AN UPDATE TO THE STUDY OF COMPETITION IN THE U.S. FREIGHT RAILROAD INDUSTRY

Final Report

Laurits R. Christensen Associates, Inc.
Madison, WI

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Report Contents

CHAPTER 6 ANALYSIS OF SELECTED MAJOR COMMODITIES

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Executive Summary

Christensen Associates previously issued *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition*. That study provided an analysis of the performance of the freight railroad industry for 1987-2006. Since the release of that report, Carload Waybill Sample (CWS) data and Rail Form 1 data (R-1 data) for 2007 and 2008 have become available. This report updates Chapters 8-15 of our original report by incorporating data for these two additional years into our analysis.

Our key findings in this update are:

- The basic findings from our original study remain unchanged.
- Overall railroad rates have been steadily increasing since 2004, with a particularly steep increase in 2008. Although 2009 rate information is preliminary, it suggests that overall railroad rates decreased in that year.
- We observe that the percentage increases in revenue per ton-mile have not been uniform across commodities. In the two-year period 2007-2008, real revenue per ton-mile for the industry increased by about 12 percent, with coal and chemicals experiencing above average increases.
- Trends in input price and productivity growth are generally consistent with the pattern of rate changes. In 2007 and 2008, input prices continued to increase faster than productivity growth, resulting in unit cost increases. Increases in fuel prices have driven the input price increases.
- Railroad industry marginal cost has been increasing at a faster average annual rate than railroad revenue per ton-mile. Consequently, the measure of railroad market power has been decreasing.
- There is no consistent relationship over time between changes in the exercise of market power and changes in cost conditions. In some years, the exercise of market power in the railroad industry changed by less than what was implied by changing cost conditions, while in other years it changed by more.

- 2007 and 2008 Carload Waybill Sample data show lower shares of tons and ton-miles moving at rates exceeding 180 percent of URCS variable cost than in 2005 and 2006.

- In 2006, the industry jumped from being 92 percent revenue sufficient to being 101 percent revenue sufficient. Since 2006, the railroad industry has remained approximately revenue sufficient.

- Because the railroad industry has remained approximately revenue sufficient in recent years, we reemphasize one of our original conclusions: providing significant rate relief to some shippers will likely result in rate increases for other shippers or threaten railroad financial viability.

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CHAPTER 1 INTRODUCTION

In November 2008, Christensen Associates issued *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition*. That study provided an analysis of the performance of the freight railroad industry for 1987-2006. Since the release of that report, two additional years of the Carload Waybill Sample (CWS) data and the Rail Form 1 data (R-1 data) have become available. The current report incorporates these additional data into our analysis to provide an update for the years 2007 and 2008. Throughout the current report updating our analysis through 2008, we make reference to the findings from the "original study" or the "original report." When we do so, we are referring to the original study as revised in November 2009.

The current report updates Chapters 8-15 of our original report. These chapters relied on the CWS and R-1 data, which are now available through 2008.

Chapter 2 of this report updates Chapter 8 of the original report. The current Chapter 2 examines freight railroad rate trends for the industry overall and for coal, the commodity with the largest share of ton-miles. We update the rate indexes we calculate from the CWS data and compare them to the Produce Price Index for line-haul railroads and the STB rate index published in January 2009. Chapter 2 also updates the analysis of railroad input price and productivity trends.

Chapter 3 updates the analysis of railroad cost and technology found in Chapter 9 of the original report. We re-estimate the variable cost function that provides the foundation for this analysis. Using the updated cost function estimates, we reconstruct the tables from Chapter 9 of the original report and extend them through 2008. We highlight trends revealed by the latest data and discuss the few notable differences from our previous findings.

Chapter 4 provides updates of the tables and analysis found in Chapter 10 of the original report. In this chapter, we examine how rail revenue per ton-mile is marked up over the competitive benchmark of marginal cost. We further investigate how the markup of revenue per ton-mile reflects the need to achieve revenue sufficiency versus the pursuit of monopoly profit. The update highlights the trends revealed by the latest data and discusses differences from the results in our original report.

Chapter 5 undertakes an econometric analysis of the CWS data to investigate railroad pricing behavior at the shipment level. This chapter updates the results found in Chapter 11 of the original report. The econometric model in this chapter relates revenue per ton-mile to cost-related and market-structure features of the shipments included in the CWS files.

Chapter 6 examines recent trends in revenue per ton-mile and shipment characteristics for coal, corn, wheat, chemicals and intermodal shipments. This chapter updates the analysis found in Chapters 12-15 of the original report.

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CHAPTER 2
OVERVIEW OF INDUSTRY PERFORMANCE

INTRODUCTION

Prior to investigating the behavior and performance of individual railroads and specific commodity markets, it is useful to have an overview of the aggregate performance for the freight railroad industry. This overview updates information that we provided in Chapter 8 of our original report. Section 2A examines freight railroad industry rate trends. In this section, we update the rate indexes that we constructed from the Carload Waybill Sample and compare them with the BLS Producer Price Index for line-haul railroads. We also compare our indexes with the rate index published by the STB in January of 2009. Section 2B examines railroad input price and productivity trends, using the Rail Cost Adjustment Factors (RCAFs) and Productivity Adjustment Factor (PAF) developed by the STB.

2A. ROLE AND IMPORTANCE OF THE RAILROAD INDUSTRY IN THE U.S. ECONOMY

In Chapter 8 of our original report, we reviewed the evidence on railroad rates since 1985. We reviewed rate indexes that were published by the GAO and STB, and the BLS Producer Price Index for line-haul railroads. Noting that there were substantial differences in the findings of these different indexes, we developed our own set of rate indexes based on data contained in the unmasked, confidential Carload Waybill Sample. Our rate indexes distinguished 835 different types of shipments based on: commodity shipped, weight of shipment, length of haul, car type, car ownership, and number of cars reported on the waybill. We computed average revenue per ton-mile for each shipment class, and used this information on revenue per ton-mile to compute rate indexes. Two alternative revenue concepts were used in computing the indexes. The first approach was to use freight revenue, while the second approach used the sum of freight and miscellaneous revenue. The second approach was included to address the fact that some railroads had included fuel surcharges in their miscellaneous revenue accounts in recent years.

Based on these two revenue concepts, we computed two industry-wide rate indexes, which showed overall rate changes for all commodities shipped. These two indexes showed rate changes that were between the GAO rate index and the BLS Producer Price Index. Our indexes showed that railroad rates had predominantly decreased up until 2000, but that since 2000 rates had increased for the most part. The indexes showed substantial rate increases in 2005 and 2006.

We also computed rate indexes for coal shipments. Once again, our indexes showed rate changes that were between the GAO rate index and the BLS Producer Price Index results. Both of our indexes show that coal transportation rates predominantly decreased between 1988 and 2000. Between 2001 and 2004, there were a series of small increases and decreases, and for 2005 and 2006, the coal transportation rate increases were substantial.

In this report, we update our industry-wide and coal transportation rate indexes through 2008. Since the release of our previous report, the GAO has not published any updates to its rate indexes, but the STB released an update of its industry-wide rate index through 2007. In this update, the STB adopted significant changes in its methods, which we discuss below. The industry-wide Producer Price Index is also available through most of 2009. Consequently, we are able to compare our two industry-wide rate indexes, the STB rate index, and the Producer Price Index in order to determine recent changes in industry-wide rates. Since the BLS no longer publishes a Producer Price Index for coal transportation, our indexes derived from the Carload Waybill Sample provide the only information available on coal transportation rates for recent years.

The New STB Rate Index

On January 16, 2009, the Surface Transportation Board released a new study of railroad rates, using different methods than those employed in its previous studies.[1] As was the case in the STB's previous studies, the railroad rate index was constructed from information on revenue and ton-miles reported in the Carload Waybill Sample. In order to better control for changes in product mix, the new study distinguished 67 commodity shipment categories when constructing the rate index. These shipment categories were distinguished by commodity, length of haul, car ownership, train type, and whether a shipment was intermodal or not.

One other methodological change addressed the fact that some railroads were recording fuel surcharges as miscellaneous revenue. The STB adopted an approach where it included miscellaneous revenues in the computation whenever a carrier included fuel surcharges in miscellaneous revenue.

[1] Surface Transportation Board, Office of Economics, Environmental Analysis and Administration, Section of Economics, Study of Railroad Rates: 1985-2007, January 16, 2009, at http://www.stb.dot.gov/stb/industry/1985-2007RailroadRateStudy.pdf.

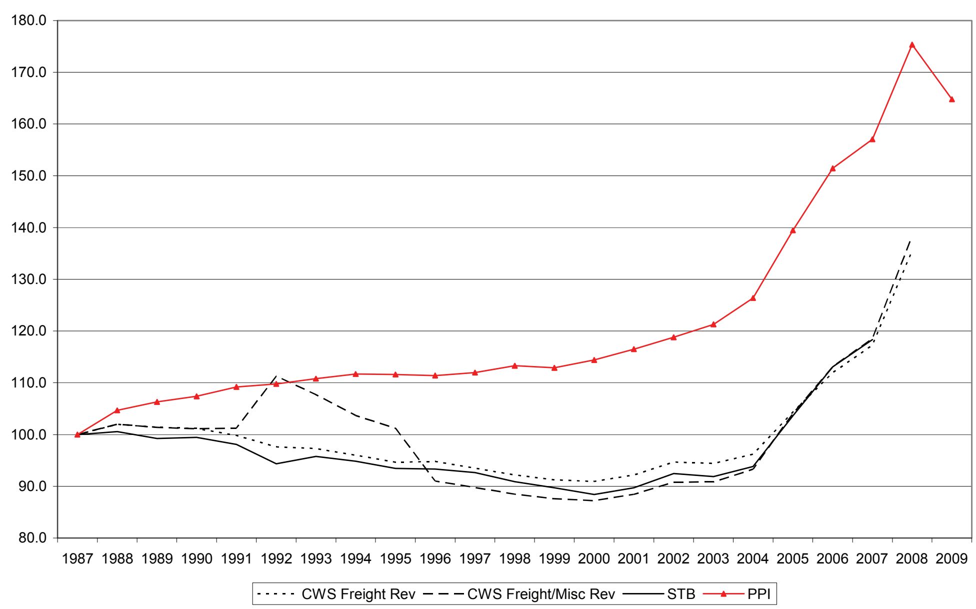
The rate index reported by the STB is a "real revenue per ton-mile" index. The idea behind the real revenue per ton-mile index is that it shows railroad rate changes relative to overall price changes in the economy. For example, if railroad rates increase more slowly than the overall price changes in the economy, the real revenue per-mile index decreases. However, such an index is not directly comparable to the indexes we construct from the Carload Waybill Sample or the Producer Price Index, as those indexes do not look at rate changes relative to overall price changes in the economy. Fortunately, the STB web site had detailed documentation of its methods and data, and we were able to compute a nominal version of the STB revenue per ton-mile index that is comparable to our indexes and the Producer Price Index, while using the same conceptual framework as the STB's real revenue per ton-mile index. In the remainder of the chapter, we refer to this latter rate index as the STB index.

Updated Industry-Wide Indexes

Figure 2-1 is an update of Figure 8-5 in our original report, with the new STB index included instead of the GAO index. The figure shows the two indexes that we construct from the Carload Waybill Sample (CWS) through 2008, the STB index through 2007, and the Producer Price Index through October of 2009.

FIGURE 2–1
INDUSTRY-WIDE RAILROAD RATE INDEXES
1987-2009

(1987=100.0)



As seen in the figure above, the new STB index generally follows the trends of the indexes we construct using data from the Carload Waybill Sample. This is noteworthy due to the fact that the STB index has a much simpler classification of commodity shipments. As we noted in our original report, the index including miscellaneous revenue shows a significant jump in 1992 and stays above the index based solely on freight revenue until 1996. We understand that the jump is an anomaly that is due to errors in the miscellaneous charges field from 1992 to 1995. This figure also shows that all four indexes have substantial increases after 2006 through 2008. The Producer Price Index is the only index available for 2009, and that index shows a decrease in rates for that year.

Recent Changes in Industry-Wide Rate Indexes

Table 2-1 shows the percentage changes in the four different industry-wide rate indexes for the years 2007 and 2008, and through 2009 for the one index calculated for that year. For purposes of comparison, we also show the average annual rates of growth between 2000 and 2006 for these four indexes. For the year 2007, our index based on freight revenue, our index based on freight and miscellaneous revenue, and the STB index show very similar rates of change.

TABLE 2–1
ANNUAL PERCENTAGE INCREASES IN INDUSTRY-WIDE RAILROAD RATE INDEXES

Index	Percentage Increase 2007	Percentage Increase 2008	Percentage Increase 2009	Average Annual Percentage Increase 2000-2006
Index Based on CWS Freight Revenue	4.6%	14.5%	---	3.5%
Index Based on CWS Freight & Misc. Revenue	4.7%	15.5%	---	4.3%
STB Index	4.6%	---	---	4.1%
Producer Price Index	3.6%	11.0%	-6.4%	4.7%

Our index based on freight revenue and the STB index show rates increasing 4.6%, while our index based on freight and miscellaneous revenue shows a 4.7% increase. The Producer Price Index shows an increase of only 3.6% in that year. In our original report, we noted some reasons why the Producer Price Index might produce different results than our indexes. The Producer Price Index includes rates for both freight and passenger transportation, and therefore it is a slightly broader measure of railroad rate changes. Furthermore, we noted that the BLS does not attempt to measure the effective price change when a railroad discontinues one service and starts a similar, but not identical, service. We also noted that indexes based on the Carload Waybill Sample may not pick up all factors that affect shipper costs. Examples include shipper discounts and incentives that are not reported in the Carload Waybill Sample, costs shifted to shippers, and changes in terms of service.

Since the STB index ends in 2007, we can only compare our two indexes with the Producer Price Index in 2008. All three rate indexes show substantially greater increases in 2008 than 2007. The Producer Price Index shows an 11.0% increase, while our index based on freight revenues increased 14.5% and our index based on freight and miscellaneous revenue increased 15.5%. The Producer Price Index is the only available source on price changes in 2009, and that index shows rates decreasing 6.4% in that year. Thus the available evidence indicates that the railroad rate increases in 2008 were very large, but there was a significant reduction in 2009.

Updated Coal Transportation Rate Indexes and Recent Changes

Figure 2-2 shows an update of Figure 8-6 from our original report. Since the PPI for coal transportation is no longer produced by the BLS and because the GAO did not update its index, the figure only shows the two coal transportation rate indexes that we compute from the Carload Waybill Sample data. The figure shows that coal transportation rates have had substantial increases since 2006.

FIGURE 2–2
COAL TRANSPORTATION RATE INDEXES

(1987=100.0)

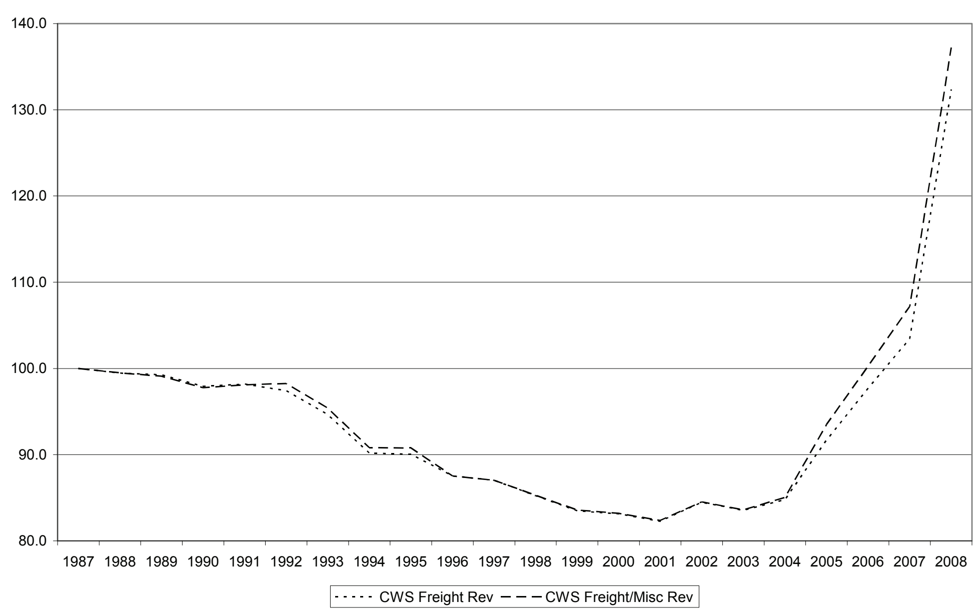


Table 2-2 shows the percentage changes in the two coal transportation rate indexes that we constructed from the Carload Waybill Sample.

TABLE 2–2
ANNUAL PERCENTAGE INCREASES IN COAL RATE INDEXES

Index	Percentage Increase 2007	Percentage Increase 2008	Average Annual Percentage Increase 2000-2006
Index Based on CWS Freight Revenue	5.7%	24.6%	2.7%
Index Based on CWS Freight & Misc. Revenue	6.7%	24.7%	3.1%

Both rate indexes show that coal transportation rates increased more rapidly than overall industry rates. In 2007, the coal transportation rate increases were one to two percentage points higher than the industry-wide rate increases. In 2008, the coal transportation rate increases were substantially higher, as the freight revenue index increased 24.6% while the freight and miscellaneous revenue index increased 24.7%. Since no Carload Waybill Sample rate information is yet available for 2009, we cannot tell whether the reduction in industry-wide railroad rates was also seen in coal transportation rates.

2B. 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 the 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.

In our original report, our primary analysis of the railroad industry's input price and productivity trends relied on the STB's Rail Cost Adjustment Factors (RCAFs) and the associated Productivity Adjustment Factor (PAF). As discussed in that report, the All-Inclusive Index, published by the Association of American Railroads, is used to construct an unadjusted Rail Cost Adjustment Factor (RCAF-U). Since 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 RCAF-U is an index of railroad input prices. The PAF is a measure of 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. Finally, a productivity-adjusted Rail Cost Adjustment Factor (RCAF-A) is computed by dividing the RCAF-U by the PAF. By construction, the RCAF-A is an index of railroad industry unit costs.

Updated Trends in RCAF-U, RCAF-A, and PAF through 2009

Figure 2-3 is an update of Figure 8-9 in our original report, and it shows the trends in the RCAF-U and the PAF since 1989. The large swings in the RCAF-U index in recent years show that there has been considerable volatility in railroad input prices. The PAF shows that the railroad industry continued to see some productivity improvements during these past few years.

