dwell time that were particularly large for most railroads.
- Since 2006, average speed for the large Western railroads increased somewhat and results for the large Eastern railroads were mixed.
- Among types of train, intermodal is the fastest, followed by multilevel.[10] Coal unit trains are generally the slowest, although average speeds for manifest and grain units are often close, and sometimes below, the average speeds for coal units.

Table 17-9 presents correlations of changes in average train speed across railroads with changes in: (a) the RPM measure of terminal dwell time, (b) the RPM measure of cars on line, and (c) net ton-miles/road miles.[11] All data are aggregated over Class I railroads for each year, 1999-2005. Except for the annual change from 1999 to 2000, annual changes in dwell time are negatively correlated with annual changes in average train speed. Annual changes in cars on line are negatively correlated with the annual changes in average train speed for all years. Annual changes in net ton-miles per road mile are negatively correlated in 2002 and 2003, but positively correlated in the other four years. Recognizing that correlations do not necessarily imply causality, these correlations suggest that network congestion became particularly acute in 2002 and 2003 (to a lesser extent also in 2001 and 2004), having a negative impact on train speed. As we have seen in Chapter 16, this congestion was likely due to congestion at particular terminals or network points for each railroad and not due to overall capacity shortages in railroad networks. Thus, similar to congestion in communications and data networks being caused by limited

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[10] Canadian Pacific's intermodal and multilevel categories had similar average train speeds in most of Period 2. Also, as noted above, the original RPM data for KCS has identical speeds throughout for intermodal and multilevel.

[11] Net-ton miles data are obtained from R-1 Schedule 755, Line 114, Col B; miles of road data are obtained from R-1 Schedule 700, Line 57, Col I.

switching capacity despite almost limitless fiber optic cable capacity, our analysis indicates localized constraints or congestion having spillover effects on network-wide performance.

TABLE 17-9
CORRELATIONS WITH CHANGES IN AVERAGE TRAIN SPEED ACROSS RAILROADS BY YEAR

	Dwell Time	Cars on Line	Net Ton-Miles/ Road Miles
2000	0.29	-0.18	0.09
2001	-0.51	-0.83	0.03
2002	-0.79	-0.92	-0.78
2003	-0.93	-0.70	-0.51
2004	-0.28	-0.63	0.09
2005*	-0.39	-0.45	0.08

*Statistics for 2005 only cover the months of January through September.

17B. IMPLICATIONS FOR SERVICE QUALITY

Average train speed is a proxy for service quality, and changes in average speed represent changes in performance and service quality. The RPM data allow us to calculate average train speeds across a railroad's network for different train types, and comparisons of changes in average speed across train types provide an indication of changes in service quality for customers of these train types.[12] However, the RPM data do not allow for route-specific or corridor-specific analysis. Nor do the RPM data allow an evaluation of on-time performance or variability of performance from a shipper's perspective.

Not only do average speeds have implications for service quality, but variability in speed is also important. In fact, one of the major complaints we heard from shippers regarding service quality was that variability in railroad performance was a larger problem than the absolute level of performance. That is, shippers found unpredictable service performance to be more costly and problematic to deal with than service that resulted in longer but predictable delivery performance.

Changes in Average Speed by Train Type

Table 17-10 and Figure 17-15 present changes in average speed by train type during Period 1 for each of the Class I railroads. Changes in service quality across shipper types would be suggested if particular train types have changes in average speeds that are markedly different than the

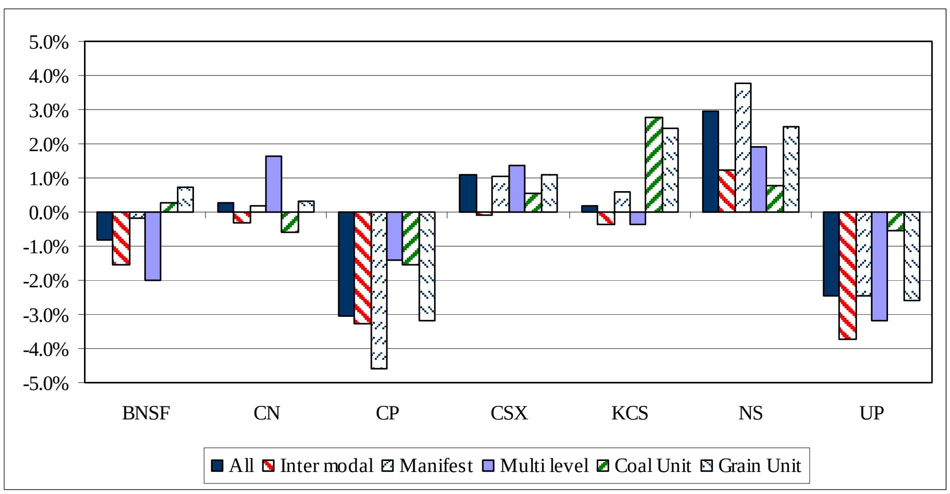
[12] Again, we caution that comparisons across railroads are not necessarily meaningful.

changes in average speeds of other train types. For example, in our stakeholder interviews, the opinion was expressed that high-margin services such as intermodal receive preferential service to the determinant of other commodity groups. Therefore, although it is admittedly at a very aggregate level, if we observe the average speed for intermodal increasing relative to the average speed of other train types, this would be evidence supporting the opinion voiced by some stakeholders.

TABLE 17-10
CHANGES IN AVERAGE SPEED BY RAILROAD AND TRAIN TYPE, 1999-2005

	All	Inter modal	Manifest	Multi level	Coal Unit	Grain Unit
BNSF	-0.8%	-1.6%	-0.2%	-2.0%	0.3%	0.7%
CN	0.3%	-0.3%	0.2%	1.7%	-0.6%	0.3%
CP	-3.0%	-3.3%	-4.6%	-1.4%	-1.5%	-3.2%
CSX	1.1%	-0.1%	1.1%	1.3%	0.5%	1.1%
KCS	0.2%	-0.4%	0.6%	-0.4%	2.8%	2.5%
NS	2.9%	1.2%	3.8%	1.9%	0.8%	2.5%
UP	-2.5%	-3.7%	-2.4%	-3.2%	-0.6%	-2.6%

FIGURE 17-15
CHANGES IN AVERAGE SPEED BY RAILROAD AND TRAIN TYPE, 1999-2005



From Table 17-10 and Figure 17-15 there does not appear to be any strong bias toward intermodal, as its average speed declined for all railroads except NS over the 1999-2005 period, and its change in speed was below that of the overall average for all the railroads. In fact, it was below the change in average speed of coal units and manifest for most railroads over this time period. There does not appear to be any systematic bias in favor of intermodal over this time period.

Variability in Average Speed by Train Type

The variability in average train speed by railroad and train type (and, presumably, the resulting variability in delivery performance to shippers) is measured by the coefficient of variation (CV), which is the ratio of the standard deviation of train speed to average train speed. Table 17-11 presents CVs of train speed by railroad and train type stated as a percent of average speed. Again, comparisons across railroads are not necessarily meaningful. However, for each railroad, examining CVs across train types reveals that the lowest CV in most cases is found for intermodal, especially during Period 1. Grain units and coal units typically have the highest CVs. The implication is that even though its average speed generally declined over this period, intermodal typically receives the most predictable service. On the other hand, coal units and grain units receive the least predictable service.

TABLE 17-11
VARIABILITY IN AVERAGE TRAIN SPEED BY RAILROAD AND TRAIN TYPE

Measured by the Coefficients of Variation

	Inter modal	Manifest	Multi level	Coal Unit	Grain Unit
1999-2005					
BNSF	3.6%	3.6%	4.2%	4.9%	4.6%
CN	3.9%	5.1%	6.1%	8.0%	9.4%
CP	5.1%	5.6%	6.8%	5.9%	7.3%
CSX	3.5%	5.1%	6.3%	4.4%	6.3%
KCS	5.5%	7.0%	5.6%	8.2%	8.9%
NS	3.2%	4.4%	5.4%	4.5%	7.1%
UP	3.6%	3.5%	3.9%	4.9%	5.1%
2006-2007					
BNSF	3.8%	4.3%	3.9%	4.4%	4.4%
CN	3.5%	3.5%	5.3%	5.9%	4.5%
CP	4.0%	3.6%	5.9%	8.9%	5.2%
CSX	3.4%	3.8%	4.5%	3.4%	4.3%
KCS	6.0%	4.6%	6.0%	6.5%	5.2%
NS	3.6%	4.1%	5.1%	3.6%	5.7%
UP	3.6%	3.1%	3.2%	4.2%	3.7%

CONCLUSION

The average train speeds calculated from RPM data provide a crude, aggregate proxy for the railroad service performance received by shippers. As discussed above, our advisory panel noted that railroads as well as many shippers record and keep data on service metrics such as cycle times. While such information is likely confidential, it was suggested that the STB may need to require the reporting of this type of data—possibly by route or by commodity—to better identify and rectify service quality issues.

Chapter 18 Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 18. CONCLUSIONS ON THE STATE OF COMPETITION IN THE U.S. FREIGHT RAILROAD INDUSTRY

INTRODUCTION

In this chapter, we provide an assessment of the current state of competition in the U.S. freight railroad industry based on the results of our research. We begin with an aggregate assessment and then provide evidence at a commodity-specific level. The aggregate assessment in Section 18A is based on our macro overview of the railroad industry from Chapter 8 and the results of our industry-wide variable cost function estimation described in Chapters 9 and 10, which relied primarily on R-1 data for the Class I railroads. The commodity-specific evidence in Section 18B is based on the estimated results from our shipment-level pricing equations presented in Chapters 11 through 15, which relied on unmasked Carload Waybill Sample (CWS) data. Section 18C provides a synthesis of our analysis as it relates to shipper captivity issues. Finally, Section 18D summarizes the findings of our research on railroad capacity and performance issues found in Chapters 16 and 17.

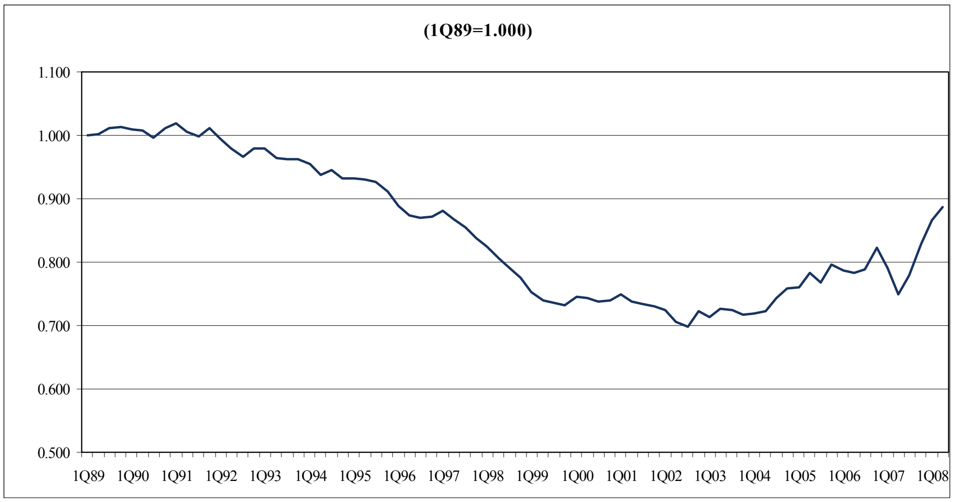
18A. AGGREGATE ASSESSMENT OF CLASS I INDUSTRY STRUCTURE AND PERFORMANCE

From our assessment of the railroad industry's financial and productivity performance, and our estimation of the industry-wide variable cost function, a number of important features of the Class I railroad industry's aggregate cost and rate structures emerge. These features cast light and valuable perspective on the industry's overall structure and performance.

Productivity and Input Prices

Our analysis in Chapter 8 established that there has been a slowdown in the railroad industry's productivity growth and an increase in its input price growth that has put upward pressure on railroad unit costs in recent years. Figure 18-1 displays the STB's RCAF-A index, which was described in Chapter 8 as the difference between railroad input price growth and productivity growth and, thus, measures changes in railroad unit costs. This figure illustrates that after reaching a minimum near the end of 2002, there has been an upward trend in railroad unit costs (captured by the RCAF-A Index) beginning in 2003.

FIGURE 18-1
QUARTERLY RCAF-A INDEX



Economic Costs, Revenue Sufficiency, and Market Power

The behavior of unit costs as measured by RCAF-A is largely consistent with the pattern of economic costs that we obtained from our estimation of the Class I railroads' variable cost function with R-1 data (Chapters 9 and 10). Figure 18-2 shows the relationship among average total cost (ATC), average variable cost (AVC), and marginal cost (MC) for the Class I railroad industry. The difference between ATC and AVC at any point represents the amount of average fixed cost (AFC) at that point. To achieve revenue sufficiency (i.e., revenue equal to total cost), on average, rates must exceed average variable costs by the amount of average fixed costs. At a minimum, this reinforces the widely recognized fact that pricing at either marginal cost or variable cost will not produce sustainable revenues for the railroad industry.