FIGURE 2–3
RCAF-U AND PAF, 1989-2009

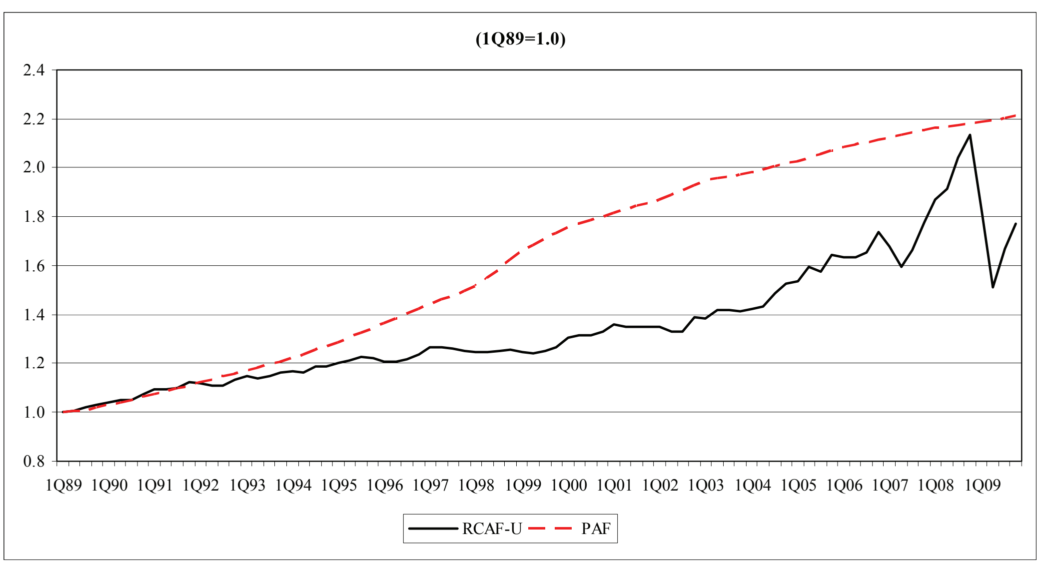


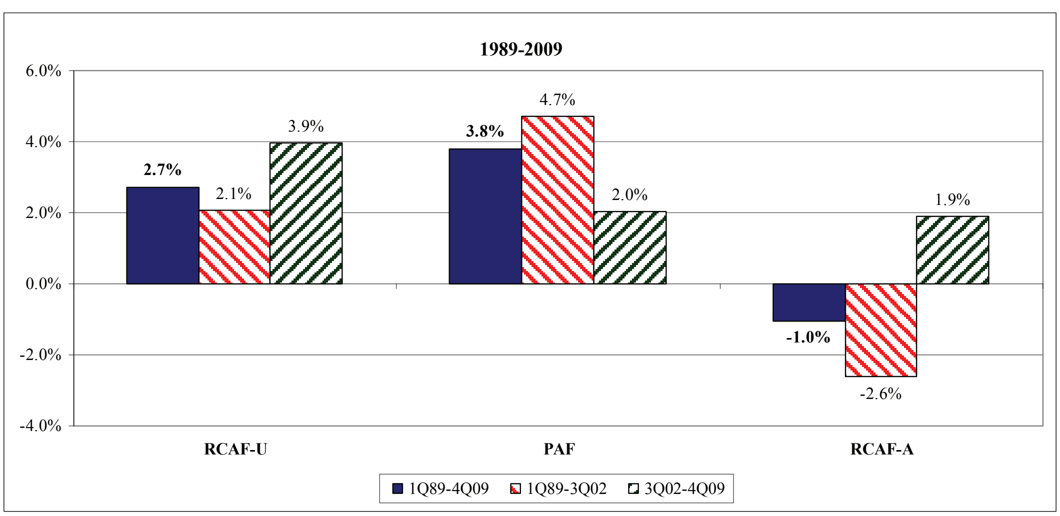
Figure 2-4 is an update of Figure 8-10 in our original report, and it shows the trends in the RCAF-A since 1989.

FIGURE 2–4
RCAF-A, 1989-2009

This figure shows that during 2007 and 2008, there were large increases in railroad industry unit cost, due to the large increases in input prices. However, mirroring the RCAF-U, there were substantial declines in 2009, as the RCAF-A returned to approximately its 2006 level.

Figure 2-5 is an update of Figure 8-11 in our original report. It shows the average annual growth rates for RCAF-A and its components, RCAF-U and PAF, over the entire 1989Q1 - 2009Q4 period, and for the 1989Q1 – 2002Q3 and 2002Q3- 2009Q4 sub-periods.

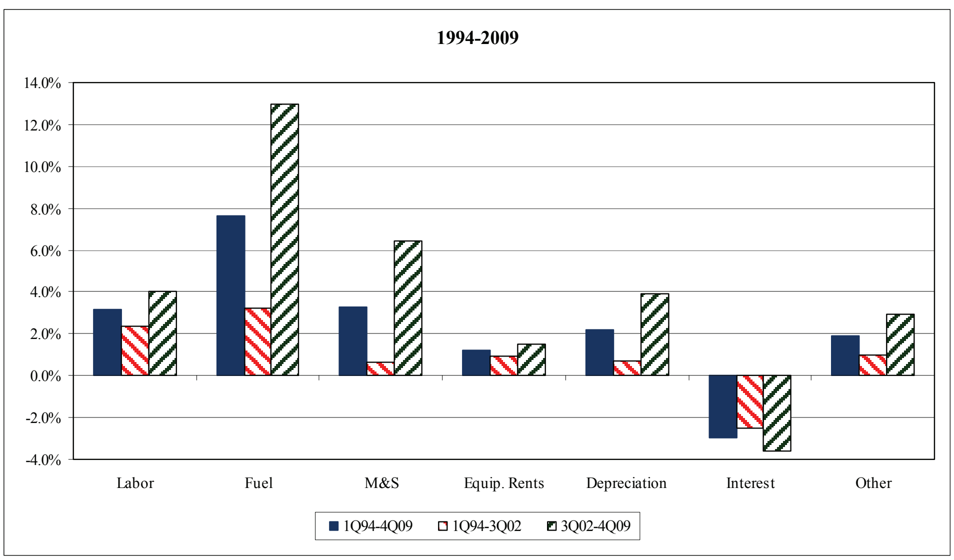
FIGURE 2–5
RCAF-U, PAF, AND RCAF-A
AVERAGE ANNUAL GROWTH



This figure shows that the inclusion of the recent data does not materially change the conclusions that we reached in our original report. Trends in input price and productivity since 2002Q3 are noticeably different than input price and productivity trends prior to that time. Before 2002Q3, the increases in the PAF were generally greater than the increases in the RCAF-U, and consequently RCAF-A declined. Since 2002Q3, the increases in the RCAF-U have been greater and the increases in the PAF have been smaller than in the prior sub-period and, as a consequence, RCAF-A increased in the 2002Q3- 2009Q4 sub-period.

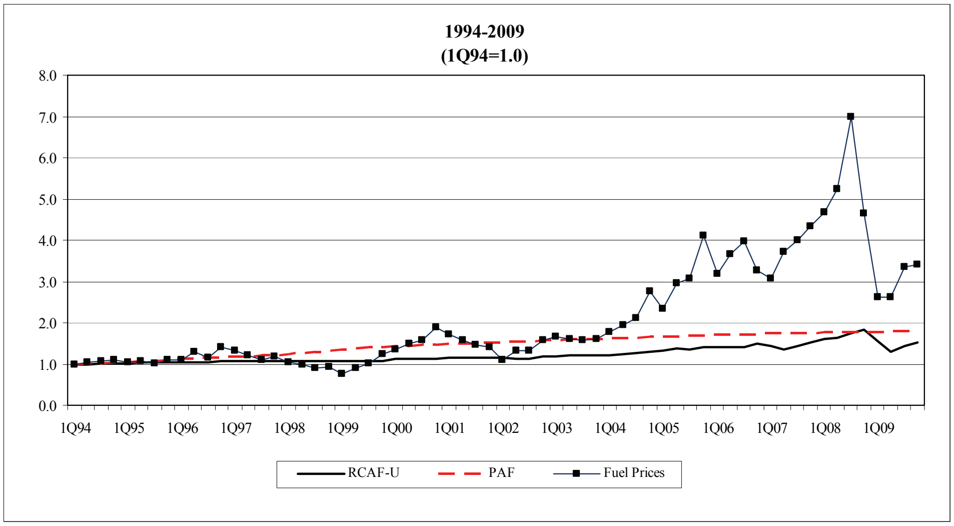
In our original report, we concluded that fuel price increases were primary causes for the RCAF-U increasing more rapidly since 2002Q3. Figure 2-6 is an update of Figure 8-12 in our original report; it shows that with the additional data available, fuel price trends still are the primary explanation of recent RCAF-U increases.

FIGURE 2–6
RCAF-U COMPONENTS
AVERAGE ANNUAL GROWTH IN PRICES



Finally, Figure 2-7 is an update of Figure 8-14 in our original report, and it shows the increases in fuel prices alongside the increases in the RCAF-U and PAF.

FIGURE 2–7
RCAF-U, PAF, AND FUEL PRICES
1994-2009



This figure illustrates the fact that the RCAF-U spike in 2008 was driven by increases in fuel prices in that year. As fuel prices decreased in early 2009, the RCAF-U also decreased.

CONCLUSIONS

Regarding freight railroad rate trends, we find that the new STB rate index, when converted to nominal terms, follows the trends of the two indexes we compute from data found in the unmasked confidential Carload Waybill Sample. We also find that there were very large railroad rate increases in 2008, but the evidence for 2009 (from the Producer Price Index) indicates that there were rate reductions in that year. Our rate indexes for coal transportation show that in 2007 and 2008, coal transportation rates increased more rapidly than the rates for all commodities, but since information for 2009 is unavailable, one cannot tell whether coal rates decreased in that year or not.

Our analysis of the trends in the STB's measures of input price and productivity growth are generally consistent with the pattern of railroad rates. Since 2002, increases in the rate of input price growth combined with slower productivity growth have resulted in unit cost increases. The increases in input prices in recent years have largely been driven by increases in fuel prices. Railroad input prices, as measured by RCAF-U, peaked in 2008, declined in early 2009 and went up again in late 2009, matching the increases and decreases in fuel prices.

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CHAPTER 3
RAILROAD COSTS AND TECHNOLOGY

INTRODUCTION

This chapter updates the analysis of railroad costs and technology presented in Chapter 9 of our original report. Econometric estimation of a variable cost function provides the foundation for our analysis. The primary source of data for the estimation is the Rail Form 1 (R-1 data) that the Class I railroads annually submit to the STB. R-1 data for 2007 and 2008 have become available since the analysis was conducted for the original report.

We re-estimate the variable cost function with the 2007 and 2008 data added. We choose to re-estimate the model rather than merely simulating the previous model using the additional two years of data. Re-estimation is appropriate because it allows us to use more information in estimating the underlying parameters of the model.

Three factors affect our re-estimation of the model. First, adding two additional years of data for the seven U.S. Class I railroads results in 14 more observations. The inclusion of this additional information can affect the cost function parameter estimates. Second, we make a change to the construction of variable cost by including capital expenses other than way and structures expenses. These additional expenses are included in the calculated cost share for materials. Third, we drop the switching regressions mechanism that had been applied to the first- and direct second-order time trend terms. In the next section, we provide more detail about these changes and their impacts.

In this chapter, we provide updates of those tables that appear in Chapter 9 of our original report. The qualitative findings about rail costs and technology remain essentially the same as in the original report. Chapter 9 of the original report remains the primary reference for our discussion of railroad costs and technology, particularly the theoretical underpinnings of the methodology and the definitions of cost and technological concepts. Our discussion in this chapter highlights trends revealed by the latest data available. We also analyze the few noticeable quantitative differences from the original report.

3A. DATA AND ESTIMATION

We estimate a variable cost function for U.S. Class I railroads over the period 1987-2008. 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. since 2001. Table 3-1 provides a summary of the Class I railroads used in our variable cost function estimation.

TABLE 3–1
CLASS I RAILROADS* USED IN VARIABLE COST FUNCTION ESTIMATION

Railroads	Modeled Years	Notes
ATSF	1987-1995	Merged with BN to form BNSF
BN	1987-1995	Merged with ATSF to form BNSF
BNSF	1996-2008	Formed by merger of ATSF and BN
CNGT	2002-2008	Formed by merger of GTW and IC
CNW	1987-1994	Merged into UP
CR	1987-1998	Divided between NS and CSX
CSX	1987-2008	
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	1987-2008	
MKT	1987	Merged into UP
NS	1987-2008	
SOO	1987-2008	
SP	1987-1996	Includes former DRGW and SSW: Merged into UP
SSW	1987-1989	Merged into SP
UP	1987-2008	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.

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.

In this update, we make a change to how variable cost is calculated. Specifically, we now include "capital expenses classified as operating expense" (CAPEXP) in the calculation of variable cost.[1] These added expenses are attributed to the materials share of variable cost. This change in the variable cost calculation introduces a source of difference between the original and updated analyses. We are able to isolate the impact from

[1] These expenses are reported in the R-1 data on Schedule 410, Lines 12-30 and 101-109, Column F.

changing the construction of variable cost by estimating the updated model with and without this change and then comparing the difference.

In the regression analysis for the original report, we had introduced switching mechanisms for parameters associated with the first and direct second-order time-trend terms. When the 2007 and 2008 data were added, the estimation of the original model with the switching mechanisms failed as the parameter estimates did not converge. Accordingly, we dropped the switching-parameter mechanisms from the model. This change in the model specification introduces a source of difference between the original analysis and the updated analysis. We are able to isolate the impact of this specification change by comparing the results from the original analysis with results obtained from estimating the model over the original time period (1987-2006) without imposing the switching-parameter mechanisms.

We re-estimated the variable cost function and input share equations by the method of seemingly unrelated regressions. Updated parameter estimates for the variable cost function are reported in the appendix to this chapter. These estimates are similar to the estimates reported in the original report. The redefinition of variable cost to include CAPEXP has little impact on the estimates, with the exception that β_M, the key parameter with respect to the materials cost share, is larger and the key parameters for the other input cost shares are slightly smaller. These results are as expected because including CAPEXP increased the materials cost share relative to the shares of other inputs. Some other parameter estimates do change as a result of adding two more years of data to the sample period and the modification to the specification of the cost function. The implications of these changes will be discussed in the next two sections of this chapter.

3B. RAILROAD TECHNOLOGY INFERRED FROM THE VARIABLE COST FUNCTION

We use several cost elasticity concepts in our analysis of railroad costs and technology. Table 3-2 reports the updated "industry average" of key elasticity estimates for selected years.[2]

[2] 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.

TABLE 3–2
KEY VARIABLE COST ELASTICITY ESTIMATES
(INDUSTRY AVERAGE*)
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	1995	2000	2008
Ton-Mile Elasticity	0.724	0.674	0.872	0.968
$(\partial \ln C^V / \partial \ln Y)$	[0.52 – 0.94]	[0.47 – 0.88]	[0.65 – 1.10]	[0.74 – 1.20]
Length-of-Haul Elasticity	-0.084	-0.017	0.067	0.143
$(\partial \ln C^V / \partial \ln ALOH)$	[-0.25 – 0.08]	[-0.21 – 0.17]	[-0.16 – 0.29]	[-0.13 – 0.40]
Capital-Stock Elasticity	-0.210	-0.201	-0.227	-0.226
$(\partial \ln C^V / \partial \ln K)$	[-0.29 – -0.12]	[-0.28 – -0.12]	[-0.32 – -0.13]	[-0.32 – -0.13]
Network-Size Elasticity	0.498	0.556	0.350	0.210
$(\partial \ln C^V / \partial \ln N)$	[0.32 – 0.68]	[0.39 – 0.73]	[0.18 – 0.52]	[0.03 – 0.39]
Rate of Cost Change	-0.077	-0.032	-0.013	0.032
$(\partial \ln C^V / \partial Time)$	[-0.09 – -0.07]	[-0.04 – -0.02]	[-0.02 – 0.01]	[0.02 – 0.04]

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

The general trends for the elasticity measures are the same in this update as those reported in the original analysis. The ton-mile elasticity decreases from 1987 to 1995, but then steadily increases thereafter; the length-of-haul elasticity estimate starts out negative in 1987, then continually trends upward and becomes positive after 1995; the capital-stock elasticity is negative and relatively constant; the network-size elasticity increases from 1987 to 1995, but steadily decreases thereafter; and the rate of cost change goes from strongly negative in 1987 to positive in recent years.

While the qualitative findings with respect to the elasticity measures remain unchanged, there are quantitative changes worth noting, as these changes result in changes in the estimates of other cost and technology concepts central to the policy analysis of the railroad industry. The appendix to this chapter includes a set of graphs showing how the updated industry elasticity estimates differ from those presented in the original report.

The updated ton-mile elasticity estimates for the industry are uniformly greater than in the original analysis. This difference is attributed to using the expanded data set and to the change in the cost function specification. For years 1987-1989, the difference arises from the use of the expanded data set. In 1998, the difference is fully attributable to the specification change. In other years, both factors contribute to the difference. For the most recent years of the original study (2003-2006), the differences in the updated ton-mile elasticity estimates result in roughly equal parts from using the expanded data set and from the change in the cost function specification.

The updated industry estimates for the length-of-haul elasticity are uniformly larger than in the original analysis. Almost all of the difference is attributable to using the expanded data set. The updated industry capital-stock elasticity estimates are uniformly of greater magnitude (i.e., more negative). Slightly more than half of the difference is attributable to the cost function specification change and slightly less than half of the difference is due to using the expanded data set.

The updated industry network-size elasticity estimates are uniformly greater than the estimates in the original report. For years 1987 to 1995, the difference is attributed mostly to the specification change, with the use of the expanded data set having a relatively small but reinforcing impact on the difference. For 1996, the specification change accounts for the entire difference. For years 1997 to 2006, the impact of using the expanded data set somewhat offsets the impact of the specification change such that in years 2003 to 2006 the updated and original estimates of the network-size elasticity are relatively close.

In comparison to the rate of cost change estimates presented in the original report, the updated rate of cost change estimates are more negative than the earlier estimates for years 1987 to 1998, less negative for years 1999 to 2002, and less positive for years 2003 to 2006. For the earlier years in the analysis, the differences are due primarily to the use of the expanded data set, but for years 1997 on, the differences are the result of the change in the cost function specification. The differences are most noticeable starting with year 1999, which was the year when the switching-parameter mechanism first entered in the original analysis.

Economies of Density

Our measure of economies of density indicates how **variable cost** changes as output increases. The capital stock and network size are held constant when measuring economies of density, and thus this 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 (density measure greater than 1.0), (b) *constant returns to density* if an increase in revenue ton-miles results in an increase in variable cost of equal proportion (density measure equal to 1.0), or (c) *diseconomies of density* if an increase in revenue ton-miles results in a more than proportional increase in variable cost (density measure less than 1.0).

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:

$$(3.1) \quad \text{DENSITY\_1} = 1/\left(\partial \ln C^{V} / \partial \ln Y\right)$$

$$(3.2) \quad \text{DENSITY\_2} = 1/\left[\left(\partial \ln C^{V} / \partial \ln Y\right) + \left(\partial \ln C^{V} / \partial \ln \text{ALOH}\right)\right].$$

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 the average length of haul, and lies between DENSITY_1 and DENSITY_2.

Table 3-3 presents the updated industry average estimates of DENSITY_1 and DENSITY_2 for selected years.

TABLE 3–3
INDUSTRY AVERAGE ECONOMIES OF DENSITY*
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	1995	2000	2008
DENSITY_1 (Average length of haul constant)	1.399 [1.08 – 1.99]	1.514 [1.15 – 2.26]	1.154 [0.91 – 1.58]	1.044 [0.84 – 1.40]
DENSITY_2 (Revenue tons constant)	1.662 [1.25 – 2.80]	1.565 [1.18 – 2.44]	1.087 [0.88 – 1.47]	0.911 [0.74 – 1.21]

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

The estimates for both DENSITY_1 and DENSITY_2 are generally lower than those presented in the original report.[3] The trends over time for DENSITY_1 and DENSITY_2 follow the same patterns as in the original report. Early in the sample period, railroads appear to have experienced fairly strong economies of density, but those economies have been diminishing since around 1995. The updated analysis indicates that this decline has continued in 2007 and 2008 such that the Class I railroad industry overall now appears to be experiencing approximately constant returns to density, with stronger density economies resulting from adding more shipments rather than from increasing the average distance of a shipment.