FIGURE 18-2
CLASS I RAILROADS' COST STRUCTURE

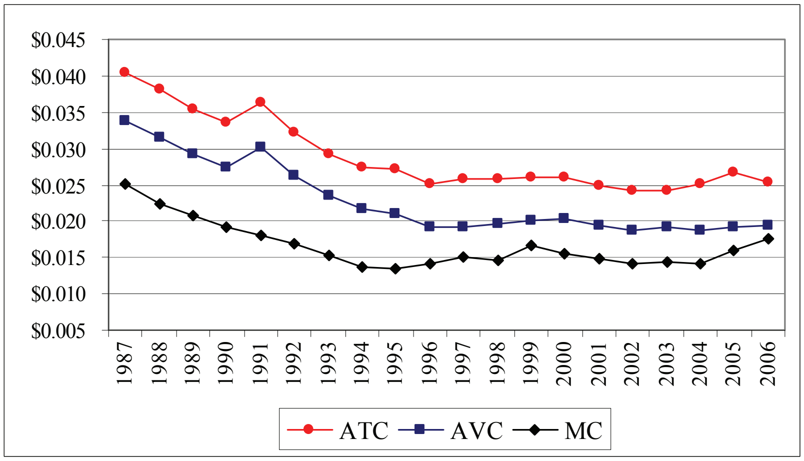
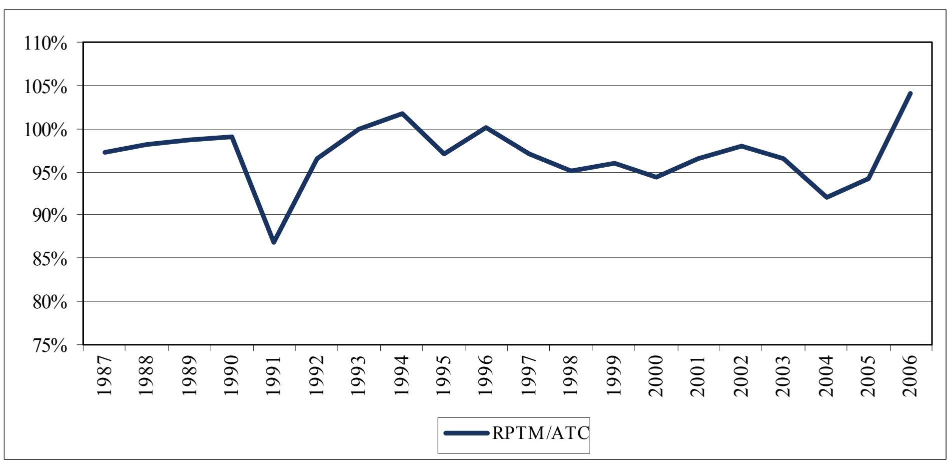


Figure 18-3 displays the average RPTM/ATC ratio for the Class I railroad industry (where RPTM represents revenue per ton-mile). This ratio is a measure of the industry's *revenue sufficiency* (indicated by RPTM/ATC = 100 percent). It can be seen from this measure that the industry has flirted with revenue sufficiency for a number of years, but has only achieved or surpassed it a few times in the mid-1990s and in 2006 (1993 = 100.0%, 1994 = 101.7%, 1996 = 100.0%, 2006 =104.1%).[1]

FIGURE 18-3
CLASS I RATIO OF AVERAGE RPTM TO AVERAGE TOTAL COST



[1] We note that the measures of costs that we develop from the R-1 data do not include any current assets, such as cash. Furthermore, our calculations are based on some variables defined for the econometric analysis undertaken in Chapter 9 and may not conform to conventional financial analysis. Thus, the ratio of revenue to cost presented in Figure 18-3 is revealing, but should not be viewed as the definitive indicator of revenue sufficiency.

Figure 18-4 shows that the railroad industry's average RPTM and marginal costs have generally tracked each other. The difference between RPTM and marginal costs was approximately 1.4 cents in 1987, and then gradually declined to approximately 1 cent by 1997. Since 1997, the difference has fluctuated around 1 cent. Although the differential between RPTM and marginal costs was relatively stable in the 1987-1994 and 1997-2006 periods, the percentage changes in RPTM and marginal costs have exhibited more noticeable differences, which one can see by looking at the Lerner Markup Index.[2]

FIGURE 18-4
CLASS I AVERAGE RPTM AND MARGINAL COSTS

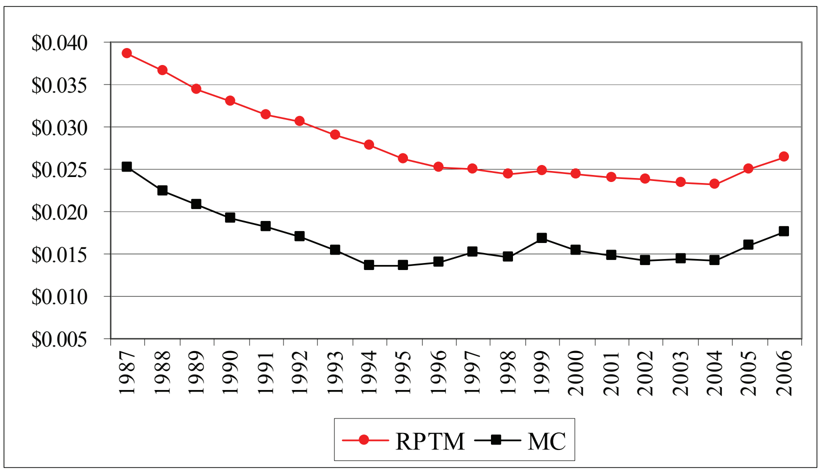


Figure 18-5 displays the Lerner Markup Index for the Class I railroad industry. It shows that between 1987 and 1994, the Class I railroads' pricing power steadily increased as the percentage decreases in marginal costs exceeded the percentage decreases in price (RPTM). However, as indicated in Figure 18-3, the railroad industry was still at or below revenue sufficiency through 1993.

[2] The Lerner Markup Index is defined as the ratio of the difference between price and marginal cost to the price, which in this case is equal to (RPTM − MC) / RPTM. As discussed in Chapter 10, the Lerner Markup Index is a measure of market power. The Lerner Markup Index is also known as the Lerner Index or the Lerner Market Power Index, and it is sometimes abbreviated as LMI in this report and elsewhere in the literature.

FIGURE 18-5
CLASS I RAILROAD'S LERNER MARKUP INDEX

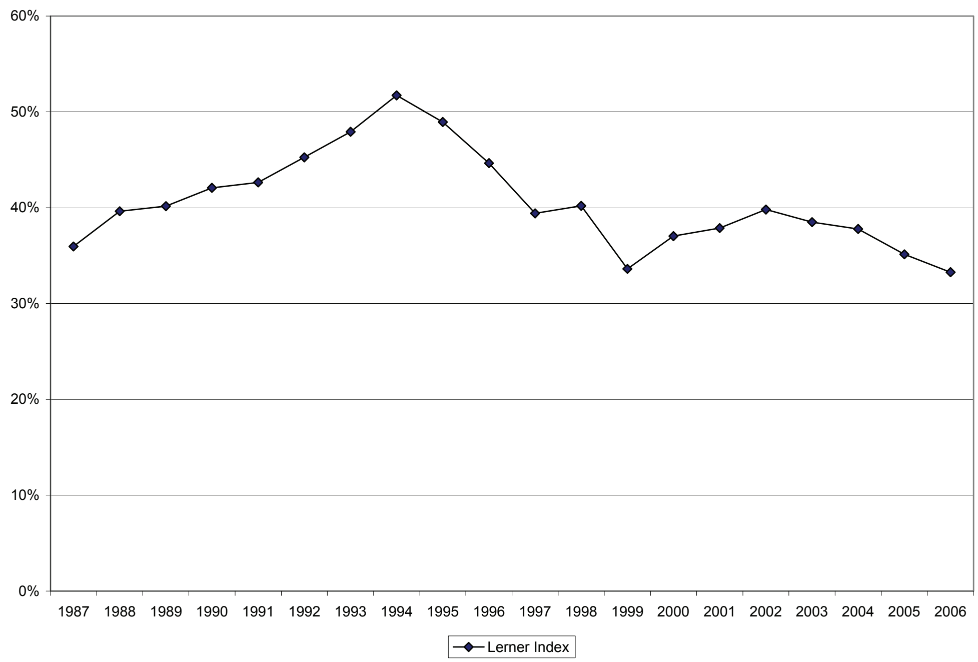
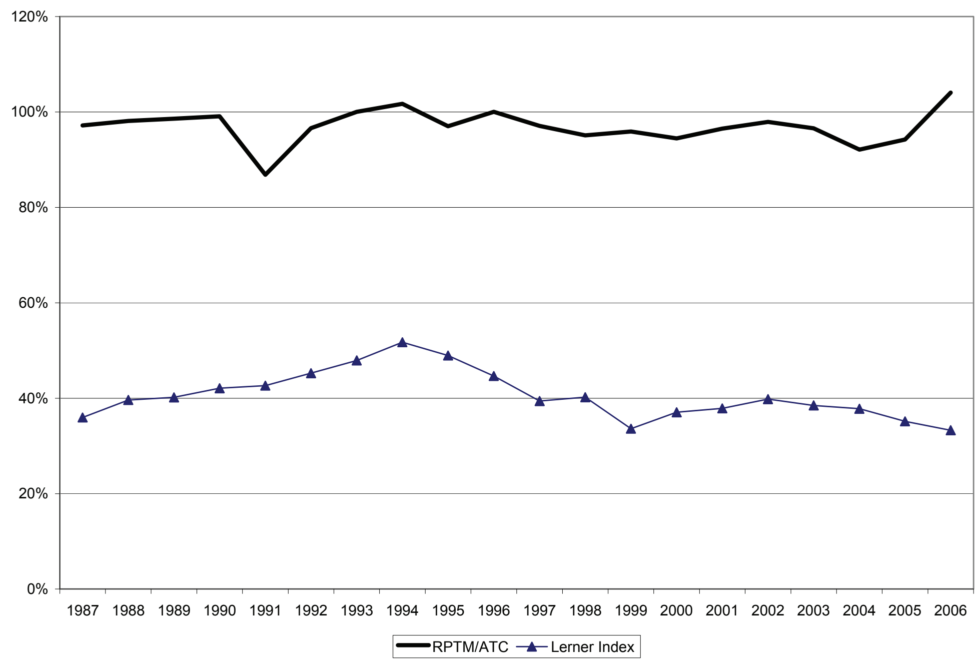


Figure 18-6 compares the Lerner Markup Index (LMI)[3] with the measure of revenue sufficiency introduced in Figure 18-3. It can be seen that, in the case of the railroad industry, periods of increasing LMI were not indicative of railroads accruing excess profits, but rather reflected a movement toward revenue sufficiency. From 1995 to 1999, the LMI generally decreased with increasing marginal costs. Between 2000 and 2002, there was some recovery of the industry's pricing power largely resulting from declining marginal costs. Again, however, viewing these results in relation to the revenue sufficiency measure shows that this run-up in the LMI is not an indication that the railroad industry accrued excess profits. Since 2003, the LMI has trended back to its 1999 level as the percentage increases in marginal cost have outpaced the percentage increases in price.

[3] Note that the vertical scale changes between Figures 18-3 and 18-6 and also between Figures 18-5 and 18-6, which causes the revenue sufficiency and Lerner Markup Index curves to appear flatter in Figure 18-6.

FIGURE 18-6
COMPARISON OF CLASS I REVENUE SUFFICIENCY AND LERNER MARKUP INDEX



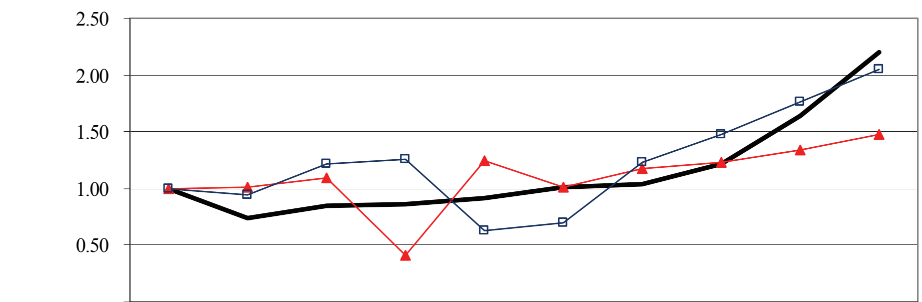
Financial Market Evidence

The results of our econometric analysis of the railroad industry's revenue sufficiency are generally consistent with the analysis of railroad financial performance we performed in Chapter 8. In that chapter, we examined the railroad industry's earnings relative to the STB's determination of the industry's cost of equity and also relative to the earnings of benchmark industries. Regarding the comparison to the STB's determination of cost of equity, we noted that there was controversy surrounding the CAPM methodology recently adopted by the STB for determining a railroad's cost of equity.[4] Recognizing this controversy, a comparison of return on shareholders' equity for railroads to the STB's CAPM measure of cost of equity for railroads, shows returns in excess of the cost of equity from 2000 through 2005 (with variation by individual railroad). However, using the STB's previous discounted cash flow method shows that railroads did not earn their cost of capital over the period of analysis (1997 to 2005). Given the methodological controversies and the divergence of these results, our assessment was that it was difficult to draw conclusions about whether the railroad industry had generated excessive profits.

[4] For example, see Petition of the Association of American Railroads to Institute a Rulemaking Proceeding to Adopt a Replacement Cost Methodology to Determine Railroad Revenue Adequacy, May 1, 2008.

Although the railroad industry's earnings have increased in recent years, earnings do not appear to be excessive from a financial market perspective. Among the financial metrics we examined in Chapter 8, two commonly cited financial measures are earnings per share (EPS) and the price-earnings (P/E) ratio. We found that over our analysis period, 1997 to 2006, there were many similarities among the financial performances of the railroad industry, the electric utilities industry, and the S&P 500 composite. Figure 18-7 shows that the upward trend in the railroad industry's EPS in recent years is somewhat greater than the trend shown for the S&P 500.