Table 3-4 presents updated railroad-specific estimates of density economies. Our updated findings are similar to those of the original report. Examination of the updated 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. By 2008, BNSF and UP appear to have just mild economies of density from increasing the number of shipments and diseconomies of density from increasing the average length of haul. In contrast, in 2008 CSX and NS appear to experience small economies of density from increasing the average length of haul and slight diseconomies of density from increasing the number of

[3] For years 1987 to 1999, the use of the expanded data set reduced the differences between the original and updated estimates. For year 2000 to 2006, both the cost function specification change and the use of the expanded data set contributed to the differences between the original and updated estimates.

shipments. However, in 2008 we cannot conclude that either of the density measures for any of the largest four Class I railroads is statistically different than 1.0.

Economies of Scale

Economies of scale indicate how **total cost** changes as output and network size increase. A railroad is said to experience (a) *economies of scale* if proportional increases in revenue ton-miles and network size result in a less than proportional increase in total cost (scale measure greater than 1.0), (b) *constant returns to scale* if proportional increases in revenue ton-miles and network size result in an increase in total cost of equal proportion (scale measure equal to 1.0), or (c) *diseconomies of scale* if proportional increases in revenue ton-miles and network size result in a more than proportional increase in total cost (scale measure less than 1.0).

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:

(3.3) $$\mathrm{SCALE\_1} = \left[1 - \left(\partial \ln C^{V} / \partial \ln K\right)\right] / \left[\left(\partial \ln C^{V} / \partial \ln Y\right) + \left(\partial \ln C^{V} / \partial \ln N\right)\right]$$

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

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.

TABLE 3–4
ECONOMIES 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	1.511	1.278
	[1.17 – 2.07]	[0.97 – 1.98]
BN 1987	1.480	1.230
	[1.08 – 2.33]	[0.92 – 1.99]
ATSF 1995	2.109	1.699
	[1.51 – 3.38]	[1.19 – 3.08]
BN 1995	1.530	1.190
	[1.10 – 2.46]	[0.88 – 1.93]
BNSF 1996	1.175	0.938
	[0.90 – 1.66]	[0.73 – 1.33]
BNSF 2006	1.228	0.910
	[0.91 – 1.86]	[0.70 – 1.35]
BNSF 2008	1.164	0.828
	[0.88 – 1.71]	[0.64 – 1.20]
SP-UP		
SP 1987	1.737	1.457
	[1.30 – 2.52]	[1.07 – 2.41]
UP1987	1.423	1.342
	[1.07 – 2.07]	[1.01 – 2.08]
SP 1996	1.545	1.436
	[1.19 – 2.14]	[1.08 – 2.18]
UP 1996	1.677	1.298
	[1.15 – 2.95]	[0.93 – 2.23]
UP 1997	1.235	0.974
	[0.93 – 1.80]	[0.75 – 1.42]
UP 2006	1.124	0.879
	[0.87 – 1.58]	[0.69 – 1.25]
UP 2008	1.060	0.834
	[0.83 – 1.45]	[0.66 – 1.15]
CSX		
CSX 1987	1.263	2.285
	[0.98 – 1.71]	[1.50 – 4.67]
CSX 1996	1.210	1.761
	[0.99 – 1.53]	[1.34 – 2.62]
CSX 2006	1.044	1.137
	[0.87 – 1.30]	[0.93 – 1.48]
CSX 2008	0.973	1.047
	[0.81 – 1.20]	[0.87 – 1.34]
NS		
NS 1987	1.215	1.952
	[0.98 – 1.57]	[1.39 – 3.26]
NS 1996	1.375	1.869
	[1.11 – 1.78]	[1.42 – 2.75]
NS 2006	0.932	1.129
	[0.79 – 1.12]	[0.93 – 1.44]
NS 2008	0.874	1.050
	[0.74 – 1.05]	[0.87 – 1.33]

Table 3-5 reports the updated industry average estimates of SCALE_1 and SCALE_2 for selected years. The updated estimates for both SCALE_1 and SCALE_2 are uniformly lower than the estimates presented in the original report.[4] However, the trends over time for SCALE_1 and SCALE_2 follow the same patterns as in the original report. The updated scale estimates indicate that the Class I railroad industry has been experiencing approximately constant returns to scale, regardless of which scale measure is used. As in the original report, we find that approximately constant returns to scale are implied when the number of shipments is changed while holding the average length of haul constant, and that this result does not vary substantially over the sample time frame.

TABLE 3–5
INDUSTRY AVERAGE ECONOMIES OF SCALE*
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	**1995**	**2000**	**2008**
SCALE_1	0.992	0.979	1.007	1.047
(Average length of haul constant)	[0.89 – 1.12]	[0.88 – 1.12]	[0.89 – 1.11]	[0.92 – 1.22]
SCALE_2	1.118	1.021	1.002	0.990
(Revenue tons constant)	[0.96 – 1.36]	[0.88 – 1.25]	[0.85 – 1.25]	[0.83 – 1.25]

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

Table 3-6 presents some railroad-specific estimates of scale economies. Our updated findings are similar to those of the original report. 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 result is in contrast to the apparent impact of these mergers on the density measures. By 2008, CSX and NS appear to have economies of scale both from increasing the average length of haul and from increasing revenue tons.

[4] For both SCALE_1 and SCALE_2, the difference between the updated estimates and those presented in the original report are due to the change in the cost function specification. However, re-estimating the model with the expanded data set reduced these differences.

TABLE 3–6
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	1.019	0.923
	[0.93 – 1.13]	[0.79 – 1.17]
BN 1987	0.935	0.846
	[0.83 – 1.08]	[0.70 – 1.08]
ATSF 1995	1.000	0.912
	[0.92 – 1.10]	[0.77 – 1.13]
BN 1995	0.927	0.811
	[0.82 – 1.08]	[0.68 – 1.04]
BNSF 1996	0.958	0.821
	[0.84 – 1.13]	[0.67 – 1.07]
BNSF 2006	0.954	0.781
	[0.83 – 1.13]	[0.64 – 1.02]
BNSF 2008	0.966	0.758
	[0.84 – 1.14]	[0.62 – 1.00]
SP-UP		
SP 1987	1.008	0.921
	[0.93 – 1.11]	[0.77 – 1.16]
UP1987	0.963	0.932
	[0.86 – 1.10]	[0.78 – 1.17]
SP 1996	0.968	0.930
	[0.87 – 1.10]	[0.78 – 1.16]
UP 1996	0.932	0.823
	[0.82 – 1.08]	[0.68 – 1.04]
UP 1997	0.953	0.817
	[0.83 – 1.13]	[0.67 – 1.06]
UP 2006	0.985	0.823
	[0.86 – 1.16]	[0.68 – 1.07]
UP 2008	1.006	0.832
	[0.88 – 1.18]	[0.68 – 1.09]
CSX		
CSX 1987	1.002	1.409
	[0.90 – 1.14]	[1.18 – 1.76]
CSX 1996	1.041	1.341
	[0.94 – 1.18]	[1.15 – 1.64]
CSX 2006	1.092	1.174
	[0.98 – 1.25]	[1.00 – 1.45]
CSX 2008	1.121	1.201
	[1.00 – 1.28]	[1.02 – 1.49]
NS		
NS 1987	1.040	1.420
	[0.94 – 1.17]	[1.21 – 1.73]
NS 1996	1.030	1.236
	[0.93 – 1.16]	[1.07 – 1.49]
NS 2006	1.146	1.390
	[1.02 – 1.31]	[1.19 – 1.71]
NS 2008	1.181	1.450
	[1.06 – 1.35]	[1.24 – 1.79]

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.

We calculate three technological change-based productivity measures:

$$(3.5)\quad PGY\_1 = -\left(\partial \ln C^{v} / \partial Time\right) \times SCALE\_1 / \left(1 - \partial \ln C^{v} / \partial \ln K\right)$$

$$(3.6)\quad PGY\_2 = -\left(\partial \ln C^{v} / \partial Time\right) \times SCALE\_2 / \left(1 - \partial \ln C^{v} / \partial \ln K\right)$$

$$(3.7)\quad PGX = -\left(\partial \ln C^{v} / \partial Time\right) / \left(1 - \partial \ln C^{v} / \partial \ln K\right).$$

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.

The updated industry average productivity estimates are presented in Table 3-7. As with the estimates in the original report, the updated estimates show an implied rate of annual productivity gain due to technological progress that was in the 6 to 7 percent range in the late 1980s, but that continually declined and vanished by about 2003. By 2008, the estimates of the productivity measures were approaching negative 3 percent.

We noted in the original report that estimating the model without the switching-parameter mechanisms 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. We find that the updated productivity estimates are very similar to the estimates reported in the original report, except for the years 1999-2001 and 2004-2006. These differences are attributable to the changes in the cost function specification (i.e., dropping the switching-parameter mechanisms).

TABLE 3–7
INDUSTRY AVERAGE PRODUCTIVITY GAINS*
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	1995	2000	2008
PGY_1	0.063	0.026	0.011	-0.027
	[0.06 – 0.07]	[0.02 – 0.03]	[0.00 – 0.02]	[-0.04 – -0.02]
PGY_2	0.072	0.028	0.011	-0.025
	[0.06 – 0.09]	[0.02 – 0.03]	[0.01 – 0.02]	[-0.04 – -0.02]
PGX	0.063	0.027	0.010	-0.026
	[0.05 – 0.07]	[0.02 – 0.03]	[0.00 – 0.02]	[-0.03 – -0.02]

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

As was shown in Table 3-5, the scale measures do not change much between 2000 and 2008. Thus the decline in productivity since 2000 is attributable almost entirely to the reversal of the time derivative, $\partial \ln C^V / \partial Time$. We hypothesized in the original report that construction projects, extreme weather-related events, and changes in the mix of services might be behind this puzzling result. Adding years 2007 and 2008 to the analysis, however, shows the continuation of negative productivity measures even though the major construction projects have been completed and weather has been less extreme.

Table 3-8 presents railroad-specific estimates of the productivity measures for selected years. An examination of these estimates shows that the four largest Class I railroads have experienced similar patterns of productivity changes.

TABLE 3–8
PRODUCTIVITY GAINS
SELECTED YEARS BY RAILROAD
[90 PERCENT CONFIDENCE INTERVAQLS IN BRACKETS]

Railroads	PGY_1	PGY_2*	PGX
ATSF-BN-BNSF			
ATSF 1987	0.063	0.057	0.061
	[0.06 – 0.07]	[0.04 – 0.07]	[0.05 – 0.07]
BN 1987	0.058	0.052	0.062
	[0.05 – 0.07]	[0.04 – 0.07]	[0.05 – 0.07]
ATSF 1995	0.018	0.016	0.018
	[0.01 – 0.02]	[0.01 – 0.02]	[0.01 – 0.02]
BN 1995	0.025	0.022	0.027
	[0.02 – 0.03]	[0.01 – 0.03]	[0.02 – 0.03]
BNSF 1996	0.028	0.024	0.029
	[0.02 – 0.03]	[0.02 – 0.03]	[0.02 – 0.04]
BNSF 2006	-0.018	-0.015	-0.019
	[-0.03 – -0.01]	[-0.02 – -0.01]	[-0.03 – -0.01]
BNSF 2008	-0.029	-0.022	-0.030
	[-0.04 – -0.02]	[-0.03 – -0.01]	[-0.04 – -0.02]
SP-UP			
SP 1987	0.059	0.053	0.058
	[0.05 – 0.07]	[0.04 – 0.07]	[0.05 – 0.07]
UP1987	0.060	0.058	0.063
	[0.05 – 0.07]	[0.05 – 0.07]	[0.06 – 0.07]
SP 1996	0.020	0.020	0.021
	[0.02 – 0.03]	[0.01 – 0.03]	[0.01 – 0.03]
UP 1996	0.017	0.015	0.018
	[0.01 – 0.02]	[0.01 – 0.02]	[0.01 – 0.02]
UP 1997	0.021	0.018	0.022
	[0.01 – 0.03]	[0.01 – 0.02]	[0.01 – 0.03]
UP 2006	-0.017	-0.015	-0.018
	[-0.03 – -0.01]	[-0.02 – -0.01]	[-0.03 – -0.01]
UP 2008	-0.027	-0.022	-0.026
	[-0.04 – -0.02]	[-0.03 – -0.01]	[-0.03 – -0.02]
CSX			
CSX 1987	0.066	0.092	0.066
	[0.06 – 0.08]	[0.08 – 0.11]	[0.06 – 0.07]
CSX 1996	0.029	0.037	0.028
	[0.02 – 0.03]	[0.03 – 0.04]	[0.02 – 0.03]
CSX 2006	-0.017	-0.018	-0.016
	[-0.03 – -0.01]	[-0.03 – -0.01]	[-0.02 – -0.01]
CSX 2008	-0.027	-0.029	-0.024
	[-0.04 – -0.02]	[-0.05 – -0.02]	[-0.03 – -0.01]
NS			
NS 1987	0.070	0.096	0.067
	[0.06 – 0.08]	[0.08 – 0.12]	[0.06 – 0.07]
NS 1996	0.024	0.029	0.023
	[0.02 – 0.03]	[0.02 – 0.03]	[0.02 – 0.03]
NS 2006	-0.015	-0.018	-0.013
	[-0.02 – -0.01]	[-0.03 – -0.01]	[-0.02 – -0.01]
NS 2008	-0.025	-0.031	-0.021
	[-0.04 – -0.02]	[-0.05 – -0.02]	[-0.03 – -0.01]

Input Demand and Substitution Elasticities

In our original report, we presented estimates for input demand elasticities, input substitution measures, and indicators of biases in technical change. For thoroughness, we include here updated tables of those estimates. The updated estimates are very similar to those presented in the original report. The most noticeable changes involve the materials input. The updated estimates have materials exhibiting more price-sensitive demand and greater substitutability with other inputs. These changes are the expected result from adding CAPEXP to the calculation of variable cost and attributing these additional expenses to the materials share of variable cost.

The updated industry own-price elasticities of demand for the variable inputs are reported in Table 3-9. Based on the similarity of elasticity estimates, we reach the same findings as in the original report. All the own-price elasticities are negative as required by theory and the demands for equipment and fuel are relatively more price sensitive than the demands for labor and materials.

TABLE 3–9
INDUSTRY AVERAGE OWN-PRICE ELASTICITIES OF INPUT DEMAND*
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

Inputs	1987	1995	2000	2008
Labor	-0.468	-0.512	-0.529	-0.550
	[-0.53 – -0.41]	[-0.59 – -0.44]	[-0.61 – -0.45]	[-0.63 – -0.47]
Equipment	-0.845	-0.839	-0.836	-0.832
	[-0.90 – -0.79]	[-0.89 – -0.79]	[-0.89 – -0.79]	[-0.88 – -0.79]
Materials	-0.515	-0.517	-0.521	-0.532
	[-0.60 – -0.49]	[-0.60 – -0.44]	[-0.60 – -0.44]	[-0.62 – -0.45]
Fuel	-0.948	-0.898	-0.872	-0.832
	[-0.96 – -0.94]	[-0.90 – -0.89]	[-0.88 – -0.87]	[-0.84 – -0.82]

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

The updated industry average Allen-Uzawa elasticities of substitution are reported in Table 3-10. As in the original report, in later years all input pairs appear as substitutes in production. The updated estimates indicate strong substitution possibilities between labor and fuel, and between equipment and materials. In the earlier years of the sample time period, equipment and fuel appear as complements in production. However, the previous finding of complementarity between materials and fuel in the earlier years disappears with the updated analysis.

TABLE 3–10
INDUSTRY AVERAGE ALLEN-UZAWA ELASTICITIES OF SUBSTITUTION*
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	1995	2000	2008
Labor-Equipment	0.540	0.518	0.505	0.479
	[0.36 – 0.72]	[0.33 – 0.71]	[0.31 – 0.70]	[0.28 – 0.68]
Labor-Materials	0.737	0.694	0.669	0.623
	[0.59 – 0.87]	[0.53 – 0.85]	[0.49 – 0.84]	[0.42 – 0.82]
Labor-Fuel	2.210	1.702	1.599	1.502
	[1.70 – 2.86]	[1.40 – 2.05]	[1.72 – 2.39]	[1.63 – 2.19]
Equipment-Materials	1.675	1.615	1.599	1.598
	[1.44 – 1.98]	[1.38 – 1.82]	[1.34 – 1.88]	[1.29 – 1.72]
Equipment-Fuel	-1.349	-0.071	0.177	0.398
	[-2.81 – -0.19]	[-0.58 – 0.44]	[-0.23 – 0.58]	[0.07 – 0.70]
Materials-Fuel	0.296	0.645	0.711	0.772
	[-0.43 – 0.94]	[0.30 – 0.97]	[0.44 – 0.98]	[0.54 – 0.98]

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

Input Biases in Technical Change

Bias in technical change describes how patterns in the cost-minimizing input mix change over time. The estimates of input biases in technical change are reported in Table 3-11. The magnitudes of the bias measures indicate the average annual rates of change in the input cost shares. For example, the labor share of variable cost has been decreasing by about six tenths of a percentage point per year, on average. The updated findings for input biases are the same as reported in the original study. The estimates indicate that technical change in the freight railroad industry since 1987 has been labor-saving, material-neutral, and equipment- and fuel-using.

TABLE 3–11
INPUT BIASES IN TECHNICAL CHANGE
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

Labor	-0.006	Labor-Saving
	[-0.0069 – -0.0047]	
Equipment	0.002	Equipment-Using
	[0.0018 – 0.0029]	
Materials	-0.001	Materials-Neutral
	[-0.0022 – 0.0005]	
Fuel	0.004	Fuel-Using
	[0.0036 – 0.0051]	

Capacity and the Employment of Capital

The variable cost function allows for the investigation 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.[5] 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,

$$(3.8) \quad C^T = C^V + W_K K$$

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: $\partial C^T/\partial K = 0 \rightarrow \partial C^V/\partial K = -W_K$, 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 impute the price for way and structures capital. Following Bitzan and Wilson, we calculate way and structures capital cost as operating expenses attributed to road.[6] We then divide this measure by the way and structures capital stock to obtain an imputed price of capital. We compare the imputed price of capital to the marginal impact of capital on variable cost. This comparison can be expressed in terms of a "Q Ratio,"

$$(3.9) \quad \text{Q Ratio} = -[\partial \ln C^V / \partial \ln K]/[W_K K / C^V]$$

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 3-12 presents the updated industry average estimates on way and structures capital employment for selected years. As already discussed, the updated capital stock elasticity ($\partial \ln C^V/\partial \ln K$) estimates are larger in magnitude than in the original analysis. As a result, the updated values for the shadow price of capital and the Q Ratio are greater than originally reported. In fact, the updated industry Q Ratio for 1987 is greater than 1.0, implying underemployment of capital. This result is at odds with the general view that

[5] 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.

[6] 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.

the railroad industry was overcapitalized coming out of the regulated era.[7] For most other years, the updated industry estimates on way and structures capital employment indicate that the railroad industry could be characterized as overcapitalized. As reported in the original study, we find that the variable cost savings from adding a dollar of capital has been increasing over time, but the imputed market price of capital has risen more rapidly.[8]

TABLE 3–12
INDUSTRY AVERAGE WAY AND STRUCTURES CAPITAL EMPLOYMENT*
[90 PERCENT CONFIDENCE INTERVALS IN BRACKETS]

	1987	1995	2000	2008
Shadow Price of Capital	0.070	0.069	0.078	0.139
$-(\partial C^V / \partial K)$	[0.04 – 0.10]	[0.04 – 0.10]	[0.05 – 0.01]	[0.08 – 0.20]
Imputed Price of Capital	0.059	0.096	0.107	0.162
– Capital Stock Elasticity	0.210	0.201	0.227	0.226
$-(\partial \ln C^V / \partial \ln K)$	[0.12 – 0.29]	[0.12 – 0.28]	[0.13 – 0.32]	[0.13 – 0.32]
Capital Cost to Variable Cost Ratio $(W_K K / C^V)$	0.191	0.278	0.296	0.326
Q Ratio	1.104	0.769	0.851	0.696
$-(\partial \ln C^V / \partial \ln K) / (W_K K / C^V)$	[0.65 – 1.54]	[0.45 – 1.08]	[0.50 – 1.21]	[0.41 – 0.99]

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

Table 3-13 presents the updated estimates on way and structures capital employment for selected railroads for selected years. As was the case in the original analysis, the updated analysis indicates that in recent years 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.

[7] We are suspicious of the high Q Ratio for 1987 and note that it is largely driven by a relatively small value for the costs of way and structures capital in that year. Way and structures capital costs for 1987 account for only about 16 percent of total cost. Years 1988, 1989, and 1991 also have Q Ratios greater than one. The fixed-cost shares of total cost for these years are 16 percent, 17 percent, and 16 percent, respectively. In contrast, between 1995 and 2008, the fixed-cost share of total cost varied between 22 and 27 percent.

[8] All monetary figures are in real dollars with 2000 as the base year.

TABLE 3–13
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	0.065	0.057	0.957
	[0.04 – 0.09]		[0.56 – 1.35]
BN 1987	0.063	0.053	1.102
	[0.04 – 0.09]		[0.65 – 1.56]
ATSF 1995	0.045	0.125	0.384
	[0.31 – 0.06]		[0.23 – 0.54]
BN 1995	0.068	0.088	0.934
	[0.04 – 0.10]		[0.55 – 1.30]
BNSF 1996	0.068	0.107	0.669
	[0.04 – 0.10]		[0.39 – 0.95]
BNSF 2006	0.137	0.147	0.776
	[0.08 – 0.20]		[0.46 – 1.10]
BNSF 2008	0.178	0.180	0.768
	[0.10 – 0.25]		[0.45 – 1.09]
SP-UP			
SP 1987	0.066	0.067	0.863
	[0.04 – 0.09]		[0.50 – 1.22]
UP1987	0077	0.060	1.147
	[0.05 – 0.11]		[0.67 – 1.60]
SP 1996	0.090	0.125	0.717
	[0.05 – 0.13]		[0.38 – 1.05]
UP 1996	0.070	0.093	0.700
	[0.04 – 0.10]		[0.41 – 0.99]
UP 1997	0.090	0.131	0.680
	[0.05 – 0.13]		[0.40 – 0.97]
UP 2006	0.132	0.150	0.764
	[0.08 – 0.19]		[0.44 – 1.08]
UP 2008	0.155	0.180	0.660
	[0.09 – 0.22]		[0.38 – 0.94]
CSX			
CSX 1987	0.073	0.054	1.257
	[0.04 – 0.10]		[0.74 – 1.78]
CSX 1996	0.072	0.087	0.832
	[0.04 – 0.10]		[0.49 – 1.16]
CSX 2006	0.082	0.105	0.715
	[0.05 – 0.12]		[0.42 – 1.01]
CSX 2008	0.103	0.131	0.666
	[0.06 – 0.15]		[0.39 – 0.94]
NS			
NS 1987	0.071	0.068	1.089
	[0.04 – 0.10]		[0.64 – 1.52]
NS 1996	0.719	0.106	0.618
	[0.04 – 0.10]		[0.37 – 0.87]
NS 2006	0.066	0.108	0.728
	[0.04 – 0.09]		[0.43 – 1.03]
NS 2008	0.079	0.133	0.657
	[0.05 – 0.11]		[0.39 – 0.92]

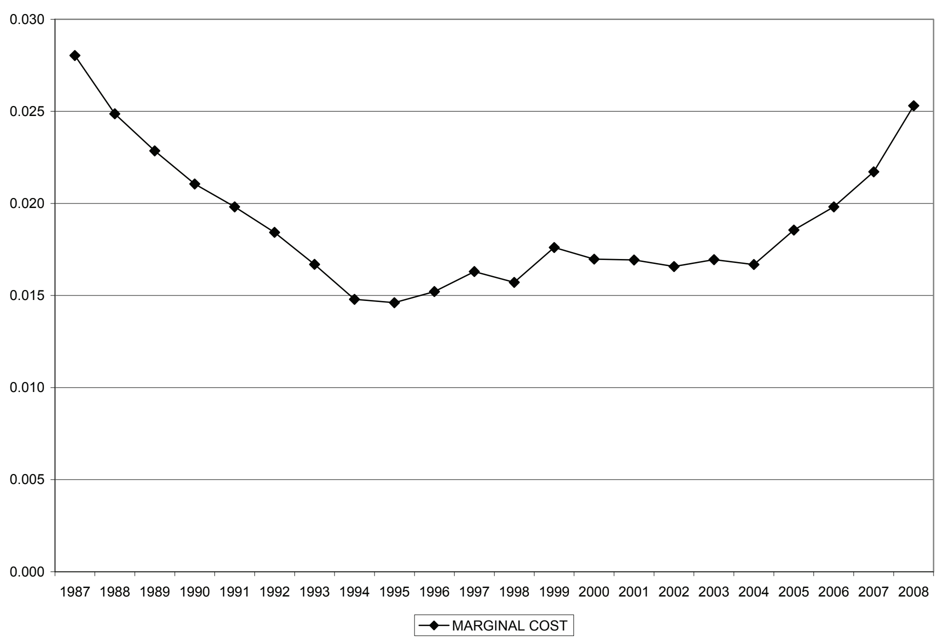
Marginal Cost Analysis

From the variable cost function, we are able to retrieve and analyze estimates for the marginal cost of transporting rail freight. To do so, we manipulate the estimated variable cost function to obtain marginal cost estimates. That is,

(3.10) $\hat{MC} = (\partial \hat{\ln} C^{v} / \partial \ln Y) \times (\hat{C}^{v} / Y)$.

Figure 3-1 presents the updated industry average estimates for the marginal cost of a revenue ton-mile over the period 1987 to 2008. We observe the same general pattern as in the original report. In 2007 and 2008, marginal cost has continued on its recent upward trajectory. This figure shows that, in constant dollars, the marginal cost of a ton-mile steadily decreased from about 2.8 cents in 1987 to less than 1.5 cents in 1995. Between 1995 and 1999, marginal cost trended upward to around 1.8 cents. From1999 to 2004 marginal cost was fairly stable, but since 2004 has been steadily increasing, reaching 2.5 cents in 2008.

FIGURE 3–1
INDUSTRY AVERAGE MARGINAL COST OF A REVENUE TON-MILE*
1987-2008
(Year 2000 Dollars)



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

Figures 3-2 through 3-5 display the marginal costs of a revenue ton-mile for the period 1987-2008 for BNSF, UP, CSX, and NS, respectively. The updated marginal cost estimates for these individual railroads are similar to those originally reported. ATSF and BN, BNSF's predecessor firms, showed declining marginal cost (and rapidly declining marginal cost in the case of ATSF) until about the time of their merger in 1995. BNSF's marginal cost initially increased after the merger, showed modest declines for 1996 to 1998, and relative stability in the 1997-2004 period. For the most recent years, 2005 to 2008, BNSF has had pronounced increases in marginal cost every year. UP's marginal cost follows a somewhat similar pattern. Both UP and SP had rapidly declining marginal cost up until about the time of their merger in 1996. UP's marginal cost increased after the merger and then showed modest decreases for 1996 to 1998, followed by relatively stable marginal cost through 2002. From 2003 to 2008, UP's marginal cost increased 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.[9] Both of these railroads have seen substantial increases in marginal cost for the period 2005 to 2008.

These figures reinforce the original report's finding that the western railroads (BNSF and UP) have similar cost structures to each other, and 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.

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

FIGURE 3–2
BNSF MARGINAL COST OF A REVENUE TON-MILE
1987-2008
(YEAR 2000 DOLLARS)

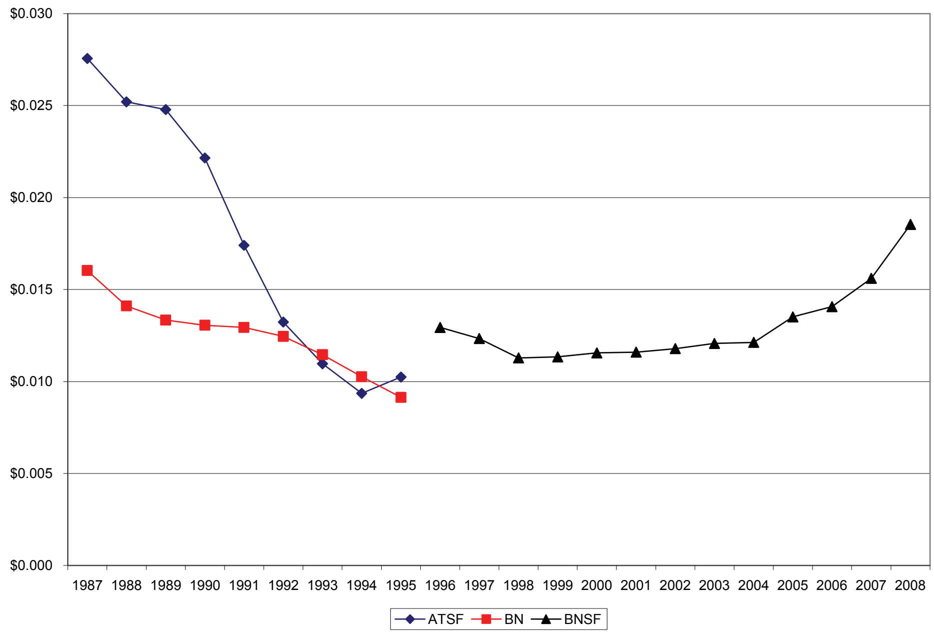


FIGURE 3–3
UNION PACIFIC MARGINAL COST OF A REVENUE TON-MILE
1987-2008
(YEAR 2000 DOLLARS)

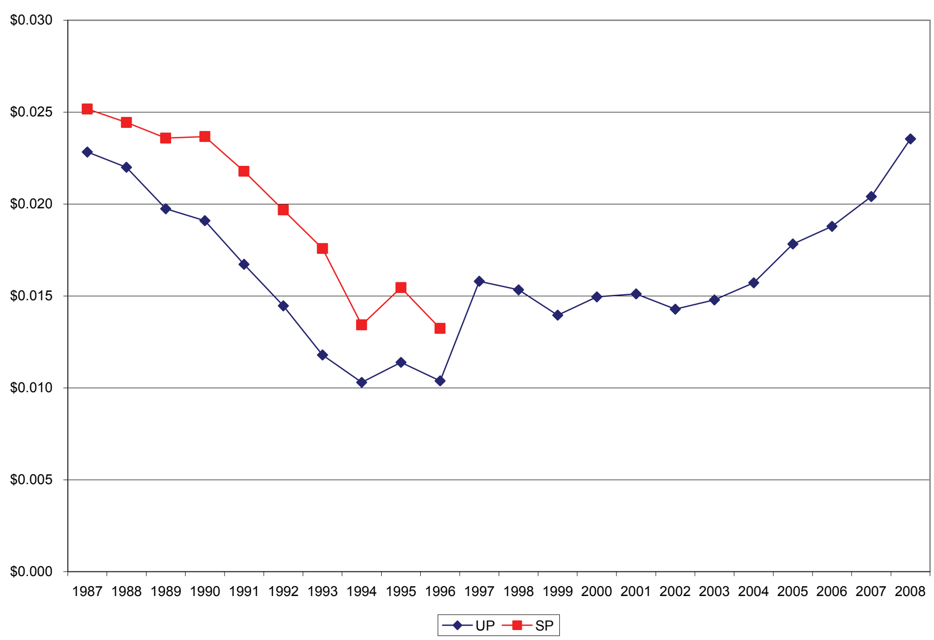


FIGURE 3–4
CSX MARGINAL COST OF A REVENUE TON-MILE
1987-2008
(YEAR 2000 DOLLARS)

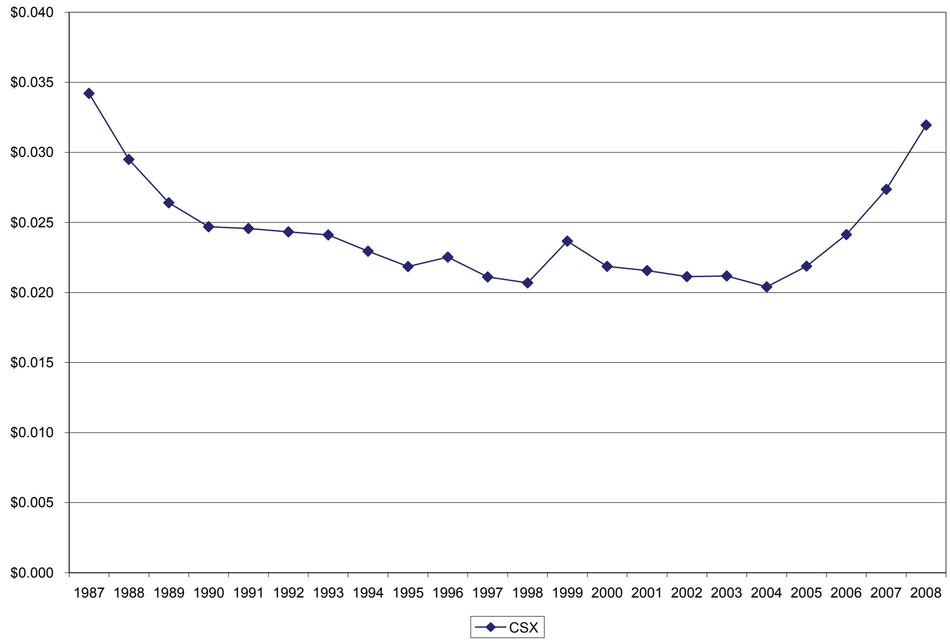
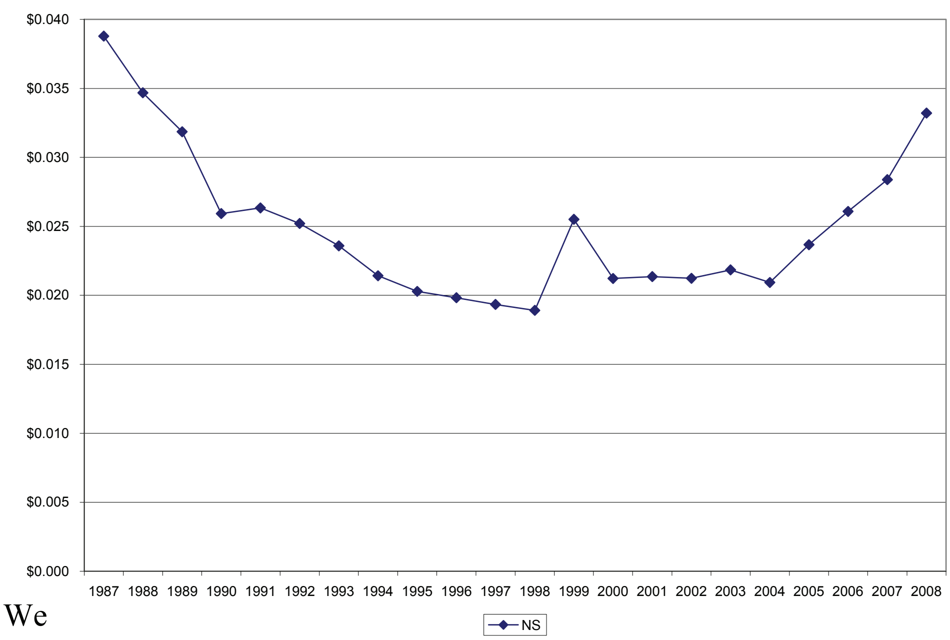


FIGURE 3–5
NORFOLK SOUTHERN MARGINAL COST OF A REVENUE TON-MILE
1987-2008
(YEAR 2000 DOLLARS)



We summarize the updated percentage changes in marginal cost over different time periods in Table 3-14. The results are fairly similar to those in the original report. Noticeable differences from the original report are that the 1987-1994 decrease in marginal cost and the increase since 2004 are more now pronounced. Also, we now divide the period 1994-2004 into two distinct periods, the first of increasing marginal cost and the second of decreasing marginal cost.

TABLE 3–14
CHANGES IN INDUSTRY AVERAGE MARGINAL COST OF A REVENUE TON-MILE OVER DIFFERENT TIME PERIODS

Time Period	Cumulative Change	Average Annual Change
1987-1994	-47.2%	-6.7%
1994-1999	19.0%	3.8%
1999-2004	-5.2%	-1.0%
2004-2008	51.6%	12.9%
1987-2008	-9.7%	-0.5%

The most rapid decline in marginal cost occurred between 1987 and 1994, when marginal cost decreased at an average annual rate of 6.7 percent. Between 1994 and 1999, marginal cost increased at about 3.8 percent per year. From 1999 to 2004, marginal cost decreased slightly, by about one percent per year. However, since 2004, marginal cost has been increasing at an average annual rate of almost 13 percent.

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

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

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

(3.12) $$X_{i,t,}\text{Impact} = [\partial \ln MC_t / \partial \ln X_{i,t}] \times [\ln X_{i,t} - \ln X_{i,t-1}].$$

Table 3-15 shows the industry-wide year-to-year changes in the exogenous variables and their estimated impacts on marginal cost for the years 2002-2008. The last two rows of this table show the sum of the impacts and the estimated year-to-year percentage change in marginal cost.[10] Overall, the first-order approximation of the total impact does a fairly good job of accounting for year-to-year marginal cost changes. The impacts through 2006 are similar to those reported in the original study, with only the "time impact" being noticeably different. This difference is the result of the change in the specification of the variable cost function (that is, dropping the switching-parameter mechanisms).

The data in Table 3-15 provide an explanation for marginal cost changes in the railroad industry. As we concluded in the original report, increasing fuel prices and apparently negative technical change were the primary factors pushing up marginal cost. Between 2003 and 2008, the average real price of fuel increased by over 200 percent. The cumulative impact of increasing fuel prices on marginal cost over this period of time is to increase marginal cost by more than 28 percent. In 2008 alone, fuel price increases of more than 33 percent resulted in an almost 7 percent increase in marginal cost.

As in the original analysis, a puzzling and unexplained time impact puts substantial upward pressure on marginal cost. This effect alone accounts for marginal cost increasing by over four percent per year for 2005 through 2008.

We again find that the upward pressure on marginal cost was mitigated in part by revenue ton-mile growth through 2006. The update, however, reveals that revenue ton-miles remained essentially constant in 2007 and 2008.

[10] The marginal cost changes reported in the last row of Table 3-15 are calculated as the weighted average of the railroad-specific percentage changes in marginal cost. In contrast, comparing consecutive data points in Figure 3-1 to obtain percentage changes in marginal cost uses the weighted average of the railroad-specific marginal cost. The two methods produce similar, but not identical, results. The most noticeable difference occurs for 2004 when Figure 3-1 shows industry marginal cost decreasing slightly and Table 3-15 shows the average percentage change in marginal cost increasing slightly.