FIGURE 18-7
EARNINGS PER SHARE

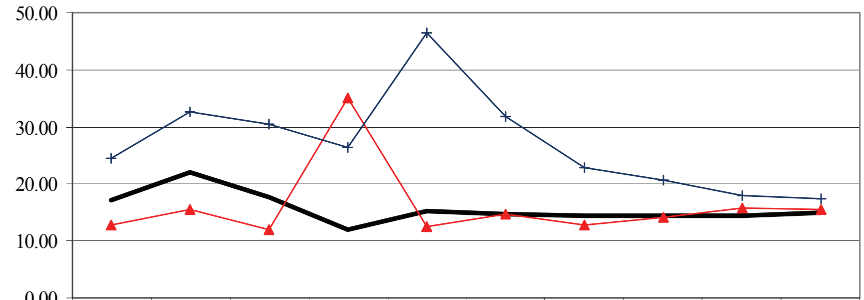


	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Rail	1.00	0.74	0.85	0.86	0.91	1.02	1.03	1.22	1.64	2.20
Util	1.00	1.01	1.09	0.41	1.25	1.01	1.18	1.23	1.34	1.48
S&P 500	1.00	0.95	1.21	1.26	0.62	0.69	1.23	1.47	1.76	2.05

Figure 18-8 shows that the railroad industry's P/E ratio has trended slightly downward since the late 1990s and was very similar to that of the electric utilities industry in 2006. The P/E ratio for the S&P 500 companies peaked in 2001 and dropped sharply afterward, but remained above the P/E ratios for railroads and electric utilities. As we illustrated in Chapter 8, the railroad industry had the second-lowest P/E ratio relative to our benchmark industries.[5] Therefore, despite the improvement in the railroad industry's financial performance since 2004, railroad stocks have not commanded higher P/E multiples. At the very least, the relatively low P/E ratio is an indication that investors do not anticipate and, hence, are not willing to pay for, the prospects of excessive returns in the railroad industry.

[5] Electric utilities, freight transportation, chemicals, and food processing are the industries used in our benchmark analysis.

FIGURE 18-8
PRICE-EARNINGS RATIOS



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Rail	17.21	21.95	17.69	11.85	15.12	14.54	14.37	14.54	14.52	14.82
Util	12.90	15.50	11.94	35.14	12.59	14.54	12.81	14.25	15.82	15.46
S&P 500	24.43	32.60	30.50	26.41	46.50	31.89	22.81	20.70	17.88	17.40

Implications for Competitive Performance of Railroad Industry

Our major conclusions from the results of our aggregate variable cost function analysis are that density and fixed costs make markups over marginal cost necessary for the railroad industry. By definition, the setting of price above marginal cost is the exercise of market power, but exercise does not imply abuse. In the case of the railroad industry, despite increasing markups at various points in time (as measured by the Lerner Markup Index), the railroad industry has only sporadically achieved revenue sufficiency.

As we concluded in Chapter 10, our overview of costs and revenues leads us to several basic findings. First, the exercise of market power appears to have increased in the freight railroad industry over the last twenty years but, for the most part, has not generated excess profits; exercise of market power is not necessarily abuse of market power. The largest increases in market power appear to occur in periods when marginal cost is declining. In these periods, the average revenue per ton-mile did not decline proportionately with marginal cost. In periods of cost increases, market power either declined or held steady. Second, the increased exercise in market power over the last twenty years has been necessary in order to obtain revenue sufficiency. That is, at an aggregate level, the markup of marginal cost has increased over time, but it does not appear that excess net revenue was generated. By our R-1 based measure of revenue sufficiency, RPTM/ATC, the railroad industry has flirted with revenue sufficiency for a number of years, but has only achieved or surpassed it a few times in the mid-1990s and in 2006. Third, economies of density are consistently the primary factor driving the markup of marginal cost for railroads. Finally, the recent substantial increase in revenue per ton-mile appears to be largely the result of increases in variable, fixed, and marginal costs (reflecting a slowdown in productivity growth and an increase in input price growth) and not due to the increased exercise of market power.

The results of our financial market analysis, found in Chapter 8, are largely consistent with our econometric findings. In particular, while the railroad industry's financial performance has improved in recent years, including a general increase in margins, this has allowed the industry to achieve revenue sufficiency. The fact that the railroad industry's P/E ratio for 2006 was in the same range as that of the electric utilities industry, and still below that of the S&P 500 companies, is an indication that investors did not expect excessively high returns in the railroad industry.

18B. Commodity-Specific Analysis of Competition and Rates

While the overall assessment of the railroad industry provides meaningful perspective, there are important issues that do not stand out in the aggregate analysis. Our commodity-specific analyses of Chapters 11 through 15 based on CWS data provide more detailed insights that are useful for assessing the structure and performance of the railroad industry. To help focus on market segments that may not be performing according to competitive standards and may suffer excessively from the exercise of railroad market power, we review our findings regarding commodity-specific marginal costs and markups as well as the responsiveness of average commodity-specific railroad rates to various types of competition.

Commodity-Level Costs and Markups for Class I Railroads

Table 18-1 displays median values of estimated adjusted marginal costs and Lerner Markup Indexes by commodity for non-interchanged shipments from our results presented in Chapter 11.[6]

TABLE 18-1
MEDIAN ESTIMATED ADJUSTED MARGINAL COSTS AND LERNER MARKUP INDEXES BY COMMODITY
CLASS I RAILROADS, 2001-2006

Commodity Group	Adjusted MC*	LMI
Farm Products (Aggregate)	0.9	0.59
Barley	0.7	0.69
Corn	0.7	0.70
Wheat	0.7	0.68
Soybeans	0.9	0.58
Metallic Ores	2.2	0.43
Coal	0.9	0.41
Nonmetallic Minerals	2.0	0.41
Food Products	1.2	0.54
Lumber or Wood Products	1.4	0.58
Chemicals	1.6	0.56
Petroleum or Coal Products	1.5	0.59
Clay, Concrete, Glass, or Stone Products	1.7	0.56
Primary Metal Products	1.9	0.49
Transportation Equipment	5.0	0.40
Intermodal Shipments (COFC/TOFC)	4.3	-0.52

*2000 Q1 cents per ton-mile.

[6] As explained in Chapter 11, we obtain marginal costs per ton-mile by Class I railroad and year from the variable cost function estimates discussed in Chapter 9, along with the average length of haul used to evaluate the marginal costs. We adjust the generic marginal cost at the shipment level using the cost-shifting variables and their estimated coefficients (ln TONS, ln TONSCAR, ln MILES, ln VOL_TONS and D_OWN) for shipments originated and terminated by the same Class I railroad. We take the railroad's weighted annual averages of these variables as the base against which the cost shift is computed.

We do not adjust the costs for the origin-destination effects, since those effects combine latent cost, competition, and market demand factors. This limits our ability to capture features that may give specific shipments higher or lower costs relative to other shipments with similar measured cost characteristics. However, we can examine the adjusted costs and RPTM for "typical" (median) shipments in order to analyze costs and markups at the commodity level.

We focus on the recent 2001-2006 period to examine the railroads' current use of their pricing flexibility, including their exercise of local market power.[7] Given that railroads must price above marginal cost in the aggregate to achieve financial viability, a major issue for analyzing railroad pricing is how mark-ups are assigned to various categories of shippers. From the economic analysis in Chapter 11, we would expect a railroad to charge higher markups to shippers whose demands for rail services are perceived by the railroad to be relatively inelastic—i.e., relatively unresponsive to railroad price changes. The perceived demand elasticity would depend on factors such as the product being shipped, shipper characteristics, and the availability of railroad and non-railroad shipping competition for the whole or segments of the shipment's route.

As discussed in Chapter 11, we find that estimates based on shipment cost characteristics available in the CWS dataset lead to commodity-level costs that may differ markedly from Class I railroads' "generic" costs (i.e., costs not differentiated by shipment characteristics). We observe relatively low adjusted costs for commodities typically hauled in large-scale bulk shipments, such as grains and coal, and high adjusted costs for transportation equipment and intermodal shipments, both of which exhibit very low average weight per carload.

We estimate relatively low markups for coal, metallic ores, nonmetallic minerals, and transportation equipment. Railroad-specific markup calculations show below-average markups for coal shipments carried by BNSF and UP, suggesting that there may be effective competition at the origin point via the joint line serving the south Powder River Basin.[8] Estimated markups are highest for grains, which have low revenue per ton-mile but also exhibit low-cost shipment characteristics.[9] In this regard, we find it unsurprising that grain shippers are relatively vocal on "captive shipper" issues.

We believe that our negative LMI estimate for intermodal shipments is an anomaly resulting from data limitations for intermodal shipment characteristics in the CWS dataset. Intermodal shipments have some low-cost characteristics that are not included in the CWS dataset and therefore cannot be incorporated in our estimated pricing models and adjusted marginal cost calculations. Intermodal shipments are billed and recorded as single-carload shipments, but tend to travel long distances as a unit, thereby avoiding substantial switching and classification costs typical

[7] This period incorporates the most recent available unmasked confidential Carload Waybill Sample data (from 2006).

[8] The high concentration of PRB coal originations in Campbell County, Wyoming, combined with the county-level measurement of railroad competition at the origin point, prevents us from observing variations in market structure for most PRB coal through the railroad competition variables in our pricing models.

[9] See Chapter 11, Table 11-3.

of non-intermodal single-carload shipments. Additional data on intermodal shipments, including service characteristics, would produce a more accurate measure of the actual markup for intermodal shipments. Since intermodal shipments represent a large share of the railroad industry's revenues, improved data collection on these shipments is highly desirable. We expect that better information on intermodal shipments' actual costs used in our pricing model would yield positive estimated markups, but still relatively low markups compared to other commodities.

The markup patterns that appear in Table 18-1 for the other commodities are mostly consistent with our expectations and with the information we gathered in our qualitative research. We expect lower markups for less time-sensitive bulk commodity shipments, which is largely borne out by our results for coal, ores, and nonmetallic minerals. Grain shippers appear to be justified in believing they are paying relatively high markups.

Table 18-2 shows the median values of estimated adjusted marginal costs and Lerner Markup Indexes for the 2001-2003 and 2004-2006 periods.

TABLE 18-2
MEDIAN ESTIMATED ADJUSTED MARGINAL COSTS AND LERNER MARKUP INDEXES BY COMMODITY BY PERIOD
CLASS I RAILROADS

	Adjusted MC*		LMI	
Commodity Group	**2001-2003**	**2004-2006**	**2001-2003**	**2004-2006**
Farm Products (Aggregate)	0.9	0.9	0.60	0.58
Barley	0.8	0.6	0.66	0.72
Corn	0.6	0.6	0.70	0.71
Wheat	0.8	0.7	0.66	0.69
Soybeans	0.9	0.9	0.61	0.56
Metallic Ores	2.3	2.7	0.41	0.39
Coal	1.0	0.9	0.39	0.45
Nonmetallic Minerals	1.8	2.3	0.46	0.30
Food Products	1.2	1.3	0.55	0.53
Lumber & Wood Products	1.4	1.4	0.58	0.56
Chemicals	1.6	1.6	0.59	0.54
Petroleum & Coal Products	1.6	1.5	0.60	0.58
Clay, Concrete, Glass, & Stone	1.7	1.7	0.57	0.56
Primary Metal Products	1.8	2.2	0.52	0.47
Transportation Equipment	4.9	5.1	0.45	0.35
Intermodal Shipments	4.3	4.3	-0.51	-0.54

*2000 Q1 cents per ton-mile.

This table provides an indication of whether recent rate increases have been mainly cost-driven or markup-driven. With respect to marginal costs, it shows that despite the increase in industry-wide marginal costs in 2004-2006 (see Figure 18-4), some commodities show decreases in their adjusted marginal costs in the 2004-2006 period. Some shippers apparently avoided, to some extent, the "generic" increases in costs by adopting lower-cost shipment characteristics. For example, we observe that average car loadings and length of haul increased materially for coal shipments between the 2001-2003 and 2004-2006 periods, partly due to the continued shift to Powder River Basin coal. These cost-saving changes in shipment characteristics for coal helped to offset the "generic" increase in marginal costs per ton-mile in the latter period. Thus, the estimated adjusted marginal costs for coal declined slightly between the two periods; the adjusted marginal costs would have been higher without the cost-reducing changes in shipment characteristics. However, this does not consider any adjustment costs that may have been incurred by shippers to adopt lower-cost shipment characteristics. In contrast, shipments of nonmetallic minerals and primary metal products did not exhibit substantial cost-saving changes in their tons per car and length of haul characteristics between the two periods; with little offset from shipment-characteristic changes, the estimated marginal costs for these two commodity groups increased in the latter period.

The estimated LMIs reported in Table 18-2 showed declines for 12 of the 16 commodity groups from the 2001-2003 period to the 2004-2006 period. Three of the four LMI increases were for grains, which already had high estimated markups. The estimated LMI also increased for coal in the latter period. It should be noted that the declining estimated LMIs for commodities other than grains and coal do not reflect constant shipment characteristics. In our qualitative research phase, we heard from shippers (particularly coal shippers) who noted that long-term, low-priced contracts had expired in this time frame and were replaced by higher-priced contracts or tariff rates.[10] Such changes increase incentives to form shipments with lower-cost characteristics to partly offset the less favorable terms. We observe material shifts to lower-cost characteristics for various commodities in the CWS data, suggesting that shippers as a whole have some ability to substitute less costly shipment characteristics. However, shippers who are unable to adjust their shipping practices towards lower-cost characteristics may face substantial rate increases in periods of increasing industry costs.

Effectiveness of Competition

A critical issue that lies at the heart of the debate over policy proposals for the railroad industry is whether there is sufficient effective

[10] Long-term contracts may contribute to stickiness of rates to the extent that they do not allow for the immediate pass-through of railroad cost increases to shippers.

competition to prevent railroads from exercising market power beyond what is necessary to achieve revenue adequacy. The economic model of Chapter 11 points to roles for intramodal and intermodal competition in limiting a railroad's market power, but does not specify which forms of competition will provide the most binding constraints on railroad pricing or the magnitudes of these price effects. The results of our commodity-specific analyses provide evidence regarding effective intramodal and intermodal (water) competition.[11]

Through our railroad competition variables (RRCOMP_ORG and RRCOMP_TER), we estimate the effects on RPTM from increasing the number of railroads, taking into account the market share of each railroad at both origin and destination.[12] As explained in Chapter 11, a value of 1.05 for the railroad competition variable implies one of the two railroads has over 97 percent of the market, a value of the railroad competition variable of 1.5 implies one of the railroads has over 80 percent of the market, two equal-sized competitors gives a value of 2, and three equal-sized competitors puts the value at 3.[13]

Figure 18-9 measures the effectiveness of railroad competition at the origination county of the shipment in terms of changes in railroad rates (i.e., RPTM) for selected commodity groups.[14]

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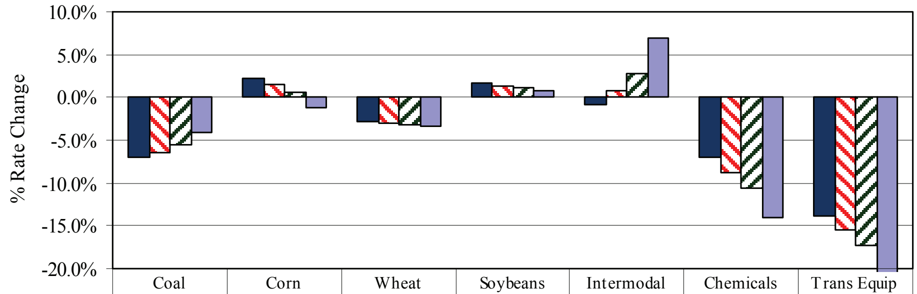
[11] In our analyses, we consider the truck transportation alternative to be both ubiquitous (theoretically accessible to any shipper, unlike other railroad or water alternatives), and generally a high marginal cost alternative. Trucks nevertheless may have total-cost and/or service-quality advantages for specific movements.

[12] As described in Chapter 11, RRCOMP_ORG and RRCOMP_TER are constructed as the reciprocal of a Herfindahl index based on shares of tons originated (RRCOMP_ORG) or terminated (RRCOMP_TER) by railroads serving the county.

[13] Pricing behavior in the absence of railroad competition may involve the exercise of local market power. But since the absence of competitive transportation options can trigger regulatory review of rail rates, railroads that otherwise could exercise market power may be constrained by regulatory mechanisms.

[14] While Figure 18-9 and 18-10 measure the effects of railroad competition at the origin and destination county, respectively, it is important to note that sizeable shares of the commodity shipments originate in counties where only one railroad shipped the specified commodity.

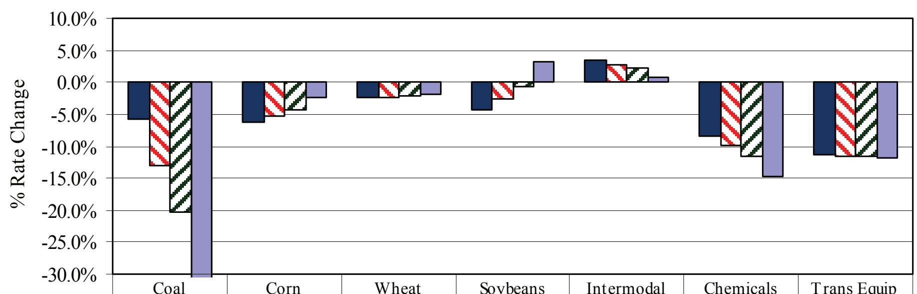
FIGURE 18-9
RAILROAD COMPETITION AT ORIGIN AND % CHANGE IN RPTM
2001-2006 SAMPLE PERIOD



	Coal	Corn	Wheat	Soybeans	Intermodal	Chemicals	Trans Equip
1.05	-7.0%	2.2%	-2.9%	1.6%	-0.9%	-7.1%	-13.9%
1.5	-6.4%	1.4%	-3.0%	1.4%	0.8%	-8.7%	-15.5%
2	-5.6%	0.5%	-3.1%	1.2%	2.8%	-10.6%	-17.3%
3	-4.1%	-1.3%	-3.4%	0.7%	6.9%	-14.1%	-20.7%

Figure 18-10 measures the effectiveness of railroad competition at the destination for these commodity groups.

FIGURE 18-10
RAILROAD COMPETITION AT DESTINATION AND % CHANGE IN RPTM
2001-2006 SAMPLE PERIOD

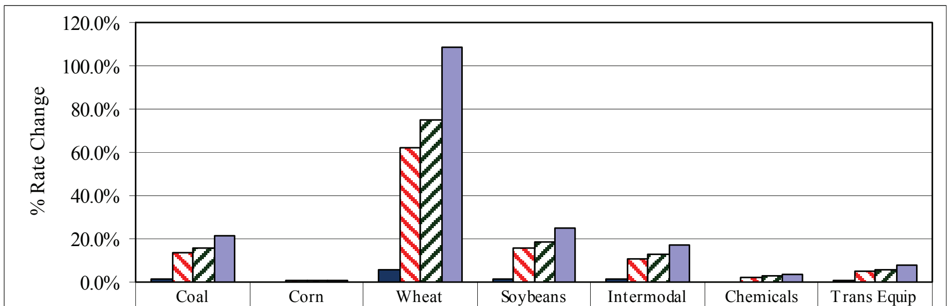


	Coal	Corn	Wheat	Soybeans	Intermodal	Chemicals	Trans Equip
1.05	-5.8%	-6.1%	-2.5%	-4.2%	3.4%	-8.4%	-11.4%
1.5	-13.0%	-5.3%	-2.3%	-2.6%	2.8%	-9.9%	-11.5%
2	-20.3%	-4.3%	-2.2%	-0.7%	2.1%	-11.6%	-11.6%
3	-33.2%	-2.3%	-1.8%	3.1%	0.8%	-14.8%	-11.8%

Figures 18-9 and 18-10 show that the responsiveness of RPTM to railroad competition varies by commodity. We observe stronger responses of RPTM to railroad competition for coal, chemicals, and transportation equipment than for corn, wheat, soybeans, and intermodal shipments. The average RPTM for coal shipments is low, but the prospect of attracting regular unit train shipments to large generating stations (railroad competition at destination) may justify the investments needed for competitive entry. Chemicals and particularly transportation equipment have relatively high average RPTMs and average to above-average markups, and thus also may be attractive targets for competitive entry. We also understand that chemical shippers have made use of reciprocal switching agreements to gain access to additional competitive options. Grain shippers, on the other hand, expressed concern during the qualitative analysis phase of our research that railroads did not seem to be very interested in competing on price for their business, and our results bear out such views. Intermodal shipments are an anomaly in that increased rail competition in some cases increases RPTM; we believe non-price competition and capacity constraints on key routes during the sample period contribute to this unexpected result.

Figures 18-11 and 18-12 provide a similar analysis for the effects of waterway competition on RPTM for selected commodities. Average effects on rates are displayed for 1-mile, 50-mile, 100-mile, and 500-mile distances from port/waterway facilities. Increasing the distances to port/waterway facilities would tend to reduce railroad pricing constraints from water transport, as the cost of accessing the alternative mode increases. Thus, we would expect increasing distances to port/waterway facilities would tend to increase RPTM, other things equal.

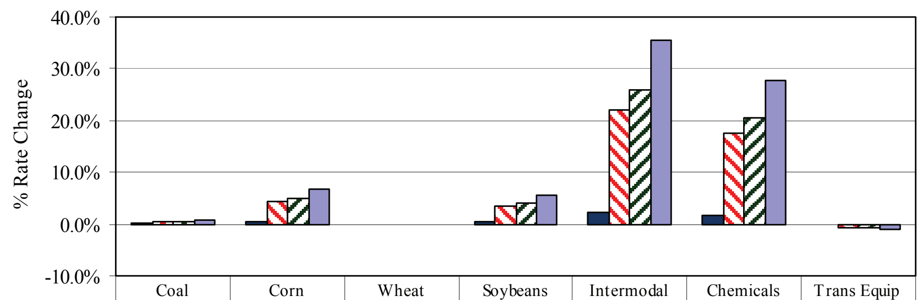
FIGURE 18-11
DISTANCE TO PORT OR WATERWAY FACILITIES AT ORIGIN AND % CHANGE IN RPTM 2001-2006 SAMPLE PERIOD



	Coal	Corn	Wheat	Soybeans	Intermodal	Chemicals	Trans Equip
1	1.4%	0.1%	5.4%	1.6%	1.1%	0.2%	0.5%
50	13.4%	0.6%	61.9%	15.8%	11.0%	2.2%	5.0%
100	15.7%	0.7%	74.7%	18.6%	12.8%	2.5%	5.8%
500	21.1%	0.9%	108.4%	25.1%	17.2%	3.3%	7.7%

Figures 18-11 and 18-12 show mostly expected results, though again the magnitudes of the effects vary considerably by commodity. The strongest effect of water competition at origin is for wheat. Rail shipments of wheat include shipments from locations, notably near the Columbia River system, where rail and truck-barge shipments may be competitive, as well as insular Plains growing areas where distances from waterways and other industrial and population centers are sufficiently great as to effectively eliminate the competitive threat from other shipping modes. Intermodal and chemical shipments show strong effects from water competition at the destination. Since intermodal import and export shipments often involve oceanic shipping as part of their end-to-end movements, rail alternatives involve shipping goods to or from different ports. We understand from our qualitative research that container shippers do use port competition to seek lower rail rates. Chemical production is somewhat concentrated along the Texas Gulf Coast and along various waterways (for example, the Delaware River), so the feasibility of the water alternative may depend in large part on water access at the shipments' destinations.

FIGURE 18-12
DISTANCE TO PORT OR WATERWAY FACILITIES AT DESTINATION AND % CHANGE IN RATES
2001-2006 SAMPLE PERIOD



	Coal	Corn	Wheat	Soybeans	Intermodal	Chemicals	Trans Equip
1	0.0%	0.5%	0.0%	0.4%	2.2%	1.8%	-0.1%
50	0.4%	4.3%	-0.2%	3.6%	22.1%	17.4%	-0.6%
100	0.5%	5.0%	-0.2%	4.2%	26.0%	20.5%	-0.7%
500	0.6%	6.7%	-0.2%	5.5%	35.5%	27.8%	-0.9%

Implications for Competitive Performance of Railroad Industry

From our analysis of particular commodity groups, we find generally expected effects on rail rates from increasing railroad competition at the origin and from increasing the distance from the origin to the nearest available water transportation. That is, rates generally tend to be lower given increased competition from other railroads or from increased proximity to water transportation alternatives at the origin, and higher for shippers with more limited railroad and water options at the origin. However, the existence of competitive responses is double-edged. Such responses illustrate the extent to which shippers who lack railroad or intermodal alternatives are at least relatively "captive" and pay higher rates (which may or may not exceed quantitative markup thresholds for market-dominance tests) for shipments with the same cost characteristics as those of more favorably situated shippers. Furthermore, in situations where other modes of transportation (such as water), and not potential railroad competition provide the effective constraint on rail rates, policies to enhance railroad competition will not benefit affected shippers.

The result that shippers with fewer transportation alternatives pay higher rates is not unexpected in light of our findings in the industry-wide variable cost model of Chapter 9 and the constrained market-dominance model of Chapter 11. Railroads' economies of density imply that they must implement positive markups over marginal cost per ton-mile in order to cover their total variable and "quasi-fixed" costs. Employing such local market power as is available is one means by which railroads achieve "revenue adequacy."

From Chapters 11 through 15, our results with respect to a single railroad serving the origin county indicate that rail rates are commonly higher than they would be in the presence of even very limited railroad competition. Railroads appear to exercise local market power where possible, but are tempered by the prospect that rates may be moderated by regulatory attention if not direct intervention. That is, monopoly railroads may effectively cede some market power to avoid regulatory scrutiny.

18C. Analysis of Shipper Captivity

GAO Analysis

The analysis of shipper captivity in the 2006 GAO report includes the computation of shares of shipments generating revenues in excess of 180 percent and 300 percent of URCS variable cost, and discussion of changes in those shares over time. GAO presented its analysis in the context of the statutory role played by the 180 percent revenue/variable cost (R/VC) threshold in triggering rate reviews, and the limited availability of data to properly measure or serve as proxies for shipper captivity:

> Nevertheless, our analysis of available measures indicates that the extent of captivity appears to be dropping, but the percentage of industry traffic traveling at rates substantially over the statutory threshold for rate relief has increased. For example, the amount of traffic traveling at rates over 300 percent of the railroad's variable cost increased from 4 percent in 1985 to 6 percent in 2004. Furthermore, some areas with access to one Class I railroad have higher percentages of traffic traveling at rates that exceed the statutory threshold for rate relief.[15]

[15] Government Accountability Office, *Freight Railroads: Industry Health Has Improved,*

In Chapter 11, we examined 2000-2001 and 2005-2006 Carload Waybill Sample data and found that the fractions of tonnage and ton-miles exceeding 180 percent R/VC were relatively constant, but the fractions exceeding 300 percent R/VC increased (see Table 18-3).. Our results are consistent with the direction of the GAO findings. We also examined the shares of traffic traveling at rates less than 100 percent R/VC, which are substantial and, interestingly, also increased between the two periods.