TABLE 3–15
INDUSTRY-WIDE SOURCES OF MARGINAL COST CHANGES*
2002-2008

Variable		2002	2003	2004	2005	2006	2007	2008
Revenue Ton-Mile	Impact	-0.05%	-1.90%	-4.71%	-1.26%	-2.69%	0.49%	-0.34%
	Difference	-0.11%	2.81%	6.81%	1.78%	3.66%	-0.63%	0.46%
Road	Impact	-1.32%	-0.99%	-1.19%	-1.05%	-0.66%	0.14%	-0.26%
	Difference	-1.00%	-0.84%	-1.10%	-1.03%	-0.57%	-0.02%	-0.24%
Time	Impact	2.19%	2.75%	3.50%	4.11%	4.67%	5.14%	5.68%
	Difference	1	1	1	1	1	1	1
Capital	Impact	0.54%	0.49%	-1.89%	0.41%	0.17%	0.30%	0.17%
	Difference	-2.43%	-2.25%	8.38%	-1.85%	-0.77%	-1.36%	-0.78%
Labor Price	Impact	1.45%	0.33%	0.71%	0.10%	0.03%	-2.35%	0.29%
	Difference	4.44%	1.02%	2.17%	0.29%	0.11%	-7.63%	0.96%
Equipment Price	Impact	-0.50%	-0.36%	0.16%	0.71%	-1.70%	1.42%	0.80%
	Difference	-5.47%	-4.19%	0.63%	7.34%	-19.18%	15.36%	8.27%
Materials Price	Impact	-0.96%	-0.81%	1.47%	2.02%	2.64%	2.31%	2.65%
	Difference	-2.38%	-2.04%	3.72%	5.14%	6.85%	5.88%	6.78%
Fuel Price	Impact	-3.14%	3.18%	2.75%	6.18%	4.38%	2.05%	6.84%
	Difference	-17.67%	16.91%	14.00%	31.76%	21.89%	10.04%	33.84%
Average Haul Length	Impact	-0.03%	0.01%	-0.04%	0.09%	0.06%	1.09%	0.16%
	Difference	0.45%	1.12%	1.21%	-0.46%	0.28%	2.99%	0.75%
	Total Impact	-1.82%	2.70%	0.76%	11.32%	6.91%	10.15%	15.98%
	Marginal Cost Change	-1.85%	2.35%	0.69%	11.58%	6.82%	10.23%	16.97%

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

CONCLUSIONS

We have updated the analysis of railroad costs and technology by re-estimating the variable cost function. The re-estimation of the model was impacted by three factors. Adding 2007 and 2008 observations to the data set resulted in 14 more observations. We also made a minor change to the construction of variable cost. Finally, we changed the specification of the variable cost function by dropping the switching-parameter mechanisms that had been applied to the first- and direct second-order time trend terms.

The qualitative findings about rail costs and technology remain essentially the same as in our original report. The updated analysis indicates that the decline in density economies has continued in 2007 and 2008 such that the Class I railroad industry overall now appears to be experiencing approximately constant returns to density. We again find that the industry experienced approximately constant returns to scale over the sample time frame. Productivity gains were strong in the first part of the sample time frame, but have continually diminished. Over the sample time frame, technological change has been labor-saving, materials-neutral, equipment-using, and fuel-using. There is no evidence that the Class I railroad industry is under-capitalized. Marginal cost decreased substantially between 1987 and 1994, went up and then down between 1994 and 2002, and has been rising at a much greater rate since 2005. Rising fuel prices have been a major factor in the recent increases in marginal cost.

APPENDIX

Exhibit 1: Variable Cost Function Definitions and Sources

	Definition: Source
Variable Cost	
Real Variable Cost	VARIABLE COST ⁄ GDPPI
VARIABLE COST	OPERCOST + 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
<u>Input Shares of Variable Cost</u>	
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
<u>Output and Network</u>	
Revenue Ton-Miles	R-1, Sched. 755, Line 110, Col. B
Miles of Road	R-1, Sched. 700, Line 57, Col. C
<u>Capital Stock</u>	

MOT	Miles of track: R-1, Sched. 720, Line 6, Col. B
Way and Structures Capital per Mile of Track	[(ROADINV – ACCDEPR)/MOT]/GDPPI
<u>Input Prices</u>	
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
<u>Other Variables</u>	
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
<u>Capital Employment Variables</u>	
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: Updated Cost Function Estimates

The translog specification of variable cost is:

$$
\begin{aligned}
\ln C^V = & \alpha_0 + \alpha_Y \ln Y + \alpha_N \ln N \\
& + 1/2\,\alpha_{YY} (\ln Y)^2 + \alpha_{YN} \ln Y \ln N + 1/2\,\alpha_{NN} (\ln N)^2 \\
& + \sum_i \beta_1 \ln W_i \\
& + 1/2 \sum_i \sum_j \beta_{ij} \ln W_i \ln W_j \\
& + \eta_K \ln K + \eta_H \ln ALOH \\
& + 1/2\,\eta_{KK} (\ln K)^2 + 1/2\,\eta_{HH} (\ln ALOH)^2 \\
& + \sum_i \alpha_{Yj} \ln Y \ln W_i \\
& + \sum_i \alpha_{Nj} \ln N \ln W_i \\
& + \tau_T\, Time + 1/2\,\tau_{TT} (Time)^2 \\
& + \tau_Y\, Time \ln Y + \tau_N\, Time \ln N \\
& + \sum_i \tau_i\, Time \ln W \\
& + \sum_k d_k\, Firm_k
\end{aligned}
\tag{3.13}
$$

where ln is the natural logarithm operator, Y represents revenue ton-miles, N the network size measured in miles of road,[11] 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 the 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 3-1, there are 22 distinct Class I firm incarnations between 1987 and 2008. This results in 21 binary firm-indicator variables being included in equation (3.13).[12]

The input share equations are obtained as the partial derivatives of ln C^V with respect to the input prices. That is,

$$M_i = \beta_i + \sum_j \beta_{ij} \ln W_j + \alpha_{Yj} \ln Y + \alpha_{Nj} \ln N + \tau_j Time \tag{3.14}$$

.

[11] 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.

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

Homogeneity of C^V with respect to input prices is imposed by the following parameter restrictions:

$$\begin{aligned} &\textstyle\sum_i \beta_i = 1; \\ &\textstyle\sum_i \beta_{ij} = \sum_j \beta_{ji} = 0; \\ (3.15)\quad &\textstyle\sum_i \alpha_{Yj} = 0; \\ &\textstyle\sum_i \alpha_{Rj} = 0; \\ &\textstyle\sum_i \tau_j = 0\ . \end{aligned}$$

Equations (3.13) and (3.14), along with the imposed restrictions in equation (3.15), comprise the four-equation system for estimation.[13] We estimate this system by the method of seemingly unrelated regressions.

Table 3-16 reports summary statistics and parameter estimates for the estimated variable cost system model.

[13] The variable cost function system consists of the variable cost equation and (any) three of four of the input share equations.

TABLE 3–16
VARIABLE COST FUNCTION SYSTEM ESTIMATES

Equation	R-Square	Adjusted R-Square
LNVC	0.9856	0.9822
LVSHARE	0.4572	0.4430
EVSHARE	0.2170	0.2123
FVSHARE	0.4862	0.4839

Parameter (Variable)	Estimate	Std. Error	t Value	Pr > |t|
A0	-0.16975	0.1242	-1.37	0.1735
TON_MILES	0.730362	0.1022	7.15	<.0001
M_O_ROAD	0.391942	0.0805	4.87	<.0001
CAPITAL	-0.18249	0.0493	-3.70	0.0003
ALOH	-0.12958	0.0933	-1.39	0.1668
EQUIP	0.123829	0.00220	56.39	<.0001
MATERIAL	0.388199	0.00536	72.47	<.0001
FUEL	0.12374	0.00308	40.17	<.0001
A11	-0.5047	0.1615	-3.12	0.0021
A12	0.764483	0.1583	4.83	<.0001
A22	-0.94463	0.1584	-5.96	<.0001
Z11	-0.05616	0.0335	-1.68	0.0951
Z22	0.606498	0.1919	3.16	0.0019
BEE	0.005272	0.00337	1.57	0.1189
BEM	0.028423	0.00589	4.83	<.0001
BEF	-0.01258	0.00359	-3.51	0.0006
BMM	0.032784	0.0178	1.84	0.0669
BMF	-0.01449	0.00835	-1.73	0.0844
C1E	-0.026	0.00682	-3.81	0.0002
C1M	0.00806	0.0169	0.48	0.6342
C1F	0.03378	0.00999	3.38	0.0009
C2E	0.025994	0.00822	3.16	0.0018
C2M	-0.0078	0.0202	-0.39	0.7003
C2F	-0.02989	0.0120	-2.50	0.0133
TG3	-0.00599	0.00368	-1.63	0.1057
TTG3	0.00432	0.000552	7.83	<.0001
TQ	0.023705	0.00766	3.10	0.0023
TROAD	-0.03754	0.00851	-4.41	<.0001
TE	0.002349	0.000357	6.58	<.0001
TM	-0.00087	0.000864	-1.01	0.3133
TF	0.004287	0.000481	8.91	<.0001
D1	0.184679	0.1296	1.42	0.1560
D2	-0.24581	0.0534	-4.60	<.0001
D3	-0.25058	0.0275	-9.13	<.0001
D4	-0.2562	0.1780	-1.44	0.1518
D5	0.045523	0.1783	0.26	0.7988
D6	0.482674	0.1429	3.38	0.0009
D7	0.202753	0.1013	2.00	0.0469
D8	-0.15894	0.1956	-0.81	0.4176

D9	0.428201	0.2140	2.00	0.0470
D10	-0.09992	0.1891	-0.53	0.5978
D11	-0.2984	0.1961	-1.52	0.1299
D12	-0.48852	0.2322	-2.10	0.0369
D13	0.233361	0.1161	2.01	0.0461
D14	-0.27575	0.2034	-1.36	0.1770
D15	-0.27939	0.1971	-1.42	0.1582
D16	0.312616	0.1396	2.24	0.0264
D17	0.139364	0.1234	1.13	0.2604
D18	-0.06979	0.1029	-0.68	0.4987
D19	-0.08412	0.0744	-1.13	0.2599
D20	0.009803	0.0691	0.14	0.8874
D21	0.026391	0.0611	0.43	0.6665

Exhibit 3: Comparison of Elasticity Estimates

The re-estimation of the variable cost function model is affected by three factors. First, adding two additional years of data for the seven Class I railroads can have an impact on the cost function parameter estimates. Second, we make a minor change to the construction of variable cost by including capital expenses other than way and structures expenses. These additional expenses become part of the calculated materials cost share. Third, we drop the switching-parameter mechanisms that had been applied to the first- and direct second-order time trend terms in our original analysis. The change in the construction of variable cost has very little impact on the cost function parameter estimates. However, the other two factors, adding data and changing specification, do have some noticeable impacts.

In this exhibit, we provide more detail about the impacts of expanding the data set and changing the specification of the variable cost function. We show the impact of each of these two factors on the key elasticity estimates underlying the cost and technology analysis. The key elasticity estimates are those reported in Table 3-2.

For each graph below, three series are presented: the elasticity estimates by year for 1987 to 2006 as originally reported (labeled “Original”), the elasticity estimates by year for 1987 to 2006 based on a cost function specification without the switching-parameter mechanisms that is estimated with the 1987-2006 data (labeled “No Switch”), and the updated estimates based on the expanded 1987-2008 data set and the specification without the switching mechanisms (labeled “Updated”). The impact of using the additional two years of data in the estimation can be discerned by comparing the “Updated” to the “No Switch” series. The impact of the specification change from dropping the switching mechanisms is inferred by comparing the “No Switch” and the “Original” series.

FIGURE 3–6
COMPARISON OF TON-MILE ELASTICITY ESTIMATES

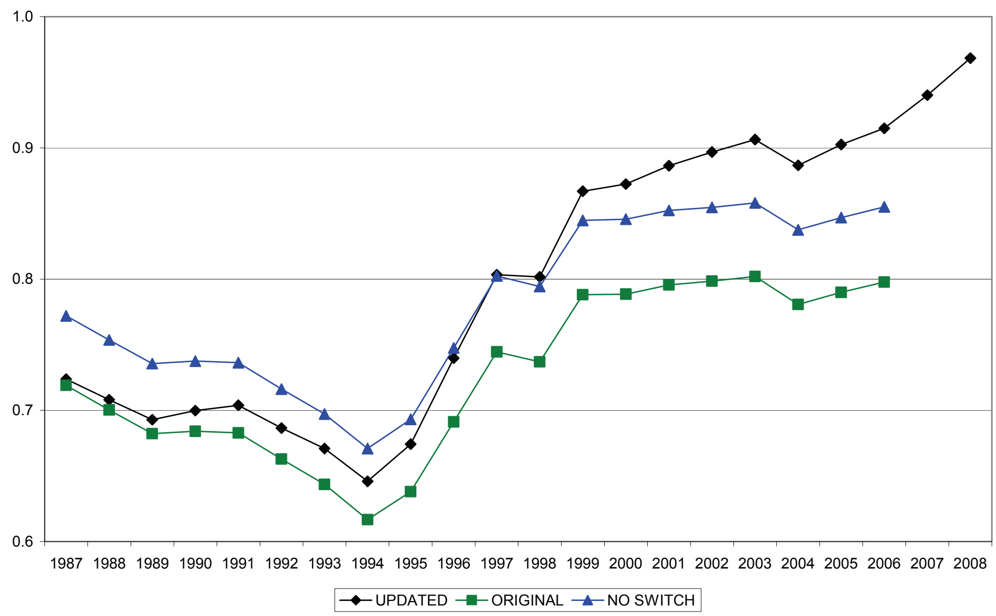


FIGURE 3–7
COMPARISON OF LENGTH-OF-HAUL ELASTICITY ESTIMATES

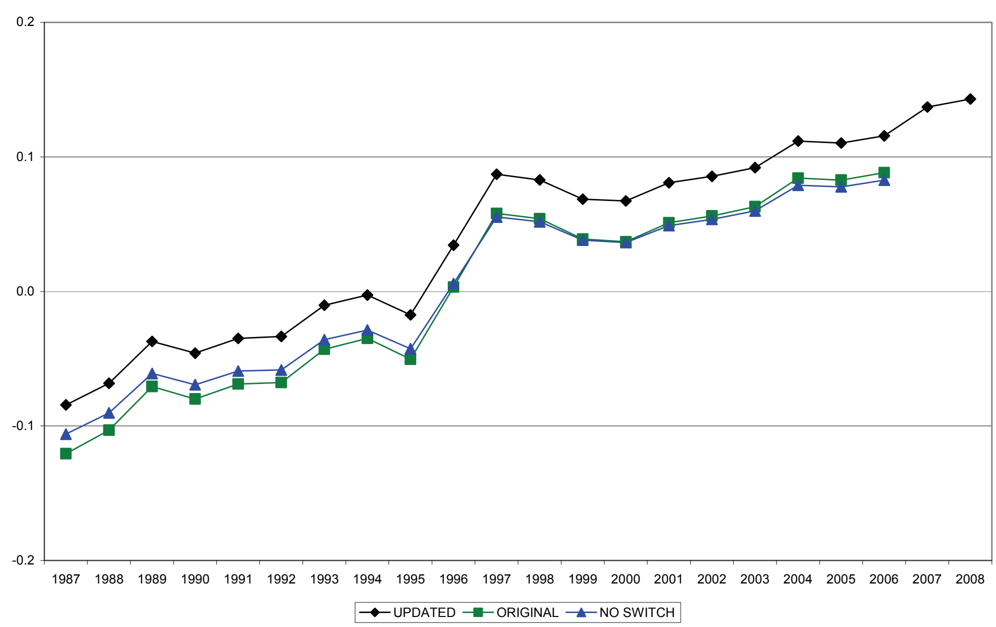


FIGURE 3–8
COMPARISON OF CAPITAL-STOCK ELASTICITY ESTIMATES

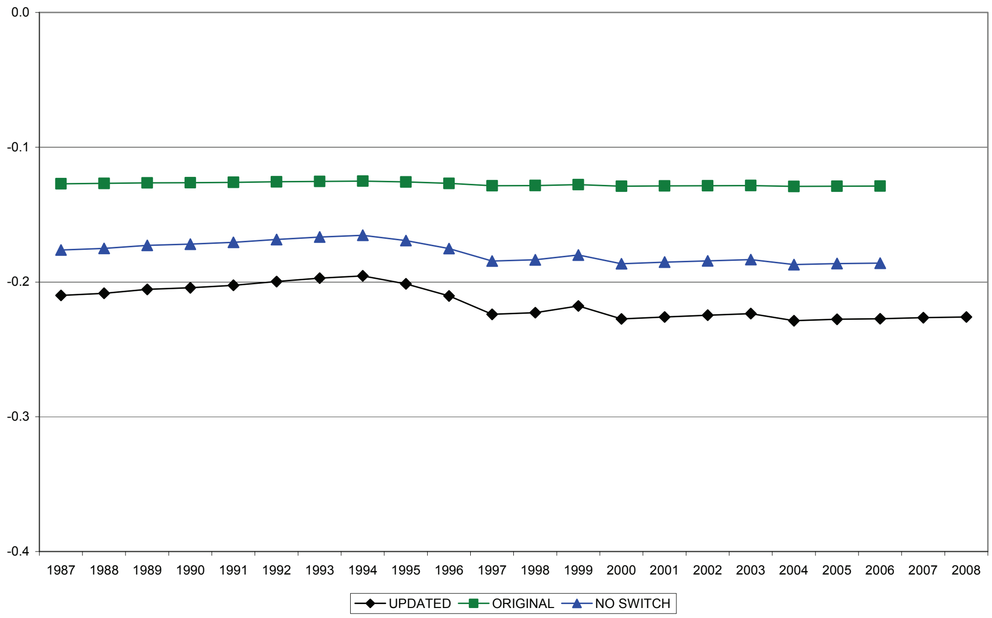


FIGURE 3–9
COMPARISON OF NETWORK-SIZE ELASTICITY ESTIMATES

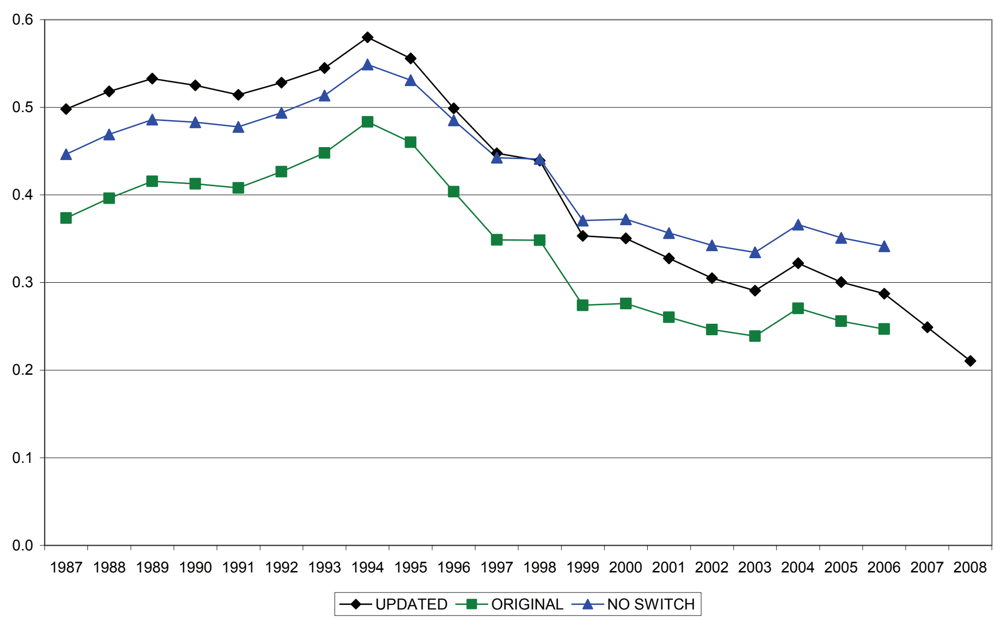
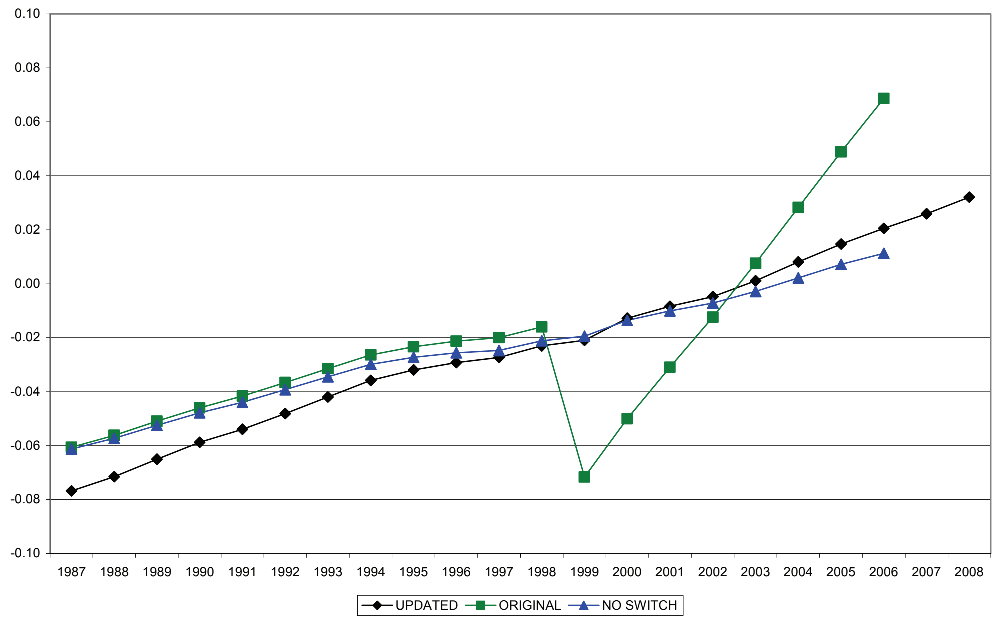


FIGURE 3–10
COMPARISON OF RATE OF COST CHANGE ESTIMATES



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CHAPTER 4
AN OVERVIEW OF COSTS AND REVENUE

INTRODUCTION

This chapter updates the high-level analysis and comparison of the railroad industry's costs and revenues that we presented in our original report. 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.