TABLE 18-3
PERCENT OF TONS AND TON-MILES BY R/VC CATEGORY
2000-2001 VS. 2005-2006 CARLOAD WAYBILL SAMPLE DATA

Period	Percent of Tons by R/VC Category				
	R/VC < 100 Percent	R/VC between 100 and 180 Percent	R/VC between 180 and 300 Percent	R/VC > 300 Percent	Subtotal R/VC > 180 Percent
2000-2001	16%	50%	28%	6%	34%
2005-2006	21%	45%	25%	9%	34%

Period	Percent of Ton-Miles by R/VC Category				
	R/VC < 100 Percent	R/VC between 100 and 180 Percent	R/VC between 180 and 300 Percent	R/VC > 300 Percent	Subtotal R/VC > 180 Percent
2000-2001	22%	57%	19%	2%	21%
2005-2006	29%	51%	16%	4%	19%

R/VC Data Issues

In Chapter 11, we discussed two main issues with the R/VC data in the CWS that we believe make this ratio an unreliable indicator of market-dominant behavior. First, there is evidence of methodological changes that might materially affect the measured shares of shipments exceeding 180 percent R/VC. Second, captivity measures based on categorizing shipment-level R/VC (or markup) data are dependent on good alignment of actual and measured costs, particularly for extreme values of R/VC, but the large shares of tons and ton-miles with R/VC below 100 percent suggest that measured and actual variable costs are not well-aligned in the tails of the R/VC distribution.

R/VC ranges remain large even after aggregation over time and geography. For example, the county-level R/VC ratios for wheat shipments range from 43 percent to 516 percent. While substantial variation in actual R/VC is certainly possible, the R/VC variations are

but Concerns about Competition and Capacity Should Be Addressed, GAO-07-94, October 6, 2006, p. 3.

large relative to the estimated effects of the market structure factors in the pricing models. The implication is that much of the R/VC variation is related to factors other than market structure features that determine shipper captivity.

R/VC and Market Structure Factors

From an economic perspective, "relative captivity" arises for shippers whose next best alternatives do not effectively constrain railroad rates. The effects of captivity may be continuous and have no definite relationship to markup thresholds. For instance, a shipper may pay a rail rate under the 180 percent R/VC threshold and nevertheless experience a degree of "captivity" relative to other shippers with similar cost characteristics because other shippers have better access to intramodal or intermodal competition that results in lower rail rates. Conceptually, more appropriate measures of captivity should focus on the effects of the transportation market structure on rail rates—and, by extension, markups—rather than on markups as indicators *per se* of market-dominant behavior. In this regard, the GAO was justified in examining additional measures using information on market structure, such as rates and R/VC in areas without Class I railroad competition.[16]

Furthermore, the R/VC ratio does not appear to perform well as a proxy for conceptually more appropriate market structure measures. We find that R/VC is weakly related to measures of railroad and water competition. Table 18-4 shows correlations between county-level R/VC ratios and market structure factors for selected commodities, including an RPTM shift factor derived from the market structure variables in the pricing models. As reported in Chapter 12, our coal pricing models find evidence of strong competitive effects from railroad competition at the destination counties, but the correlation between county-level R/VC and our measure of destination competition in Table 18-4 is only -0.13.

[16] Government Accountability Office, *Freight Railroads: Industry Health Has Improved, but Concerns about Competition and Capacity Should Be Addressed,* GAO-07-94, October 6, 2006, p. 36.

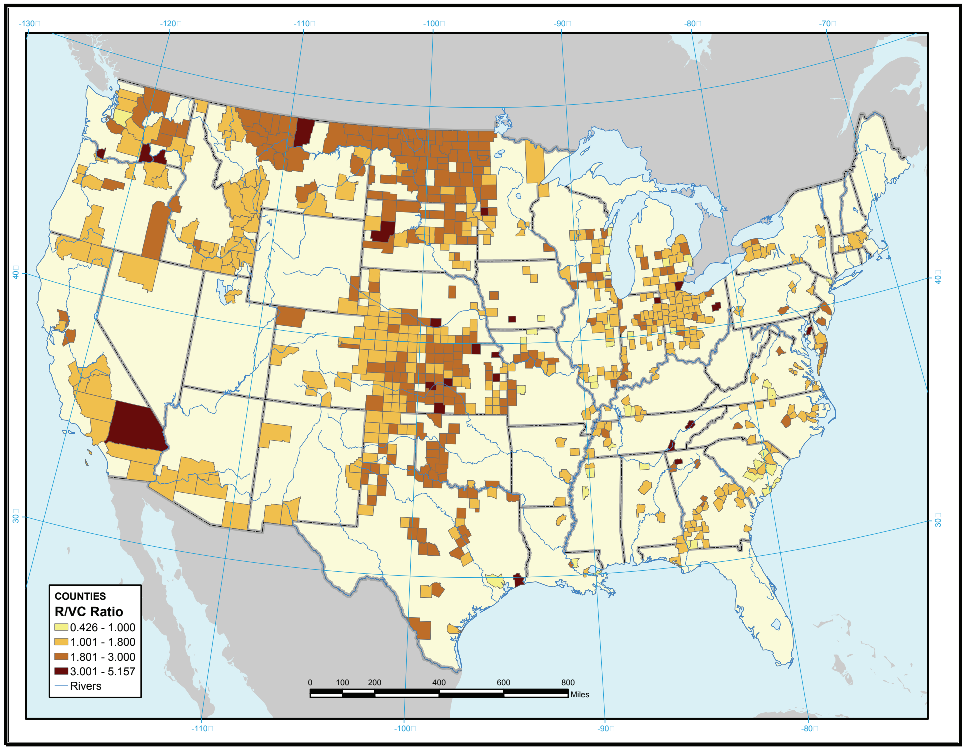
TABLE 18-4
CORRELATIONS OF ORIGIN COUNTY* R/VC WITH REVENUE PER TON-MILE AND MARKET STRUCTURE FACTORS, 2001-2006 DATA, SELECTED COMMODITIES

	Correlation coefficient with R/VC Ratio					
Commodity Group	RPTM	Distance to Water (Origin)	Distance to Water (Destination)	Railroad Competition at Origin	Railroad Competition at Destination	Econometric Market Structure Shifter
Chemicals	0.29	-0.02	0.00	-0.12	-0.11	0.14
Coal	0.65	-0.23	0.06	-0.25	-0.13	0.01
Corn	0.19	-0.02	0.11	-0.03	-0.03	0.01
Intermodal	0.10	-0.04	0.12	-0.04	-0.23	0.19
Transportation	0.15	-0.16	-0.15	0.04	-0.01	-0.06
Wheat	0.21	0.21	-0.03	-0.07	0.07	0.19

* Note: Coal based on destination county data.

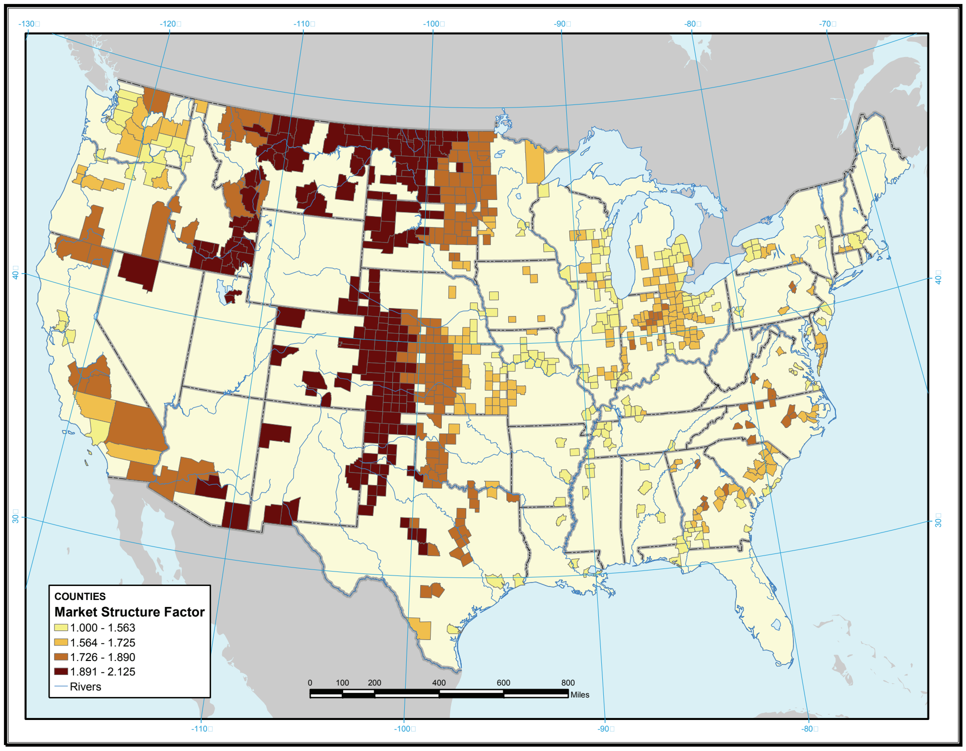
Using wheat as an example, the correlation between R/VC and the distance to water at origin is 0.21. Comparing Figures 18-13 and 18-14 reveals the relatively weak correlation. Figure 18-13 shows high R/VC ratios in some areas implicated in wheat shippers' "captivity" complaints—notably, the far northern Plains—but not in other areas well-removed from water alternatives such as western Kansas. Figure 18-13 also shows high R/VC ratios in Pacific Northwest counties and other areas that would be expected to have better modal alternatives.

FIGURE 18-13
R/VC AVERAGES BY ORIGIN COUNTY FOR WHEAT SHIPMENTS
2001-2006 CARLOAD WAYBILL SAMPLE



The pricing models for wheat imply a strong effect of distance from the origin county to water transportation on wheat rates; that effect dominates the market structure effect as seen in Figure 18-14. These results are typical of the weak relationships between R/VC and market structure measures observed for other commodities.

FIGURE 18-14
COUNTY-LEVEL EFFECTS OF MARKET STRUCTURE VARIABLES IN WHEAT PRICING MODELS ON REAL REVENUE PER TON-MILE



Evaluating "Captivity" and Market Structure Factors

The R/VC ratio, applied prudently, may be able to identify categories of shipments that travel at high rates relative to costs, but the R/VC ratio is not very useful as an indicator of the presence of market structure factors that would increase a shipper's "captivity" to an individual railroad. The weak relationships between R/VC ratios and market structure factors illustrated in Table 18-4 imply that correctly assessing the presence of market-dominant behavior requires direct assessment of relevant market structure factors. Thus, regulatory reforms that would establish R/VC tests as the sole quantitative indicator of a railroad's market dominance are not appropriate.

In contrast, analyses of railroad rates (real revenue per ton-mile or RPTM) using data sources such as the CWS can indicate the effects of railroad and water competition factors on RPTM directly. These analyses permit us to identify market structure factors that have greater effects on RPTM by commodity, and also counties with combinations of market structure factors that will tend to increase a shipper's relative captivity.

18D. RAILROAD NETWORK CAPACITY AND PERFORMANCE

Issues concerning railroad competition, rates, service quality, and network capacity are intrinsically interrelated. For example, in our stakeholder interviews, some respondents expressed the opinion that railroads could manipulate their capacity to create artificial shortages, thereby enabling the railroads to increase their rates to shippers. Whether railroad capacity is manipulated or not, capacity constraints can have significant impacts on railroad rates and terms of service. In instances where capacity is constrained, prices often serve as a rationing mechanism that regulates the demand for rail service to meet the level of supply that the railroads are able to provide. When excess capacity for rail service exists, rate reductions and discounts can be used to increase demand, resulting in increased capacity utilization. Railroad performance and service quality can also be affected by railroad capacity, as capacity constraints often result in railroad performance issues.

Conceptual Framework for Assessing Railroad Network Capacity

Through our stakeholder interviews and independent background research conducted in the qualitative analysis phase of this project, we determined that a railroad's capacity can be generally thought of as anything that affects a railroad's ability to transport shipments (in a given amount of time) over its network.[17] Thus, railroad capacity is analogous to the factors affecting throughput in a communications or data network. From a physical inputs perspective, factors that affect a railroad's ability to transport shipments generally depend on the amount of capital and labor employed by the railroad. Railroad capital includes way and structures, locomotives, railcars, signaling, and other information systems. Railroad labor consists of workers possessing various skill levels and other characteristics such as union status. The amount of effective capacity available to provide services from a given quantity of production inputs (i.e., productivity) will be affected by factors such as technological innovations (often embodied in capital), work rules and other regulations, railroad operating practices, and learning by doing.[18] The railroad's ability to adjust capacity depends on its ability to adjust these various types of capital and labor inputs as well as other attributes, with some more easily adjusted than others.

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[17] This definition of capacity could be refined by looking at particular network segments or origin-destination pairs.

[18] As discussed below, in a cost function framework, capacity utilization has been defined in terms of the marginal product of capital relative to its price. When the marginal product of capital is higher than its price, then there is a capacity shortage. When the marginal product of capital is lower than its price, there is a capacity surplus. Thus capacity utilization is a function of market variables.

A very important influence on a railroad's capacity is the existence of congestion at points in its network. While congestion can occur on mainline segments that are heavily utilized, it often occurs in terminal areas, highly crowded urban areas, ports, and other transloading facilities. In fact, while other measures of capacity along a given route may indicate sufficient capacity to meet demand, congestion at terminals or other specific network locations can often become a binding constraint on the utilization of route or network capacity.[19] This is similar to the effects of blocking or congestion in other types of networks. For example, congestion at specific points in communications and data networks caused by capacity limits in switches or routers creates a restriction in network throughput despite the virtually unlimited capacity of fiber optic cable.

Indicators of Railroad Network Capacity

Railroad network capacity has been analyzed from a number of perspectives. Information is available on physical indicators, such as miles of track, number of cars and locomotives, and employee counts. Also, engineering models have been constructed that analyze capacity from a transportation-flows perspective. Economic analysis has examined the amount of railroad capacity available and the incentives to invest in additional capacity by computing the economic value of way and structures capital relative to the price of additional capital.

Figure 18-15 charts the 1987-2006 Class I data for total and mainline miles (including second and other mainline miles) of track for the industry. This table shows that there was a decline in both total and mainline miles until the mid-1990s, while both series have been relatively flat since then.

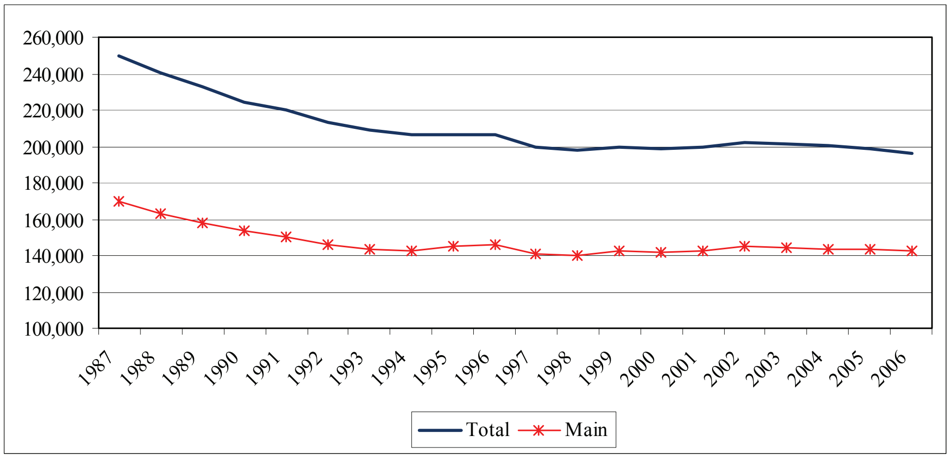
A key to accommodating ever-increasing traffic on fewer miles of track lies in the technological advancements that have occurred in the railroad industry. Pivotal technological breakthroughs include a number of computer-related applications such as centralized traffic control (CTC) and the automation of waybills. A number of critical advancements relate to equipment technology—e.g., AC traction, distributed power, aluminum cars with higher capacity, containerization and double-stack cars, and end-of-train devices—and way and structures—e.g., continuous welded rail, concrete ties, and integrated maintenance of way machines.[20] Key developments that currently are taking hold in the industry or are on the horizon include electronically controlled pneumatic (ECP) brakes, positive

[19] James McClellan, "Railroad Capacity Issues," in *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007, p. 32.

[20] Recent discussions of technological advances in the railroad industry can be found in "6 High-Tech Advances," *Trains*, Vol. 68, No. 11, November 2008; and generally *Progressive Railroading*, Vol. 51, No. 6, June 2008.

train control (PTC), remote control on the main line, digital inspection technologies, electrification, and applications of nanotechnology.[21]

FIGURE 18-15
CLASS I MILES OF TRACK
1987-2006



In some cases, these technological advancements have been augmented by additions to second and other mainline miles of track. While there was an across-the-board reduction in total Class I mainline miles of track between 1987 and 1999, the more recent 1999-2006 period has witnessed an increase in second and other mainline miles of track, driven by increases in multiple mainline trackage by Western railroads (BNSF, KCS and UP).[22] Much of this increase in multiple mainline trackage, particularly for BNSF and UP, has occurred on coal and intermodal routes. For example, it has recently been reported, "The coal line reached a milestone on May 14, 2008, when 21 miles of fourth main track went into service over the 1 percent grades of Logan Hill. BNSF claims it's the world's longest stretch of four-track main line exclusively for freight."[23]

While total Class I miles of track have declined, usage of that track has intensified as revenue ton-miles have grown continuously over the study time period. Between 1987 and 1999, Class I net ton-miles grew by 51.5 percent, compared to the 19.9 percent decline in total track miles. Between 1999 and 2006, Class I net ton-miles grew by 23.1 percent, compared to the 1.7 percent decline in total track miles.[24] The increasingly

[21] See "6 High-Tech Advances," *Trains*, Vol. 68, No. 11, November 2008.

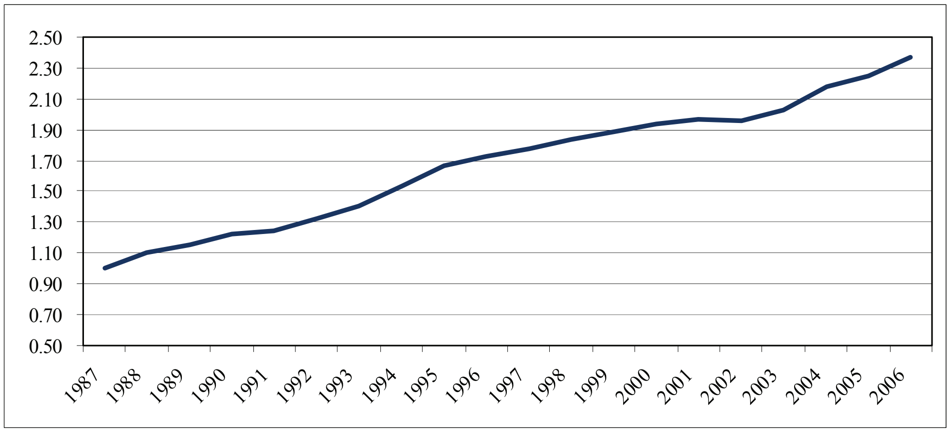
[22] R-1 Annual Reports, Schedule 700, Line 57.

[23] "Wyoming Coal Line Expansion," *Trains*, Vol. 68, No. 11, November 2008.

[24] Net ton-mile data are from R-1 Annual Reports, Schedule 755, Line 114, Column B.

intensive use of Class I track miles is illustrated in Figure 18-16, which charts the ratio of net ton-miles to total track miles.

FIGURE 18-16
RATIO OF NET TON-MILES TO TOTAL TRACK MILES
1987-2006



Other physical measures of railroad capacity include the number of railcars and locomotives. As discussed in Chapter 16, railcar and locomotive data suggest fluctuations over time, with flat-to-declining values in the early to mid-2000s. Recent years have seen an increase in spending as well as in the number of units. Furthermore, railcar capacities and locomotive horsepower have been increasing over time.

Cambridge Systematics conducted an engineering transportation flows study of rail-corridor capacities.[25] The study classified different corridors by their ratio of volume to capacity. Corridors were assigned to one of four levels of service categories:

- *Below capacity* - low to moderate train flows with sufficient capacity to accommodate maintenance and recover from incidents.
- *Near capacity* - heavy train flows with moderate capacity to accommodate maintenance and recover from incidents.
- *At capacity* - very heavy train flows with very limited capacity to accommodate maintenance and recover from incidents.
- *Above capacity* - have conditions for service breakdown.

Based on this categorization of rail corridors, the study's findings were that currently less than one percent of system mileage is above capacity,

[25] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007.

while three percent is at capacity. Approximately 88 percent of system mileage is substantially below capacity and nine percent is near capacity.[26] However, this categorization does not consider potential congestion points in networks such as terminal areas.

Based on a comparison of the value of capital's marginal product to its price, our econometric results in Chapter 9 (and also reported in Chapter 16) are consistent with the Cambridge Systematics results. Our analysis shows that, overall, the industry as a whole still has an excess amount of way and structures capital. While the variable cost savings that result from employing more capital has increased over time, the cost of that additional capital has increased at a more rapid rate. These results are also consistent with the findings of Friedlaender and her associates,[27] and with the conclusion of Bitzan and Keeler, that the railroad industry still has a considerable amount of excess capacity on its system.[28]

It is important to recognize, however, that these results apply to the aggregate network of each railroad. These studies do not examine whether there are capacity shortages or choke points on individual segments of a railroad's network that are critical components that affect railroad performance. A recent study by the Rand Corporation has noted that, in order to determine capacity needs at particular points of the network, much more detailed information on the network is required than what is currently available to the public.[29] Burton developed a promising approach to evaluate the need for and cost of additional railroad capacity at particular points of the railroad network.[30] His approach is based on a statistical analysis of railroad traffic levels on particular route segments and the characteristics of those route segments.

As discussed above, the capacity of railroad networks to provide service is similar to that of communications and data networks where throughput is often limited by constraints on switching or router capacity despite almost unlimited "corridor capacity" in fiber optic cable. As a means to address location-specific issues that may create congestion and

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[26] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 4.4.

[27] Ann F. Friedlaender, Ernst R. Berndt, Judy Shaw-Er Wang Chiang, Mark Showalter, and Christopher A. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-Regulated Environment," *Journal of Transport Economics and Policy*, May 1993, pp. 131-152.

[28] John D. Bitzan and Theodore Keeler, "Economies of Density and Regulatory Change in the U.S. Railroad Freight Industry, *Journal of Law and Economics*, February 2007, pp. 157-179.

[29] Brian A. Weatherford, Henry H. Willis, and David S. Ortiz*, Infrastructure, Safety, and Environment: A Review of Capacity and Performance Data*, Rand Corporation, 2008, p. xii.

[30] Mark l. Burton, "Measuring the Cost of Incremental Railroad Capacity: A GIS Approach," http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf.

reduce network throughput, we examined the available data on railroad terminal dwell time.

Terminal Dwell Time

The Rail Performance Measures (RPM) data consist of weekly reported data by each Class I railroad for terminal dwell time, average train speed, and cars on line.[31] We have complete panel data for the Class I railroads from 1999 (when reporting began) through 2007. The RPM terminal dwell time data can be used to help identify congestion points.[32] In October 2005, standardized definitions of dwell time were adopted and, therefore, pre-October 2005 data ("Period 1") are not directly comparable to post-October 2005 data ("Period 2").

Terminal dwell time can be considered an indicator of numerous dimensions of railroad operations. It can be thought of as a measure of capacity, a reflection of railroad operational efficiency, a contributor to performance and customer satisfaction, and a symptom of capacity constraints or network congestion. With respect to capacity or congestion, it may be the case that there is sufficient mainline capacity but, as discussed above, congestion at terminals creates a slowdown in railroad performance. Or increased terminal dwell time may be symptomatic of congestion elsewhere in the network.

Each railroad has its own unique pattern, but one common theme is general increases in terminal dwell time in the 2003-2004 time period, followed by sizeable declines in early 2005. Moreover, as documented in our analysis of quarterly terminal dwell time data in Chapter 16, the patterns of the large Western railroads (BNSF and UP) exhibit similarities during the 2003-2005 period, increasing through mid- to late 2004 and generally declining before bottoming out in mid-2005. Regarding the large Eastern railroads, CSX has a similar pattern in the 2003-2005 period. While NS does decline throughout 2005, its pattern prior to that is more of a series of peaks and troughs.

As detailed in Chapter 16, each railroad exhibits a wide range of dwell times across its different terminals. Terminals also differed considerably in the variability of their dwell times, suggesting that those

[31] Association of American Railroads, at http://www.railroadpm.org/.

[32] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

> Terminal Dwell is the average time a car resides at the specified terminal location expressed in hours. The measurement begins with a customer release, received interchange, or train arrival event and ends with a customer placement (actual or constructive), delivered or offered in interchange, or train departure event. Cars that move through a terminal on a run-through train are excluded, as are stored, bad ordered, and maintenance of way cars.

Some limitations of RPM terminal dwell time data were noted in Chapter 16.

terminals with the longest dwell times and largest variability might be affected by capacity constraints. Average dwell times in the 2003-2004 period were generally higher than the entire Period 1 averages for the Western railroads (BNSF and UP), but this relationship was more mixed for the Eastern railroads (CSX and NS).

Congestion at various points or corridors in railroad networks appears to be the major culprit in capacity-related performance issues over the last ten years. While other measures of capacity along a given route may indicate sufficient capacity to meet demand, congestion at terminals or other specific network locations can often become a binding constraint on the utilization of route capacity or network-wide capacity. For example, as we discuss below, the terminal congestion issues in the 2003-2005 period are linked to service performance issues during that time period.

Train Speed

In our stakeholder interviews, respondents expressed perceptions of service quality concerns that included captive shippers receiving poorer service quality, and service quality declining as capacity became tighter. “Poor service” was defined in various ways, including failure to meet all service commitments, delivery variability, and unresponsiveness to shippers’ requests.

The primary data set we are aware of for examining service quality issues is the weekly RPM data.[33] The elements compiled in the RPM data that are most closely related to service quality and operating performance are average train speed and average terminal dwell time. Terminal dwell time was defined above.[34] Average train speed is defined as follows in the RPM:

> Train Speed measures the line-haul movement between terminals. The average speed is calculated by dividing train-miles by total hours operated, excluding yard and local trains, passenger trains, maintenance of way trains, and terminal time.[35]

The major limitation of the RPM train speed data is that it is at a highly aggregate level, which does not allow us to adequately address service quality issues that may be specific to certain routes, commodities, or shippers. For example, these data do not allow us to test hypotheses about the relationship between shipper captivity and service quality. We

[33] Association of American Railroads, at http://www.railroadpm.org/.

[34] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

[35] Association of American Railroads, at http://www.railroadpm.org/Definitions.aspx.

asked members of our advisory panel if they were aware of any other data that would allow a more thorough examination of service quality issues. One panel member responded that railroads as well as many shippers record and keep data on service metrics such as cycle times. While such information is likely confidential, it was suggested that the STB may need to require the reporting of this type of data—possibly by route or by commodity—to better identify and rectify service quality issues.[36]

Train speed is an indicator of how well the network is performing. It is a measure of service quality as well as an indicator of network capacity and operational efficiency. The RPM data report overall train speed for each railroad as well as for the following types of trains: intermodal, manifest, multilevel, coal unit, and grain unit. We use the weekly data on train speed to construct annual averages of train speed, which we call "annual train speed," for each railroad and train type.