In this chapter, we provide updates of the tables and analysis that appear in Chapter 10 of the original report. The qualitative findings remain largely the same as in the original report, but there are some quantitative differences that result from changes in the marginal cost estimates. As described in Chapter 3 of the current report, the updated cost estimation is affected by three factors: adding two additional years of data, changing the specification of the cost function by dropping the switching-parameter mechanisms, and a change in the construction of variable cost by including capital expenses other than way and structures expenses. Our discussion in this chapter highlights the trends revealed by the latest data and examines notable differences from the original report.

4A. DATA

Our analysis relies upon data reported annually to the STB in Railroad Form 1 (R-1 data). For each railroad included in our analysis, we calculate the average annual revenue per ton-mile (RPTM). 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. All revenue per ton-mile and cost measures are reported in constant dollars (base year 2000).

Additionally, we use the updated marginal cost estimates obtained from the variable cost function analysis presented in Chapter 3. The estimated variable cost function and resulting marginal cost estimates are also founded on the R-1 data.

4B. REVENUE PER TON-MILE AND COSTS

Figure 4-1 presents industry averages[1] by year for revenue per ton-mile and short-run marginal cost over the 1987-2008 period.[2] As described in the previous chapter, marginal cost steadily decreased in 1987-1994, increased in 1995-1999, was relatively stable for 2000-2004, and then steadily increased in 2005-2008. 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 2005-2008. These patterns are similar to the ones described in the original report, except that the original report found marginal cost to be decreasing for 2000-2004. Our updated analysis finds the recent trend of increasing marginal cost continued in 2007 and 2008, averaging over 13 percent for this two-year period. Revenue per ton-mile increased by only two percent in 2007, but then increased by nine percent in 2008. Overall, since 2004, revenue per ton-mile has increased by an average of almost 7 percent per year while the estimate of marginal cost has increased by almost 13 percent per year. As we noted in the original report, 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 4-2 provides more detail on how revenue per ton-mile and marginal cost change over time. This figure shows that changes in marginal cost have not, in general, been matched by proportional changes in revenue per ton-mile.[3] Between 1987 and 2008, marginal cost estimates show a year-to-year decrease in 13 years. Only in two of these years did revenue per ton-mile decrease by a larger percentage than did marginal cost. Over this same period, we find eight cases of year-to-year increases in marginal cost. In all of these cases, including 2005-2008, the percentage change in revenue per ton-mile was less than that of marginal cost.

[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.

[3] Less than proportional price responses to marginal cost changes are consistent with theories of oligopoly behavior where firms are hesitant to match marginal cost decreases lest they trigger a price war, and are reluctant to match marginal cost increases because they fear losing market share.

FIGURE 4–1
INDUSTRY AVERAGE ANNUAL REVENUE PER TON-MILE AND MARGINAL COST FOR A TON-MILE
(Year 2000 Dollars)

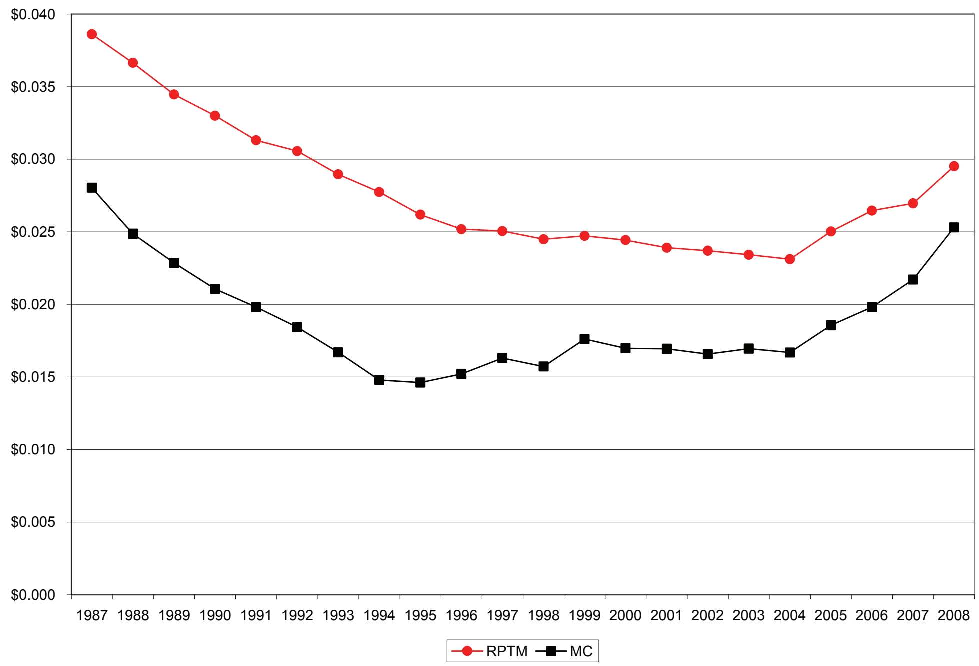


FIGURE 4–2
PERCENT CHANGES FOR INDUSTRY AVERAGE ANNUAL REVENUE PER TON-MILE AND MARGINAL COST

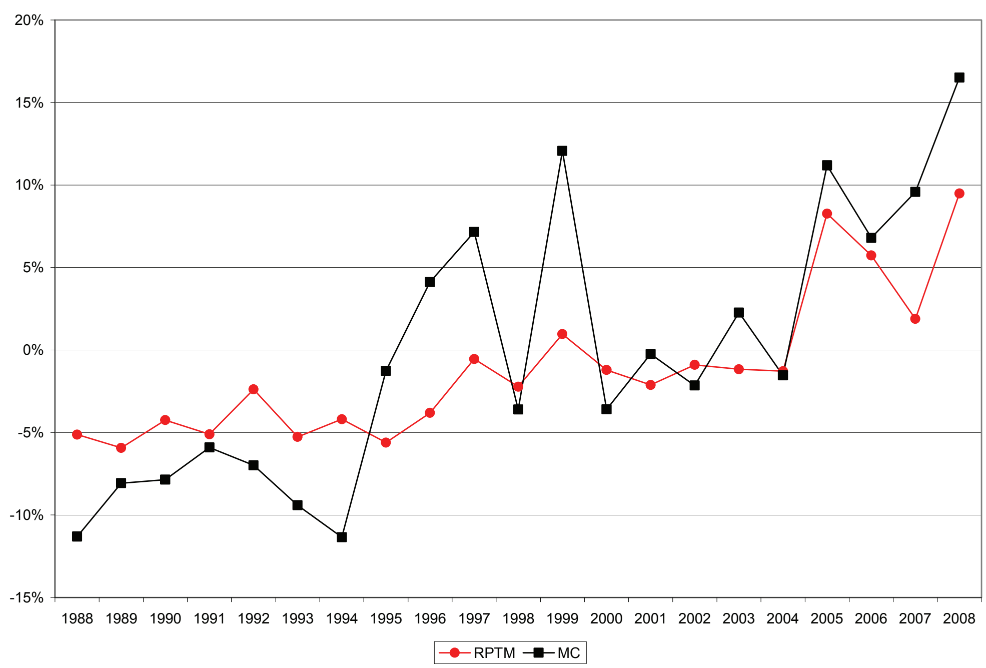


Figure 4-3 provides annual values for the average total cost of shipping a ton-mile (ATC), as well as its components, average variable cost (AVC) and average fixed cost (AFC). Compared to the original report, the series for ATC and AVC have shifted up by about $0.001 as a result of the change in how we calculate variable cost. The patterns of these costs over time are exactly the same as shown in the original report. Looking at the 2007 and 2008 data points, we see that AFC, AVC, and ATC increased by averages of 9.4 percent, 5.0 percent and 6.0 percent, respectively.

FIGURE 4–3
INDUSTRY AVERAGE TOTAL COST, AVERAGE VARIABLE COST, AND AVERAGE FIXED COST
(Year 2000 Dollars)

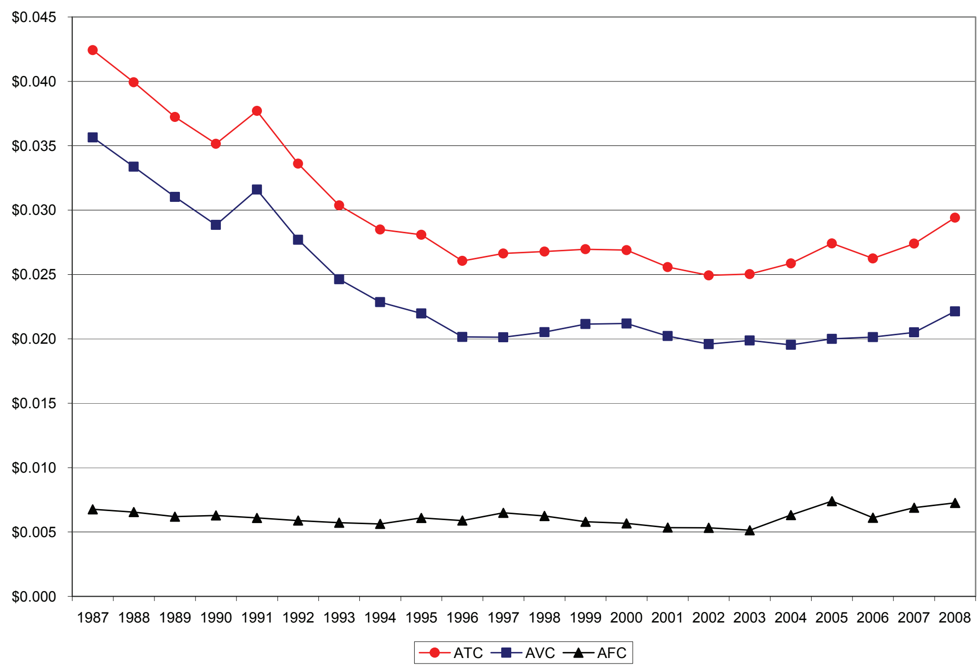
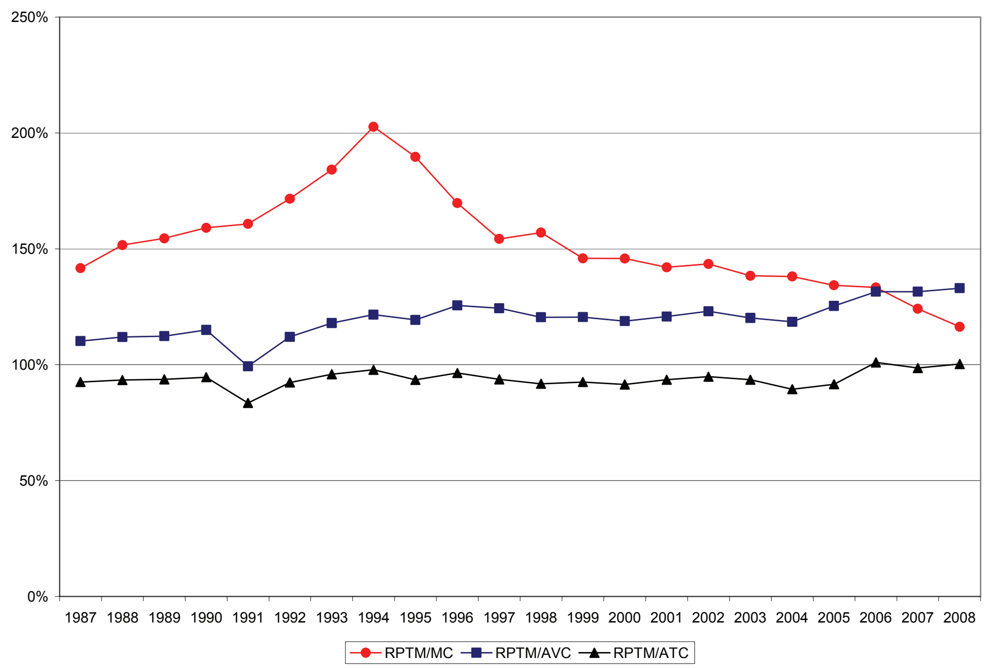


Figure 4-4 presents three different markup ratios for the railroad industry. The top series shows the ratio of the average revenue per ton-mile to the marginal cost estimated in Chapter 3. The lower two series, RPTM/AVC and RPTM/ATC, are calculated directly from the R-1 data.

The series presented in this figure follow the same patterns over time as we reported in our original report. In our original report, however, we had not included "capital expenses classified as operating expenses" in the calculations of variable and total costs. The inclusion of these expenses causes the RPTM/AVC and RPTM/ATC ratios to be smaller than the corresponding ratios presented in our original report. Compared to the original report, the calculations of RPTM/AVC have shifted down by 5 to 7 percentage points and the calculations of RPTM/ATC have shifted down by 3 to 5 percentage points, with the shifts at the lower end of these ranges occurring in the years since 2000. The RPTM/MC series shifts down by almost 17 percentage points, on average. The shifts in the estimates of RPTM/MC range from a 9 percentage point decrease to a 27 percentage point decrease, with the larger shifts occurring in the years since 2001. The causes of the shifts in the RPTM/MC estimates are the change in specification of the estimated cost function and the addition of two years of data to the sample period. On average, the specification change accounts for a 12.5 percentage point decrease and the addition of data accounts for a 4.1 percentage point decrease in the estimates of RPTM/MC.

FIGURE 4–4
INDUSTRY MARKUP RATIOS

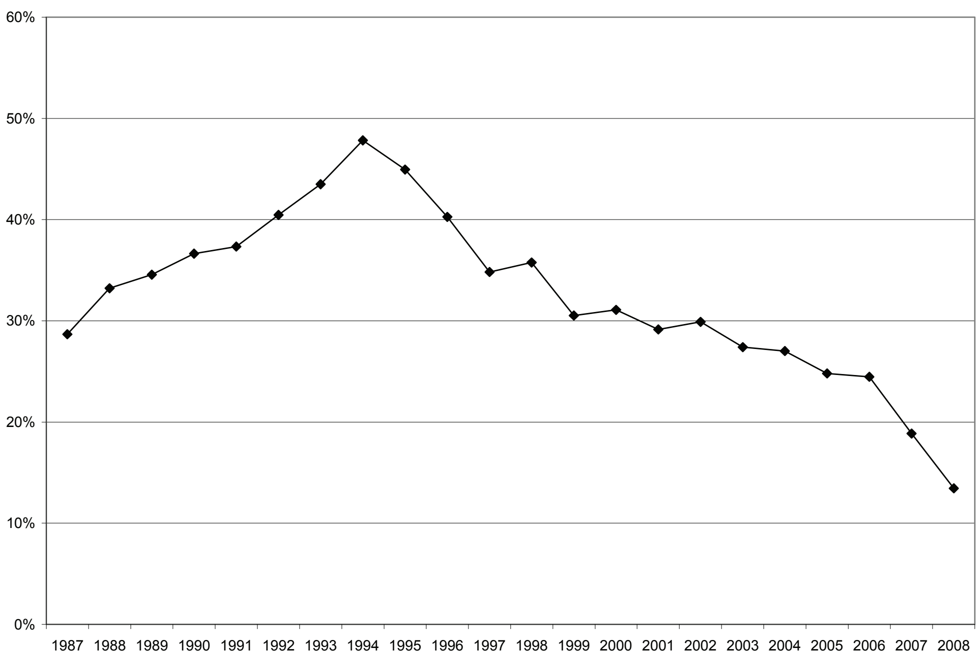


As we found in our original report, the RPTM/ATC series shows the railroad industry struggling with revenue sufficiency until 2006. In 2005 and 2006, the industry saw substantial increases in revenue per ton-mile. As a result, the RPTM/ATC ratio was 101 percent in 2006.[4] Looking at the three markup ratios in 2007 and 2008, we see that RPTM/MC has continued its downward trend, while RPTM/AVC has risen slightly in both of these years. The RPTM/ATC series shows that the industry ratio continues to hover around 100 percent. This ratio declined slightly in 2007 to less than 99 percent and then rebounded in 2008 to just over 100 percent.

[4] In our original study, we reported that RPTM was 104 percent of ATC in 2006. The inclusion of the capital expenses classified as operating expenses in variable and total costs results in the shift down in this ratio to 101 percent.

Figure 4-5 presents the updated industry average values for the Lerner Markup Index (LMI). The LMI reflects the percentage markup of the revenue per ton-mile over marginal cost.[5] 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. Greater values of the LMI indicate greater market power. Figure 4-5 reflects what we have observed in Figures 4-2 and 4-4, 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. This measure of market power showed continuing declines in 2007 and 2008.

FIGURE 4–5
INDUSTRY LERNER MARKUP INDEX



The updated LMI estimates show the same general pattern over time as the estimates in our original report, with the exception of the period 2000-2002. In the original report, the LMI estimates increased over this period, whereas the update shows the LMI series oscillates over this period. Both the original and the updated estimates show market power declining since 2002. The updated estimates show this decline in LMI has continued in 2007 and 2008.