Table 18-5 presents changes in overall average annual train speeds by railroad for 1999 through 2007.

TABLE 18-5
CHANGES IN OVERALL ANNUAL TRAIN SPEED BY RAILROAD

	BNSF	CN	CP	CSX	KCS	NS	UP
2000	4.6%	-0.2%	2.0%	5.0%	8.0%	9.9%	1.8%
2001	-4.6%	1.7%	-2.7%	13.4%	0.7%	9.5%	-2.2%
2002	4.4%	10.3%	3.3%	4.2%	-2.4%	5.0%	2.2%
2003	-3.7%	-5.0%	-5.0%	-6.2%	7.3%	-0.6%	-5.9%
2004	-7.4%	-7.6%	-2.2%	-3.9%	0.2%	-1.9%	-9.4%
2005*	2.4%	3.3%	-12.7%	-4.6%	-11.4%	-3.5%	-0.7%
2007	2.0%	-6.0%	-6.4%	4.5%	0.0%	-0.2%	1.7%
Average 1999-2005*	-0.8%	0.3%	-3.0%	1.1%	0.2%	2.9%	-2.5%

*Statistics for 2005 only cover the months of January through September.

Also, as discussed above, because of definitional changes in the RPM data, pre-October 2005 data are not necessarily comparable to post-October 2005 data. Therefore, we segment the data into two time periods.

[36] The STB has available on its website complaint statistics by type of complaint and by commodity group going back to 2005. However, because of the aggregate nature of these statistics and the short time frame over which they are available, they are not useful for our purposes here.

Furthermore, as cautioned in Chapter 17, unique characteristics of each railroad renders comparisons across railroads meaningless.[37]

This caveat noted, the following general observations emerge from our analyses of train speeds and terminal dwell time (Chapters 16 and 17) based on the RPM data.

- Average train speed for the large Western railroads (BNSF and UP) declined, while average train speed for the large Eastern railroads (CSX and NS) increased in the 1999-2005 period.
- In 2003 and 2004, there were widespread declines in average train speed across railroads (except for KCS) and increases in average dwell time that were particularly large for most railroads.
- In 2006 and 2007, average train speed for the large Western railroads increased somewhat and results for the large Eastern railroads were mixed.
- In the last few years, volatility in average speed has generally subsided.
- Among types of train, intermodal is the fastest, followed by multilevel.[38] Coal unit trains are generally the slowest, although average speeds for manifest and grain units are often close, and sometimes below, the average speeds for coal units.

To assess the interrelatedness of railroad performance and capacity, Table 18-6 presents correlations with changes in average train speed across railroads for changes in: (a) the RPM measure of terminal dwell time, (b) the RPM measure of cars on line, and (c) net ton-miles/road miles.[39]

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[37] Association of American Railroads, at http://www.railroadpm.org/.

> Despite the use of a common methodology, one railroad's performance metrics cannot meaningfully be compared to another railroad's, due to differences including, but not limited to, those associated with network terrain and design characteristics, traffic mix, traffic volume, length of haul, extent of passenger operations, and operational practices — as well as external factors such as weather and port operations which can impact carriers differently.

[38] Canadian Pacific's intermodal and multilevel categories had similar average train speeds in most of Period 2. Also, as noted in Chapter 17, the original RPM data for KCS has identical speeds throughout for intermodal and multilevel.

[39] Net-ton miles data are obtained from R-1 Schedule 755, Line 114, Col B; miles of road data are obtained from R-1 Schedule 700, Line 57, Col I. All data are aggregated over Class I railroads for each year, 1999-2005.

TABLE 18-6
CORRELATIONS WITH CHANGES IN AVERAGE TRAIN SPEED ACROSS RAILROADS BY YEAR

	Dwell Time	Cars on Line	Net Ton-Miles/ Road Miles
2000	0.29	-0.18	0.09
2001	-0.51	-0.83	0.03
2002	-0.79	-0.92	-0.78
2003	-0.93	-0.70	-0.51
2004	-0.28	-0.63	0.09
2005*	-0.39	-0.45	0.08

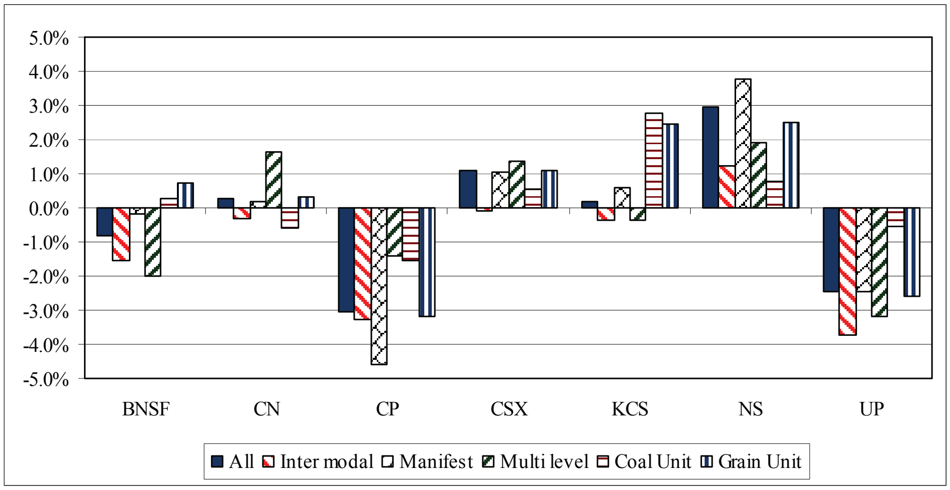
*Statistics for 2005 only cover the months of January through September.

Except for the annual change from 1999 to 2000, annual changes in dwell time are negatively correlated with annual changes in average train speed. Annual changes in cars on line are negatively correlated with the annual changes in average train speed for all years. Annual changes in net ton-miles per road mile are negatively correlated in 2002 and 2003, but positively correlated in the other four years. Recognizing that correlations do not necessarily imply causality, these correlations suggest that overall industry-wide network congestion became particularly acute in 2002 and 2003 (to a lesser extent also in 2001 and 2004), having a negative impact on train speed (results may vary across railroads). As we saw in our analysis of terminal dwell times in Chapter 16, this congestion was likely due to congestion at particular terminals for each railroad and not an overall capacity shortage on railroad networks. Thus, our analysis appears to indicate localized constraints or congestion having spillover effects on network-wide performance. Again, this is analogous to blocking at switching points in communications or data networks creating reductions in network throughput regardless of the potential available capacity at other points in the network.

Changes in Average Speed by Train Type

An indication of differences in service quality across shipper types is if particular train types have changes in average speeds that are markedly different than the changes in average speeds of other train types. For example, in our stakeholder interviews, we heard the opinion that high-margin services such as intermodal receive preferential service to the determinant of other commodity groups. Figure 18-17 presents changes in average speed by train type during Period 1 (January 1999-September 2005) for each of the Class I railroads. Although it is admittedly at a very aggregate level, there does not appear to be any strong bias toward intermodal, as its average speed declined for all railroads except NS over the 1999-2005 period, and its change in speed was below that of the overall average for all the railroads. In fact, it was below the change in average speed of coal units and manifest for most railroads over this time period.

FIGURE 18-17
CHANGES IN AVERAGE SPEED BY RAILROAD AND TRAIN TYPE, 1999-2005



Variability in Average Speed by Train Type

The variability in average train speed by railroad and train type (and, presumably, the resulting variability in delivery performance to shippers) is measured by the coefficient of variation (CV), which is the ratio of the standard deviation of train speed to average train speed. Table 18-7 presents CVs of train speed by railroad and train type, stated as a percent of average speed. Again, comparisons across railroads are not necessarily meaningful. The lowest CV in most cases is found for intermodal, especially during Period 1. Grain units and coal units typically have the highest CVs. Thus, the implication is that even though its average speed generally declined over this period, intermodal typically receives the most predictable service. On the other hand, coal units and grain units receive the least predictable service.

The average train speeds calculated from RPM data provide a crude, aggregate proxy for the railroad service performance received by shippers. As discussed above, our advisory panel noted that railroads as well as many shippers record and keep data on service metrics such as cycle times. While such information is likely confidential, it was suggested that the STB may need to require the reporting of this type of data—possibly by route or by commodity—to better identify and rectify service quality issues.

TABLE 18-7
VARIABILITY IN AVERAGE TRAIN SPEED BY RAILROAD AND TRAIN TYPE

Measured by the Coefficients of Variation

	Inter modal	Manifest	Multi level	Coal Unit	Grain Unit
1999-2005					
BNSF	3.6%	3.6%	4.2%	4.9%	4.6%
CN	3.9%	5.1%	6.1%	8.0%	9.4%
CP	5.1%	5.6%	6.8%	5.9%	7.3%
CSX	3.5%	5.1%	6.3%	4.4%	6.3%
KCS	5.5%	7.0%	5.6%	8.2%	8.9%
NS	3.2%	4.4%	5.4%	4.5%	7.1%
UP	3.6%	3.5%	3.9%	4.9%	5.1%
2006-2007					
BNSF	3.8%	4.3%	3.9%	4.4%	4.4%
CN	3.5%	3.5%	5.3%	5.9%	4.5%
CP	4.0%	3.6%	5.9%	8.9%	5.2%
CSX	3.4%	3.8%	4.5%	3.4%	4.3%
KCS	6.0%	4.6%	6.0%	6.5%	5.2%
NS	3.6%	4.1%	5.1%	3.6%	5.7%
UP	3.6%	3.1%	3.2%	4.2%	3.7%

Summary

Post-Staggers declines in Class I miles of track have stabilized in recent years and track continues to be used more intensively, as net ton-miles per mile of track continue to increase.[40] Railcar and locomotive data suggest fluctuations over time, with flat-to-declining values in the early- to mid-2000s. Recent years have seen an increase in spending as well as in the number of units. Other aggregate measures of railroad capacity indicate that, overall, excess capacity may still exist. Combined with a relatively weak economy, all of this indicates that any capacity tightness that may have existed at the beginning of this decade has likely loosened in recent years.

However, localized congestion points are often a binding constraint on effective capacity and the ability of railroads to efficiently and reliably provide services. The general increase in terminal dwell times during the mid-2000s indicates greater congestion at points in the railroad networks. In recent years terminal dwell times have subsided. Those terminals with the longest dwell times and greatest variability might have been affected by capacity constraints. Furthermore, the relationship

[40] As indicated above, some but not all of the decline in Class I miles of track has been offset by increases in regional and shortline track miles.

between increased network congestion (represented by terminal dwell times) and diminished railroad performance (represented by train speed) illustrates the complex interaction between a number of factors that affect the railroad industry's ability to provide service and resulting productivity.

CONCLUSION

The presence of density economies and fixed costs in the Class I railroad industry necessitates that, on average, Class I railroads set rates above marginal costs so that revenues cover total costs. By definition, the setting of price above marginal cost is the exercise of market power, but exercise does not imply abuse. Rates on average need to be marked up over marginal cost by about 70 percent to achieve revenues sufficient to cover cost. The post-Staggers Act regulatory system allows railroads to exercise market power (or pricing power), within limits, in order to earn sufficient revenues. While there are differences among the individual railroads, we find no evidence that the railroad industry as a whole has achieved sustained results above revenue sufficiency. By our R-1 based measure of revenue sufficiency, RPTM/ATC, the railroad industry has flirted with revenue sufficiency for a number of years, but has only achieved or surpassed it a few times in the mid-1990s and in 2006.

The Class I railroad industry has experienced reductions in productivity growth and increases in input price growth in recent years, which have added to the upward pressures on the rail rates paid by shippers. Our analysis indicates that changes in density economies and the ratio of fixed to variable costs are important factors that have contributed to recent rate increases, and not the increased exercise of market power. The positive gap between Class I industry revenues relative to total cost in 2006 was primarily due to declining fixed costs, as the railroads' margins relative to marginal cost remained essentially the same.

The railroad industry's proximity to and achievement of financial viability is reflected in financial statistics such as earnings per share and price-to-earning ratios. In general, financial market results indicate that Class I railroads performed comparably to the utility sector, but with much more stable growth in earnings and price-to-earning ratios than in the utility sector or the S&P 500 overall. The relatively low price-to-earning ratio indicates that investors have not anticipated excessive returns in the railroad industry.

We analyzed the 2001-2006 period to examine the current state of railroads' exercising their pricing flexibility, including their exercise of local market power. We found rate markup patterns by commodity are generally consistent with economic theory and with the information we gathered in our qualitative research. We found relatively small markups for coal, metallic ores, nonmetallic minerals, and transportation equipment, and relatively large markups for grains. It should be noted that the relatively constant or declining markups for commodities other than grains do not reflect constant shipment characteristics. In our qualitative research phase, we heard from shippers (particularly coal shippers) who noted that long-term, low-priced contracts had expired in this time frame and were replaced by higher-priced contracts or tariff rates. Such changes increase incentives to form shipments with lower-cost characteristics to partly offset the less favorable terms. We observe material shifts to lower-cost characteristics for various commodities in the CWS data, suggesting that shippers as a whole have some ability to substitute less costly shipment characteristics. However, shippers who are unable to adjust their shipping practices towards lower-cost characteristics may face substantial rate increases in periods of increasing industry costs.

We have investigated at a commodity-specific level whether there is effective competition to prevent railroads from exercising market power beyond that necessary to achieve revenue adequacy. We find generally expected effects on rail rates from increasing railroad competition at the origin and from increasing the distance from the origin to the nearest available water transportation. With respect to intramodal competition, the responsiveness of RPTM to railroad competition varies by commodity. Coal, chemicals, and transportation equipment display stronger RPTM responses to railroad competition than do corn, wheat, soybeans, and intermodal shipments. Intermodal shipments are an anomaly in that increased rail competition in some cases increases RPTM. This finding could reflect non-price competition and capacity constraints on key routes during the sample period. The strongest effect of water competition at origin is for wheat. At the destination, intermodal and chemical shipments show strong effects from water competition.

We conclude that R/VC ratios are weak indicators of market-dominant positions. We believe that regulatory reforms that would establish R/VC tests as the sole quantitative indicator of a railroad's market dominance are ill-advised. In contrast, analyses of railroad rates using data sources such as the CWS can indicate the effects of railroad and water competition factors on RPTM directly. These analyses can identify market structure factors by commodity that relate to a shipper's rail captivity. The CWS-based analyses can also identify small geographic areas such as counties with combinations of market structure factors that will tend to increase a shipper's relative captivity.

Localized congestion points are often a binding constraint on effective capacity and the ability of railroads to efficiently and reliably provide services. The general increase in terminal dwell times during the mid-2000s indicates greater congestion at specific points in the railroad networks. In recent years terminal dwell times have subsided. Those terminals with the longest dwell times and greatest variability might have been affected by capacity constraints. Furthermore, the relationship between increased network congestion (represented by terminal dwell times) and diminished railroad performance (represented by train speed) illustrates the complex interaction between a number of factors that affect the railroad industry’s ability to provide service and resulting productivity. Aggregate measures of railroad capacity indicate that, overall, excess capacity may still exist. Combined with a relatively weak economy, all of this indicates that any capacity tightness that may have existed at the beginning of this decade has likely loosened in recent years.

Policies that would facilitate shippers’ access to competing railroads, such as reciprocal switching and terminal access agreements, could potentially increase competition among railroads. However, some shippers are subject to relatively high rail rates because of geography and shipper density characteristics restricts both railroad and intermodal (water) competition. These shippers are not likely to get as much relief from railroad-focused policy initiatives. While some shippers and shipment recipients might be able to relocate in response to modal competition, much economic activity is not able to do so. Regulatory oversight is required to ensure that shipper captivity, driven by unavoidable limitations of shipment geography, does not result in railroad prices that are determined to be unreasonable.”

VOLUME 2 REFERENCES

"6 High-Tech Advances," *Trains*, Vol. 68, No. 11, November 2008.

Roy G. D. Allen, *Mathematical Analysis for Economists*, (London: Macmillan), 1938.

Association of American Railroads, Definitions of Railway Performance Measures are found at http://www.railroadpm.org/Definitions.aspx.

Association of American Railroads, "Petition of the Association of American Railroads to Institute a Rulemaking Proceeding to Adopt a Replacement Cost Methodology to Determine Railroad Revenue Adequacy," Motion filed with the STB, May 1, 2008.

Association of American Railroads, *Railroad Facts*, 1987 through 2006.

Association of American Railroads, Railroad Performance Measures covering the 1987 through 2006 time frame are found at http://www.railroadpm.org/.

Association of American Railroads, "Railroad Ten-Year Trends: 1980-1989," Vol. 7.

Association of American Railroads, "Railroad Ten-Year Trends: 1990-1999," Vol. 17.

Association of American Railroads, "Railroad Ten-Year Trends: 1997-2006," Vol. 24.

William J. Baumol and Hrishikesh D. Vinod, "An Inventory Theoretic Model of Freight Transport Demand," *Management Science* 16(7), 1970, pp. 413-421.

Hans P. Binswanger**,** "The Measurement of Technical Change Biases with Many Factors of Production," *American Economic Review*, 64(6), 1974, pp. 964-976.

John D. Bitzan and Theodore Keeler, "Economies of Density and Regulatory Change in the U.S. Railroad Freight Industry," *Journal of Law and Economics*, February 2007, pp. 157-179.

John D. Bitzan and Wesley W. Wilson, "A Hedonic Cost Function Approach to Estimating Railroad Costs," *Research in Transportation Economics*, 20(1), 2007, pp. 69-95.

Randall S. Brown and Laurits R. Christensen, "Estimating Elasticities of Substitution in a Model of Partial Static Equilibrium: An Application to U.S. Agriculture, 1947 to 1974," in *Measuring and Modelling Natural Resource Substitution*, E. R. Berndt and B. C. Field, eds., (Cambridge, MA: MIT Press), 1981, pp. 209-29.

Bureau of Economic Analysis, Price Index for Gross Domestic Product, available at

http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=4&Freq=Qtr&FirstYear=2006&LastYear=2008.

Bureau of Labor Statistics, Multifactor Productivity Indexes, at http://www.bls.gov/mfp/.

Bureau of Labor Statistics, Producer Price Indexes, at http://www.bls.gov/PPI/.

Mark L. Burton, "Measuring the Cost of Incremental Railroad Capacity: A GIS Approach," at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf.

Mark L. Burton, "Railroad Deregulation, Carrier Behavior, and Shipper Response: A Disaggregated Analysis," *Journal of Regulatory Economics* 5, 1993, pp. 417-34.

Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007.

Douglas W. Caves, Laurits R. Christensen, and Joseph A. Swanson, "Productivity Growth, Scale Economies, and Capacity Utilization in the U.S. Railroads, 1955−74," *American Economic Review*, 71(5), 1981, pp. 994-1002.

Laurits R. Christensen, Dale W. Jorgenson, and Lawrence J. Lau, "Conjugate Duality and the Transcendental Logarithmic Production Function," *Econometrica*, 39(4), July 1971, pp. 255-256.

Laurits R. Christensen, Dale W. Jorgenson, and Lawrence J. Lau, "Transcendental Logarithmic Production Frontiers," *Review of Economics and Statistics*, 55(1), February 1973, pp. 28-45.

Charles W. Cobb and Paul H. Douglas, "A Theory of Production," *American Economic Review*, 18 (Supplement), 1928, pp. 139-165.

T. G. Cowing and A. G. Holtmann, "The Multiproduct Short-run Hospital Cost Function: Empirical Evidence and Policy Implication from Cross-section Data," *Southern Economic Journal* 49, 1983, pp. 637-653.

B. Kelly Eakin, Daniel P. McMillen and Mark J. Buono, "Constructing Confidence Intervals Using the Bootstrap: An Application to a Multi-Product Cost Function," *The Review of Economics and Statistics*, 72(2), 1990, pp. 339-344.

Federal Trade Commission, Staff Discussion Draft, "How Do Courts and Agencies Evaluate Market Power?" in *The Role and Assessment of Classical Market Power in Joint Venture Analysis*, October 1997, at http://www.ftc.gov/opp/jointvent/classic3.shtm.

Ann F. Friedlaender, Ernst R. Berndt, Judy S. W. Chiang, Mark Showalter, and Christopher A. Vellturo, "Rail Costs and Capital Adjustments in a Quasi-Regulated Environment," *Journal of Transport Economics and Policy*, 27(2), May 1993, pp. 131-152.

Government Accountability Office, *Freight Railroads: Industry Health Has Improved, but Concerns about Competition and Capacity Should Be Addressed,* GAO-07-94, October 6, 2006.

Government Accountability Office, Freight Railroads: Updated Information on Rates and Other Industry Trends, Letter to Congressional Requesters, GAO-07-291R, August 15, 2007.

John R. Hicks, *The Theory of Wages*, (London: Macmillan & Co., Ltd.), 1932.

Intermodal Association of North America, "2003-2007 Yearly Traffic Totals, Private vs. Rail," at http://www.intermodal.org/statistics_files/stats11.shtml.

Intermodal Association of North America, "5-Year Trailer Activity Volume by Ownership," at http://www.intermodal.org/statistics_files/stats12.shtml.

Jan Kmenta, *Elements of Econometrics,* Second Edition, (New York: Macmillan Publishing Company), 1986.

John G. Larkin and Daniel S. Taylor, *Railroads: Striving to Drive Improved Return on Invested Capital,* (Baltimore, MD: Legg Mason Wood Walker, Inc.), 2004.

Lawrence Lau and Pan Yotopolus**,** "A Test for Relative Efficiency and an Application to Indian Agriculture," *American Economic Review*, March 1971, pp. 94-109**.**

James M. MacDonald, "Competition and Rail Rates for the Shipment of Corn, Soybeans, and Wheat," *Rand Journal of Economics* 18(1), 1987, pp. 151-163.

James M. MacDonald, "Railroad Deregulation, Innovation, and Competition: Effects of the Staggers Act on Grain Transportation," *Journal of Law and Economics* 32, 1989, pp. 63-96.

G. S. Maddala, *Limited-Dependent and Qualitative Variables in Econometrics*, Cambridge University Press, 1983.

James McClellan, "Railroad Capacity Issues," in *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007.

Morningstar, *Cost of Capital Yearbook*, 2007.

Progressive Railroading, Vol. 51, No. 6, June 2008.

Reebie Associates, with the assistance of Dr. Ralph L. Nelson, Dr. Richard Levin, Dr. Curtis M. Grimm, and Dr. M. Daniel Westbrook, "Railroad

Productivity Evaluation, Final Report, Proposed Measures for RCAF and URCS Application," prepared for the Interstate Commerce Commission, October 11, 1988.

Mark A. Schankerman and M. Ishaq Nadiri, "A Test of Static Equilibrium Models and Rates of Return to Quasi-Fixed Factors, with an Application to the Bell System," *Journal of Econometrics,* 33(1-2), 1986, pp. 97-118.

Ronald W. Shephard, *Cost and Production Functions,* (Princeton, NJ: Princeton University Press), 1953.

Surface Transportation Board, Carload Waybill Sample, 2001 through 2006.

Surface Transportation Board, Class I Railroad Annual Report (Form R-1), Reports filed by all Class I railroads, 1987 through 2006.

Surface Transportation Board, data indexes are available at http://www.stb.dot.gov/stb/industry/econ_rateindex.html.

Surface Transportation Board, Ex Parte No. 664, *Methodology to be Employed in Determining the Railroad Industry's Cost of Capital*, August 20, 2007.

Surface Transportation Board, Ex Parte No. 671, complete set of filings can be found at http://www.stb.dot.gov/FILINGS/all.nsf/(Personal-216.170.165.28)?OpenView&Count=300.

Surface Transportation Board, Ex Parte No. 671, Rail Capacity and Infrastructure Requirements, Notice, March 6, 2007.

Surface Transportation Board, Uniform Rail Costing System, described at http://www.stb.dot.gov/stb/industry/urcs.html.

U.S. Army Corps of Engineers, Navigation Data Center, "Port and Waterway Facilities," available at http://www.iwr.usace.army.mil/ndc/data/datapwd.htm.

U.S. Department of Agriculture, *Agricultural Outlook*, March 1998.

U.S. Department of Agriculture, *2002 Census of Agriculture*, Vol. 1, Ch. 2, Table 24, at http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_US_State_Level/st99_2_024_024.pdf (accessed October 11, 2008).

U.S. Department of Agriculture, "Production, Supply and Distribution Online" at http://www.fas.usda.gov/psdonline/.

U.S. Department of Energy, *Annual Coal Report 2005* (Report No.: DOE/EIA-0584 [2005]).

U.S. Department of Energy, *Annual Coal Report 2006* (Report No.: DOE/EIA-0584[2006]).

U.S. Department of Energy, *Annual Energy Outlook 2008* (Report No.: DOE/EIA-0383[2008]).

U.S. Department of Energy, *Average Duration of Utility Coal Contracts*, 1979-1997, at http://www.eia.doe.gov/cneaf/coal/ctrdb/tab33.html.

U.S. Department of Energy, *Domestic Distribution of U.S. Coal by Origin State, Consumer, Destination and Method of Transportation*, at http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/coal_distributions.htm.

Hirofumi Uzawa, "Production Functions with Constant Elasticities of Substitution," *Review of Economic Studies*, 29(4), October 1962, pp. 291-99.

Value Line, *Value Line Investment Survey*, 1997 through 2006.

Christopher A. Vellturo, *The Deregulation of the U.S. Rail Industry: Efficiency and Equity in Attaining Rail Viability*, Ph.D. Thesis, Massachusetts Institute of Technology, September 1989.

Brian A. Weatherford, Henry H. Willis, and David S. Ortiz, *Infrastructure, Safety, and Environment: A Review of Capacity and Performance Data*, Rand Corporation, 2008.

Wesley W. Wilson, "Legislated Market Dominance," *Research in Transportation Economics* 4(1), 1986, pp. 33-48.

Wesley W. Wilson, "Market-Specific Effects of Rail Deregulation," *Journal of Industrial Economics* 42(1), 1994, pp. 1-22.

William W. Wilson and Bruce L. Dahl, "Railcar Auctions for Grain Shipments: A Strategic Analysis," *Journal of Agricultural and Food Industrial Organization*, 3(2), 2005, Article 3.

Clifford Winston, Scott M. Dennis, and Vikram Maheshri, "Duopoly Equilibrium Over Time in the Railroad Industry," Working Paper, April 2007.

K. Eric Wolfe, "The Carload Waybill Statistics: A Content Analysis," *Transportation Research Forum – Proceedings* 27(1), 1986, pp. 244-252.

K. Eric Wolfe, "The Interstate Commerce Commission's Public Use Waybill File: Concern for Misinterpretation," *Journal of the Transportation Research Forum* 32(1), 1991.

"Wyoming Coal Line Expansion," *Trains*, Vol. 68, No. 11, November 2008.

Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," *Journal of the American Statistical Association, 57, 1962, pp. 348-368.*