While the pattern over time of updated LMI estimates is similar to that presented in the original report, the overall level of the LMI estimates for all years has decreased with the update. This downward shift results from the change in cost function specification and from adding two more years of data

[5] The Lerner Markup Index is calculated as (RPTM – MC)/RPTM and is sometimes referred to as the Lerner Market Power Index or simply the Lerner Index.

in the estimation. LMI estimates since 2001 seem particularly sensitive to use of the expanded dataset.

Based on our analysis presented in this section, we reach the same conclusion as in our original study. The increase in rail rates in recent years appears to be the result of increasing cost and does not appear to reflect an increase in the exercise of market power. However, we temper this conclusion with the observation that the estimates of marginal cost and the market power measure since 2001 are sensitive to the addition of new data.

We caution that looking at how the exercise of market power changes from year to year does not give a complete picture of the competitive performance of the U.S. railroad industry. The exercise of market power may change because the railroads' opportunities to mark up rates over marginal cost have changed. On the other hand, the mark up of rates may change because underlying cost conditions have changed, specifically the extent of density economies and the amount of fixed costs. The next three sections of this chapter provide a more detailed analysis of the markup of rates over marginal cost. We introduce the concepts of "revenue sufficiency," "market-power pricing," and "excess markup" to distinguish profit-enhancing changes in the exercise of market power from those driven by changing cost conditions.

4C. Revenue Sufficiency

As seen in Figure 4-4, achieving revenue sufficiency has been a challenge for the railroad industry. The existence of any economies of density would mean that marginal cost pricing, the competitive ideal, is insufficient to recover variable costs. Likewise, any fixed costs add to the collection burden. Consequently, revenue sufficiency may require 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.

(4.1) $$RPTM = AVC + AFC = ATC .$$

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

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

Substituting (4.2) into (4.1) and manipulating[6] the terms gives:

$$(4.3) \quad \tau = Density \times (1 + FC / VC) - 1$$

where Density is the economies of density measure, $[\partial \ln C^V / \partial \ln Y]^{-1}$, defined in Chapter 3, and FC/VC is the ratio of fixed to variable costs. Inspection of equation (4.3) 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 either economies of density or fixed costs mandates that some market power be exercised if revenue sufficiency is to be achieved.

4D. MARKET POWER PRICING

A profit-maximizing firm will mark up its price, thereby restricting sales, 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 of these basic equations says that the firm marks up marginal cost.

$$(4.4) \quad RPTM = (1 + \mu) \times MC .$$

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

$$(4.5) \quad MR \equiv RPTM(1 + 1/\varepsilon) = MC \quad [Note : \varepsilon \equiv \partial \ln Q_D / \partial \ln RPTM < 0]$$

where ε is the price elasticity of demand perceived by the firm and Q_D is the quantity demanded. Equations (4.4) and (4.5) can be solved for the profit-maximizing markup factor μ. That is,

$$(4.6) \quad \mu = -1/(1 + \varepsilon).$$

[6] Substituting equation (4.2) into equation (4.1) 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, $\tau = Density \times (1 + FC/VC) - 1$.

4E. 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.[7] That is,

$$\gamma = \mu - \tau \tag{4.7}$$

where γ is the excess markup factor.

We can take the derivative of equation (4.7) with respect to time to analyze the causes of changes in the excess markup factor. That is,

$$\begin{aligned} d\gamma / dt &= d\mu / dt - d\tau / dt \\ &= 1/(1+\varepsilon)^2 \, d\varepsilon / dt \\ &\quad - (1 + FC/VC) dDensity / dt - Density \, d(FC/VC)/dt \end{aligned} \tag{4.8}$$

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 factor, 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 3. 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.[8] Estimates for dDensity/dt are obtained by the quotient rule for differentiation.[9] 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 3. 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 4-1 shows year-to-year percentage changes for the revenue per ton-mile and cost variables presented in Figures 4-1 and 4-3, over the 2002-2008 period.

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

[8] This corresponds to the Density_1 measure from Chapter 3. This measure holds the average length of haul (ALOH) constant.

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

TABLE 4–1
YEAR-TO-YEAR PERCENT CHANGES IN REVENUE PER TON-MILE AND COST VARIABLES
2002-2008

	2002	2003	2004	2005	2006	2007	2008
Revenue Per Ton-Mile	-0.90%	-1.16%	-1.29%	8.26%	5.73%	1.89%	9.48%
Marginal Cost	-2.15%	2.27%	-1.54%	11.18%	6.80%	9.59%	16.51%
Average Variable Cost	-3.09%	1.45%	-1.72%	2.40%	0.63%	1.85%	7.97%
Average Fixed Cost	-0.37%	-3.43%	22.76%	17.08%	-17.45%	12.84%	5.36%
Average Total Cost	-2.52%	0.41%	3.32%	5.99%	-4.25%	4.41%	7.31%

Table 4-2 presents an accounting for changes in the railroad industry's average excess markup factor over the period 2002-2008. Perusal of Tables 4-1 and 4-2 gives a more complete understanding of the exercise of market power in the environment of overhead collection and revenue sufficiency. The first row of Table 4-2 shows the excess markup factor given by equation (4.7). Positive values for the excess markup indicate the industry is revenue sufficient, while negative values indicate revenue insufficiency. Only in 2006 and 2008 does the industry appear revenue sufficient. The next three rows present the three components from equation (4.8) that account for changes in the markup factor. The last row indicates the change in the excess markup from the previous year.

The "density impact" shows the effect on the excess markup measure from changes in marginal cost relative to average variable cost. The density impact is positive for all years reported in Table 4-2, except in 2004. This is due to the fact that the economies of density are getting smaller and, consequently, the markup needed to recover variable cost is also decreasing.

TABLE 4–2
CHANGES IN THE EXCESS MARKUP FACTOR, 2002-2008

	2002	2003	2004	2005	2006	2007	2008
Excess Markup	-7.69%	-9.37%	-16.08%	-12.14%	1.54%	-1.63%	0.55%
Density Impact - (1 + FC/VC) dDensity/dt	1.10%	1.70%	-1.48%	11.69%	6.84%	8.41%	7.94%
Fixed Cost Impact - Density d(FC/VC)/ dt	-0.64%	1.58%	-4.51%	-4.71%	6.76%	-3.02%	0.70%
Market Power Change $1/(1 + \varepsilon)^2\, d\varepsilon/dt$	1.61%	-4.91%	-0.14%	-3.66%	-0.88%	-8.40%	-6.75%
Total Change in Excess Markup	2.06%	-1.64%	-6.13%	3.32%	12.71%	-3.01%	1.90%

The "fixed cost impact" shows the effect on the excess markup measure from an increase in fixed cost relative to variable cost. Table 4-2 shows three years with a positive fixed cost impact and four years with a negative impact. Positive values indicate a decrease in fixed cost relative to variable cost and negative values indicate the opposite. Correspondingly, a positive fixed cost impact indicates the markup of marginal cost required to recover fixed cost is getting smaller, while a negative value implies a larger markup is needed.

The "market power change" indicates how the exercise of market power has changed from year to year. This measure is reflective of the Lerner Index presented in Figure 4-5 and the RPTM/MC ratio shown in Figure 4-4. Positive values of this impact correspond to an increase in the exercise of market power while negative values imply a decrease in the exercise of market power. Table 4-2 shows a positive value for the market power change in 2002 and negative values for every year 2003-2008.

The last row of Table 4-2, "total change in excess markup," is the sum of the three components. 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 year-to-year change in the excess markup factor.[10] The total change in excess markup is the profit-enhancing part of a year-to-year change in the exercise of market power. That is, it represents the amount of the change in the markup beyond what is justified by changes in cost conditions. In contrast, the sum of the density impact and the fixed cost impact indicate by how much the exercise of market power could be reduced without worsening the revenue sufficiency situation.

Tables 4-1 and 4-2 allow us to get a better understanding of the performance of the freight railroad industry in recent years. For example, in 2005, marginal cost increased relative to average variable cost. This reduced the markup burden for variable cost recovery. However, fixed cost increased by a larger percentage than did average variable cost, as shown in Table 4-1. Consequently, the markup burden for fixed cost recovery increased. The relief in variable cost recovery exceeded the added burden of fixed cost recovery such that the exercise of market power could have been loosened by about 7 percentage points without worsening the revenue sufficiency situation. But, the exercise of market power decreased by only 3.7 percent points. Thus, the excess markup increased by about 3.3 percentage points, but still remained negative. The increase in the excess markup factor allowed the industry to improve its revenue sufficiency situation as rates increased by a larger percentage than did average total cost, as shown in Table 4-1 and indicated by RPTM/ATC series in Figure 4-4.

[10] For example, the markup factor changes by -1.68 percentage points from 2002 to 2003 (i.e., [-9.37 – (-7.69)] = -1.68); however, the estimates of the three components accounting for this change add up to -1.64 percentage points.

Table 4-1 shows that marginal cost continued to increase relative to average variable cost in 2006. Average fixed cost decreased substantially while average variable cost increased slightly. Thus, as shown in Table 4-2, both the density impact and the fixed cost impact worked to reduce the markup burden. However, while the exercise of market power appears to have decreased in 2006, it was only a small decrease compared to the sizeable density and fixed cost impacts. Thus, Table 4-2 indicates the excess markup jumped by almost 13 percentage points in 2006. This profit-enhancing gain by the railroads is reflected in Figure 4-4 and Table 4-1 as the RPTM/ATC jumps substantially from 92% in 2005 to 101% in 2006.

In 2007, marginal cost once again increased relative to average variable cost, further reducing the variable cost collection burden.[11] Table 4-2 shows that this density impact is almost exactly offset by the decrease in the exercise of market power. But, fixed cost again increased by a larger percentage than did variable cost. Consequently, the railroads lost ground as the fixed cost impact resulted in a decrease in the excess markup factor. As a result, the industry fell just below revenue sufficiency as RPTM/ATC decreased to 99 percent.

In 2008, marginal cost again increased by a greater percentage than did average variable cost, creating sizeable relief on the markup needed for variable cost recovery. Fixed cost increased, but by a smaller percentage than variable cost, so that the fixed cost recovery burden lessened by a small amount. There was a decrease in the exercise of market power, but the decrease did not fully offset the combined density and fixed cost impacts. Thus, the railroads regained some ground and again became just revenue sufficient.

The analysis of the excess markup provides insight into the exercise of market power relative to the overhead recovery burden. The excess markup factor can increase (that is, the railroads gain as their revenue sufficiency situation improves) even though the exercise of market power is decreasing. Likewise, an increase in the exercise of market power could be accompanied by a worsening of the revenue sufficiency situation. Since 2002, the excess markup increased in four years and decreased in three years, but increased overall, mainly as a result of the big increase in 2006. The excess markup factor increase in 2006 brought the industry to a state of revenue sufficiency, and the industry has closely bounced around that state in 2007 and 2008. As density economies are exhausted, the burden to markup marginal cost for variable cost recovery disappears and, other things the same, the markup of rates over marginal cost needed to achieve revenue sufficiency decreases. In recent years, we have observed the simultaneous lessening of the exercise of

[11] In fact, in 2007 the estimate of marginal cost exceeds average variable cost calculated from the R-1 data. If marginal cost is greater than average variable cost, then setting price at marginal cost would generate revenues in excess of variable cost and thereby reduce the markup need to recover fixed cost.

market power and the improvement in the railroad industry's revenue sufficiency position.

CONCLUSIONS

This updated overview of costs and revenues leads us to the same basic findings that we reported in our original study. First, the last twenty-two years include periods of increasing exercise of market power and periods of declining exercise of market power for the railroad industry. The largest increases in market power appeared 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-two year period, as the railroad industry was still attempting to achieve revenue sufficiency. Only in the most recent years does industry revenue appear to equal or exceed industry cost. Third, economies of density and fixed costs are the primary factors driving the markup of marginal cost. Economies of density appear to have been exhausted in recent years. The fact that marginal cost is now about the same as average variable cost for the industry means that there is less of a burden to markup marginal cost in order to achieve revenue sufficiency. Finally, the recent substantial increase in revenue per ton-mile appears to be largely the result of increases in marginal cost and not due to an increased exercise of market power.

Chapter 5 Contents

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CHAPTER 5
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 (CWS) data. We use the profit-maximization model of railroad behavior, subject to constraints from alternative shipping modes, and "reduced form" pricing equations we developed in Chapter 11 of our original report. The econometric models relate revenue per ton-mile (RPTM) for shipments in the CWS to several cost and market-structure features of sampled shipments. The econometric methods also control for latent factors associated with the originating and terminating railroads, the time period of the shipment, and the route as defined by the origin-destination state pair.

The pricing equations allow us to characterize the extent to which measurable cost and market-structure features of shipments account for variations in unit revenues (RPTM) at the commodity level. The models' estimates of yearly intercepts also may be used to estimate changes in commodity-level "real" RPTMs with more explicit controls 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 4 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 major factors that may limit a railroad's ability to exert local market power: the availability of water-transportation alternatives and the presence of railroad competition (at origin and destination).

Section 5A briefly reviews the pricing models we detailed in Chapter 11 of our original report. Section 5B describes how we incorporate generic marginal cost information with pricing model results to estimate commodity-level costs and markups. Section 5C reviews the specifications of the pricing models as well as the data and estimation methods. Section 5D provides the main results of our analysis.

5A. PRICING BEHAVIOR WITH CONSTRAINED "MARKET DOMINANCE" AND CAPTIVE DEMANDERS

Our pricing models are based on a model in which railroads' profit-maximizing behavior considers pricing constraints arising from shippers' transportation alternatives. This approach provides a framework by which factors such as intramodal competition, intermodal competition, geography, and product-market aspects enter into the railroads' pricing decisions.[1]

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^s) for each option. The shipper chooses the option that yields the greatest payoff. That is, the option chosen *i* is such that $\pi_i^s = \max(\pi_1^s, \ldots, \pi_N^s)$. 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.

The shipper has a number of options. For example, it could use a different transportation mode, a different railroad, or a number of different modal combinations and options. If the shipper is a "captive demander" in that it has no modal options, it may choose not to ship if it is priced out of the market. It could also ship to or receive from different locations. In this setting, assuming 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:

$$(5.1) \quad \max rR(r) - C(R(r)) \text{ such that } \pi^s(r) \geq \pi^O$$

where *r* is the rail rate, *R* is the rail transportation demand function, and *C* is the railroad's cost function. The profit maximization problem has first-order conditions:

$$(5.2) \quad R(r) + (\partial R / \partial r)(r - MC) + \lambda \partial \pi^s(r) / \partial r \leq 0$$

$$(5.3) \quad \pi^s(r) - \pi^O \geq 0\,.$$

where *MC* denotes marginal cost. The first order condition (5.2) can be written as:

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

$$(5.4)\quad \frac{r\ -\ MC}{r} = \frac{(\lambda\ -\ 1)}{\varepsilon}. \qquad\qquad [\text{note: } \partial\pi^{s}(r)/\partial r = -R]$$

where ε is the elasticity of demand, $\partial \ln R / \partial \ln r$.

In equation (5.4), 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 from shipping by rail 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 the monopoly rate). The value of λ lies between zero and one. 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 (5.3) and (5.4), in general it depends on market-structure, firm-specific, and shipment-specific factors.

Rearranging terms in equation (5.4) yields a pricing equation:

$$(5.5)\quad \ln r = \ln MC + \ln[\varepsilon/(\varepsilon - \lambda + 1)].$$

Equation (5.5) serves as the basis for our reduced-form pricing model. We linearize (5.5) to take the form:

$$(5.6)\quad \ln r = \alpha_0 + \sum_j \beta_j\ cost\ variable_j + \sum_k \gamma_k market-structure\ variable_k\ .$$

Applications of equation (5.6) 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.[2] 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 3 of the current report and Chapter 9 of our original report.

[2] See, for example, 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.

5B. Calculating Commodity-level Costs and Markups

A limitation of equation (5.6) is that it allows the estimation of factors that cause *variations* in costs and markups for railroad movements, but not the *levels* of costs and markups themselves.[3] 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 of Chapter 3 with pricing equation estimates. This step allows us to analyze pricing at the commodity and/or railroad level for Class I railroads.

We decompose a shipment's marginal cost per revenue ton-mile (RTM) into a "generic" marginal cost and a shipment-specific adjustment (SSA) factor:

$$(5.7) \quad MC_i = MC^{Generic} \times SSA_i.$$

We estimate the generic marginal cost using the variable cost model from Chapter 4, evaluating the marginal cost function to yield estimates of marginal cost by railroad and year. The shipment-specific adjustment factor is estimated from the cost variable terms in equation (5.6):

$$(5.8) \quad SSA_i = \exp\left(\sum_j \hat{\alpha}_j \text{cost variable}_j\right) / \exp\left(\sum_j \hat{\alpha}_j \overline{\text{cost variable}_j}\right),$$

where $\overline{\text{cost variable}_j}$ is a value for the cost variable consistent with the evaluation of the generic marginal cost. The estimated LMI is:

$$(5.9) \quad LMI_i = (r_i - MC^{Generic} \times SSA_i) / r_i \ .$$

Due to data limitations, we cannot measure sufficient shipment-level cost factors to meaningfully evaluate equations (5.7) and (5.9) at the shipment level, but the available data allow us to evaluate these equations at the commodity level for Class I railroads.[4] We present our results below.

5C. Data and Estimation

We estimated pricing equations by commodity group using shipment-level observations drawn primarily from the unmasked confidential 2001-2008 Carload Waybill Sample (CWS) files. We estimated pricing models for the full

[3] In equation (5.6), 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.

[4] The notable exception is intermodal shipments, discussed below.

2001-2008 period, and for the 2001-2003, 2004-2006, and 2007-2008 periods by partitioning the main sample period. We also estimated the models for the 2003-2008, 2003-2005, and 2006-2008 periods to check the sensitivity of our main results to the exclusion of the 2001-2002 CWS data as well as the specification of time periods partitioning the full panel.

Table 5-1 lists the commodity groups covered by the pricing model estimation. The included commodity groups represent nearly 94 percent of tonnage, 93 percent of ton-miles, and 89 percent of revenue in the 2008 CWS.

TABLE 5–1
COMMODITY GROUPS USED IN PRICING ANALYSIS

Commodity Group	Standard Transportation Commodity Code (STCC)	Share of Revenue (2008)	Share of Tonnage (2008)	Share of Ton-Miles (2008)
Farm Products	1	8.8%	8.5%	11.0%
Corn	1132	3.7%	3.8%	5.1%
Wheat	1137	2.4%	2.5%	2.6%
Barley	1131	0.2%	0.2%	0.2%
Soybeans	1144	1.2%	1.1%	1.7%
Metallic Ores	10	1.1%	2.9%	1.0%
Coal	11	22.1%	41.0%	38.0%
Nonmetallic Minerals	14	3.0%	6.7%	2.5%
Food Products	20	7.7%	5.8%	7.2%
Lumber or Wood Products	24	3.2%	2.2%	3.0%
Chemicals*	28	13.1%	9.9%	10.0%
Petroleum or Coal Products*	29	3.5%	2.6%	2.4%
Clay, Concrete, Glass or Stone Products	32	2.9%	2.6%	2.0%
Primary Metal Products	33	4.5%	3.2%	3.0%
Transportation Equipment	37	6.6%	2.2%	2.3%
Intermodal Shipments (COFC/TOFC)	Various	18.2%	8.7%	15.1%
Total in Analysis		**88.7%**	**93.6%**	**93.0%**

*Including hazardous materials.

Pricing Model Specifications

The pricing model specifications used in our implementation of equation (5.6) roughly follow the form of the estimating equations from MacDonald.[5] 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 expectation 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 from using 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.[6]

• Indicators of Market Structure (Railroad and Modal Competition)

- Distance from origin to nearest port or waterway facility
- Distance from destination to nearest port or waterway facility
- Effective railroad competitors[7] at origin
- Effective 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 include dummy variables indicating counties with a single serving railroad, which allows for a discontinuity in the response of RPTM in counties where a railroad has a local monopoly. 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.

[5] 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.

[6] 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 Economics,* 32, 1989, pp. 63-96.

[7] We measure "effective railroad competitors" with the reciprocal of the Herfindahl index.

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 marginal cost alternative. Thus, for long-distance bulk commodity hauls, we would not expect trucks to be a constraining mode for railroad pricing. Otherwise, the effect of the trucking alternative would be absorbed in the models' intercepts, which, as discussed below, are designed to capture the 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 (5.10), below.

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

The definitions and sources of the variables included in equation (5.10) are listed in the appendix to this chapter.

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.[8] 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.[9] 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.

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

[9] See, for example, G. S. Maddala, *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge University Press, 1983.

We also 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). For example, in the upper tail of the distribution of tons per carload, we observe small numbers of CWS records with 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 with 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, we exclude observations indicating distances under 20 shortline miles (100 miles for intermodal shipments).

Table 5-2 presents sample sizes and selected descriptive statistics by commodity group. Note that the mean RPTM values reported in Table 5-2 are not directly comparable to the values reported in Table 11-3 of our original report. The mean RPTM calculation reported below gives greater weight to large shipments; comparable average RPTM for the 2001-2006 period are provided in parentheses.

Estimation Method

We estimated equation (5.10) using panel data "fixed effects" models, with the individual effects developed from the origin-destination state combinations to provide the location-specific intercepts. We did 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.

TABLE 5–2
SAMPLE SIZE AND SUMMARY STATISTICS BY COMMODITY GROUP (2001-2008 PANEL)

Commodity Group	Sample Size (Regression N)	Mean* RPTM**	Mean*** Tons/ Shipment	Mean*** Tons/ Car	Mean*** Shortline Miles	Mean*** Carloads
Farm Products	123,010	2.1 (2.0)	490	95	1,241	5.2
Barley	4,284	2.9 (2.8)	300	93	1,033	3.2
Corn	41,715	1.9 (1.8)	1,475	102	775	14.5
Wheat	30,318	2.4 (2.4)	825	102	872	8.1
Soybeans	11,261	1.8 (1.7)	1,506	100	915	15.1
Metallic Ores	23,810	2.8 (2.7)	1,270	86	770	14.8
Coal	274,228	1.4 (1.3)	4,383	111	600	39.4
Nonmetallic Minerals	101,858	2.8 (2.8)	605	98	762	6.1
Food Products	282,959	2.6 (2.6)	81	70	1,155	1.2
Lumber or Wood Products	120,317	2.8 (2.8)	81	79	1,119	1.0
Chemicals	327,149	3.2 (3.1)	97	85	922	1.1
Petroleum or Coal Products	75,814	3.3 (3.1)	131	80	904	1.6
Clay, Concrete, Glass, or Stone Products	105,819	3.5 (3.4)	113	91	757	1.2
Primary Metal Products	126,308	3.5 (3.2)	98	85	817	1.2
Transportation Equipment	438,875	7.8 (7.8)	23	22	907	1.0
Intermodal Shipments	2,487,122	3.2 (3.2)	14	14	1,443	1.0
All Commodities	n/a	2.5 (2.5)	95	61	1,202	1.5

*Expanded total revenue divided by expanded ton-miles for the commodity group.

**2000 cents per ton-mile. The figure in parentheses is the 2001-2006 average calculated using the same method.

***Weighted by the CWS expansion factor.

5D. MAIN RESULTS FROM MODEL ESTIMATION

Shipment Cost Characteristics

Table 5-3 presents coefficient estimates for the variables representing shipment cost characteristics, based on the pricing model estimated over the 2001-2008 sample period.[10]

[10] The estimates reported in Tables 5-3 and 5-4 are from the same set of commodity-specific regressions. Thus, the R^2 statistics reported in Table 5-3 also apply to Table 5-4.

TABLE 5–3
SELECTED ESTIMATION RESULTS (2001-2008 SAMPLE PERIOD)
SHIPMENT COST CHARACTERISTICS

DEPENDENT VARIABLE: LN RPTM
COEFFICIENT
(T-STATISTIC)

Commodity Group	ln TONS	ln TONSCAR	ln MILES	D_OWN	R^2
Farm Products	-0.040	-0.328	-0.560	-0.096	0.436
	(-60.609)	(-102.142)	(-219.67)	(-53.106)	
Barley	-0.033	-0.675	-0.613	-0.020	0.625
	(-10.014)	(-21.371)	(-57.547)	(-2.293)	
Corn	-0.060	-0.814	-0.690	-0.089	0.591
	(-64.557)	(-102.335)	(-162.861)	(-36.146)	
Wheat	-0.023	-0.941	-0.562	-0.040	0.549
	(-23.319)	(-97.709)	(-129.293)	(-14.304)	
Soybeans	-0.015	-0.563	-0.600	-0.128	0.505
	(-6.12)	(-46.225)	(-72.707)	(-21.551)	
Metallic Ores	-0.022	-0.791	-0.543	-0.028	0.667
	(-12.704)	(-125.657)	(-78.998)	(-5.437)	
Coal	-0.006	-0.863	-0.478	-0.115	0.451
	(-8.267)	(-105.682)	(-275.605)	(-73.322)	
Nonmetallic Minerals	-0.137	-0.359	-0.582	-0.215	0.613
	(-146.799)	(-60.571)	(-301.412)	(-98.861)	
Food Products	-0.067	-0.255	-0.573	-0.159	0.357
	(-54.017)	(-131.999)	(-236.306)	(-100.899)	
Lumber or Wood Products	-0.136	-0.383	-0.519	-0.185	0.373
	(-32.995)	(-75.411)	(-171.816)	(-52.02)	
Chemicals	-0.048	-0.205	-0.526	0.063	0.242
	(-28.582)	(-64.084)	(-261.392)	(17.676)	
Petroleum or Coal Products	-0.063	-0.430	-0.634	-0.057	0.502
	(-38.9)	(-83.395)	(-209.22)	(-11.816)	
Clay, Concrete, Glass, or Stone Products	-0.067	-0.419	-0.569	-0.120	0.486
	(-46.806)	(-138.596)	(-198.661)	(-60.884)	
Primary Metal Products	-0.072	-0.342	-0.586	-0.222	0.503
	(-58.029)	(-88.99)	(-280.153)	(-61.072)	
Transportation Equipment	0.018	-0.756	-0.737	-0.922	0.459
	(7.235)	(-234.27)	(-323.575)	(-358.136)	
Intermodal Shipments	-0.846	n/a	-0.650	0.104	0.657
	(-2096.941)		(-331.128)	(177.321)	

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 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. The magnitudes of the coefficient estimates are similar to those we previously reported for the 2001-2006 panel. Results for the 2003-2008 panel are reported in the appendix to this chapter, and are also similar to the results in Table 5-3.

Market-Structure Characteristics

Table 5-4 presents coefficient estimates for variables representing local railroad and modal competition characteristics based on the 2001-2008 sample period. The corresponding results using the 2003-2008 panel are presented in the appendix to this chapter.

We find the expected positive effects on RPTM from increasing the distance to the nearest available water transportation access point at both origin and destination in most cases. That is, increasing the distance to port or waterway facilities, which makes the water alternative less attractive to shippers (and hence less constraining on rail rates), tends to increase RPTM, other things equal. The water alternative effects are particularly strong for wheat at the origin, and for intermodal shipments at the destination. We previously found a similar origin water alternative effect for wheat from 2001-2006 panels, which is consistent with captive-shipper complaints from insular Great Plains wheat-growing regions. Destination port facilities constrain intermodal RPTM as shippers may have the option of unloading containers at a facility closer to the ultimate destination.

TABLE 5–4
SELECTED ESTIMATION RESULTS (2001-2008 SAMPLE PERIOD)
MARKET-STRUCTURE CHARACTERISTICS

DEPENDENT VARIABLE: LN RPTM
COEFFICIENT
(T-STATISTIC)

Commodity Group	ln KMWATER _ORG	RRCOMP _ORG	DLM_ORG	ln KMWATER _TER	RRCOMP _TER	DLM_TER
Farm Products	0.032	-0.024	0.003	0.011	0.029	0.079
	(33.206)	(-12.429)	(1.365)	(13.044)	(15.107)	(29.18)
Barley	0.078	-0.074	-0.038	0.002	0.049	-0.008
	(13.732)	(-8.3)	(-3.229)	(0.509)	(3.437)	(-0.459)
Corn	0.005	-0.015	-0.021	0.010	0.029	0.071
	(2.856)	(-6.057)	(-7.005)	(6.994)	(9.946)	(21.263)
Wheat	0.098	-0.010	0.030	0.003	-0.005	0.018
	(42.475)	(-2.7)	(8.472)	(2.152)	(-1.479)	(3.209)
Soybeans	0.039	-0.037	-0.031	0.006	0.045	0.065
	(10.647)	(-5.998)	(-4.513)	(1.657)	(8.864)	(5.165)
Metallic Ores	-0.018	-0.051	0.158	0.065	-0.642	-0.073
	(-3.407)	(-5.743)	(10.398)	(19.12)	(-26.668)	(-7.409)
Coal	0.028	-0.019	0.035	0.002	-0.189	0.056
	(21.174)	(-7.037)	(15.224)	(2.196)	(-104.497)	(33.82)
Nonmetallic Minerals	0.005	0.021	0.031	0.010	-0.011	0.097
	(2.775)	(4.935)	(9.438)	(9.632)	(-3.422)	(34.791)
Food Products	0.006	0.008	0.097	0.029	-0.033	0.026
	(7.804)	(5.884)	(40.096)	(40.815)	(-22.723)	(11.057)
Lumber or Wood Products	0.033	0.018	0.039	0.017	0.005	0.000
	(21.392)	(5.109)	(10.427)	(12.692)	(1.782)	(0.057)
Chemicals	0.001	-0.058	0.045	0.037	-0.043	0.091
	(0.598)	(-35.992)	(13.721)	(43.571)	(-29.561)	(33.057)
Petroleum or Coal Products	0.026	-0.043	0.071	0.025	-0.061	0.027
	(16.617)	(-15.028)	(15.325)	(18.595)	(-21.877)	(6.477)
Clay, Concrete, Glass, or Stone Products	0.022	-0.009	0.073	0.002	-0.025	0.059
	(16.808)	(-4.495)	(25.032)	(2.524)	(-15.667)	(22.789)
Primary Metal Products	0.023	-0.051	-0.029	0.033	0.019	0.054
	(19.776)	(-23.332)	(-6.846)	(34.594)	(13.823)	(18.281)
Transportation Equipment	-0.000	-0.035	0.153	-0.000	-0.004	0.123
	(-0.245)	(-16.077)	(43.715)	(-0.321)	(-3.1)	(39.589)
Intermodal Shipments	0.020	0.050	-0.006	0.043	-0.003	-0.037
	(67.627)	(115.282)	(-3.999)	(141.388)	(-5.952)	(-21.952)

Increasing the number of effective railroad competitors at the origin generally reduces RPTM. Note that DLM_ORG is defined such that a positive coefficient implies increased RPTM, other things equal, at counties served by exactly one railroad. Thus, for lumber and wood products, food products, and nonmetallic minerals, which have positive coefficients on the number of effective railroad competitors at the origin (RRCOMP_ORG), RPTM tends to be lower for some range of RRCOMP_ORG (>1) than for shipments originating in counties served by a single railroad. We also suspect that in some cases, such as intermodal shipments, railroad competition may be along costly service quality dimensions not measured in the CWS.[11] Results for railroad competition at the destination are mixed.

The railroad RPTM generally increases with the distance from the shipments' originating or terminating counties to available port facilities (coefficients on ln KMWATER_ORG and ln KMWATER_TER), indicating that there are railroad pricing constraints from the availability of the water alternatives. The estimated effects are particularly strong for grains other than corn and for intermodal shipments.

The results in Table 5-4 are not unexpected in light of our findings in Chapter 9 of our original report. 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." We may expect railroads to exercise local market power where possible; our expectations are tempered somewhat by the prospect that rates may be moderated by increased regulatory attention, if not direct intervention, in the limiting case where a single railroad serves the origin or destination point. That is, railroads may effectively cede some market power to avoid regulatory intervention, or otherwise may be subject to implicit or explicit regulatory constraints.

Commodity-Level Costs and Markups for Class I Railroads

Increasing railroad rates, as discussed in the price index calculations of Chapter 2, do not indicate whether the railroads' market power is increasing in the form of their ability to command higher markups over marginal costs. A limitation of the pricing models is that they can estimate the effects of factors that shift costs and market conditions but cannot identify costs or markups at the commodity level without auxiliary information. However, we may construct estimates of marginal costs and markups by adjusting generic

[11] To the extent this is true, there is some confounding of market-structure and unobserved cost characteristics; this limits our ability to separate the effects of cost and market-structure factors.

marginal cost information obtained from the variable cost model for the estimated effects of measured cost-related variables from the pricing models.

We present median values of estimated marginal costs adjusted for observed cost-causing characteristics and estimated markups (Lerner Markup Indexes or LMIs) by commodity in Table 5-5. As with our original report, we implement the adjusted cost and LMI calculations for shipments hauled end-to-end by a single Class I railroad.

TABLE 5–5
MEDIAN ESTIMATED ADJUSTED MARGINAL COSTS AND MARKUPS (LMIS) BY COMMODITY CLASS I RAILROADS, 2001-2008 AND 2003-2008 SAMPLES

	2001-2008 sample		2003-2008 sample	
Commodity Group	Adjusted MC*	LMI	Adjusted MC*	LMI
Farm Products	1.0	0.52	1.1	0.50
Barley	1.3	0.60	1.0	0.71
Corn	0.7	0.65	0.6	0.68
Wheat	0.8	0.66	0.8	0.68
Soybeans	0.9	0.53	0.8	0.53
Metallic Ores	2.9	0.38	2.8	0.42
Coal	0.8	0.30	0.8	0.31
Nonmetallic Minerals	2.1	0.38	2.2	0.36
Food Products	1.4	0.47	1.5	0.46
Lumber or Wood Products	1.5	0.52	1.5	0.51
Chemicals	1.7	0.48	1.8	0.47
Petroleum or Coal Products	1.8	0.54	1.8	0.54
Clay, Concrete, Glass, or Stone Products	2.0	0.50	2.0	0.49
Primary Metal Products	2.1	0.42	2.3	0.42
Transportation Equipment	5.3	0.30	5.4	0.26
Intermodal Shipments	4.4	-0.74	4.4	-0.77

* 2000 cents per ton-mile.

The addition of 2007 and 2008 CWS data does not alter the pattern we identified in our original report, where estimated marginal cost per ton-mile is relatively low for commodities typically hauled in large-scale bulk shipments, such as grains and coal, and highest 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 5-2. The general pattern also is robust to the use of an alternative sample period excluding the 2001 and 2002 CWS observations. We caution that the cost and markup estimates for intermodal shipments should not be relied upon since data limitations prevent the cost adjustment model from reflecting certain low-cost characteristics of these shipments, notably that they tend to move as unit trains. 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.

The estimated markups are relatively low for bulk commodity shipments including metallic ores, coal, and nonmetallic minerals. Transportation equipment shipments have high-cost characteristics, notably low tonnage per carload, but a relatively low estimated LMI of 0.30 in the 2001-2008 sample. The estimated markups for grains are relatively high. Our results continue to suggest that grain shippers are not unjustified in viewing themselves as paying relatively high markups. The estimated markups over marginal cost for other commodities range from 42 to 54 percent[12] in the 2001-2008 sample period.

We would expect modal competition to keep markups for intermodal shipments low, but we believe that the negative estimated LMI is an anomaly reflecting limitations of the CWS data for measuring intermodal shipments' cost characteristics. The modeled cost adjustments effectively treat intermodal shipments as having the cost characteristics of low-weight single-carload shipments, when, in fact, trailers and containers travel long distances as a unit, avoiding substantial switching and classification costs typical of other single-carload shipments. 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.

Since coal, in particular, accounts for a very large share of total railroad 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 result 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.

Tables 5-6 and 5-7[13] show, respectively, adjusted marginal costs and LMIs estimated from 2001-2003, 2004-2006, and 2007-2008 sample periods. These tables provide an indication of whether recent rate increases at the commodity level have been mainly cost-driven or markup-driven. We observe broad-based increases in estimated adjusted marginal costs for the 2007-2008 period over the 2004-2006 estimates. The increases in marginal cost generally exceed the corresponding increases in RPTM, so estimated LMIs decline for the commodities analyzed, except for metallic ores and nonmetallic minerals. Both the metallic ores and nonmetallic minerals groups exhibit volatile adjusted MC and LMI estimates.

[12] The exception is for intermodal shipments, which is discussed in the next paragraph.

[13] Intermodal shipments have been excluded from Tables 5-6 and 5-7.

TABLE 5–6
MEDIAN ESTIMATED ADJUSTED MARGINAL COSTS
BY COMMODITY BY PERIOD
CLASS I RAILROADS

	Adjusted MC*		
Commodity Group	**2001-2003**	**2004-2006**	**2007-2008**
Farm Products	1.0	1.0	1.2
Barley	1.0	1.0	1.6
Corn	0.7	0.6	0.7
Wheat	0.9	0.8	1.1
Soybeans	0.8	0.8	1.0
Metallic Ores	2.8	3.5	3.3
Coal	0.8	0.8	0.9
Nonmetallic Minerals	1.9	2.5	1.9
Food Products	1.3	1.4	1.7
Lumber or Wood Products	1.4	1.5	2.0
Chemicals	1.6	1.7	1.9
Petroleum or Coal Products	1.9	1.8	1.8
Clay, Concrete, Glass, or Stone Products	1.9	2.0	2.3
Primary Metal Products	1.9	2.3	2.7
Transportation Equipment	5.2	5.4	6.1

*2000 cents per ton-mile.

TABLE 5–7
MEDIAN ESTIMATED MARKUPS (LMI)
BY COMMODITY BY PERIOD
CLASS I RAILROADS

	LMI		
Commodity Group	**2001-2003**	**2004-2006**	**2007-2008**
Farm Products	0.55	0.54	0.45
Barley	0.68	0.69	0.50
Corn	0.68	0.68	0.62
Wheat	0.64	0.68	0.58
Soybeans	0.56	0.56	0.47
Metallic Ores	0.32	0.26	0.36
Coal	0.31	0.35	0.25
Nonmetallic Minerals	0.41	0.27	0.44
Food Products	0.50	0.48	0.40
Lumber or Wood Products	0.54	0.53	0.36
Chemicals	0.55	0.47	0.45
Petroleum or Coal Products	0.55	0.56	0.52
Clay, Concrete, Glass, or Stone Products	0.51	0.51	0.43
Primary Metal Products	0.44	0.42	0.41
Transportation Equipment	0.38	0.25	0.20

Periods of increasing costs can erode the railroads' pricing power, at least temporarily, to the extent that they are unable to pass through their full input cost increases. Factors such as long-term contracts with shippers and practical limitations on the frequency of fuel surcharge changes can contribute to this phenomenon. Shippers may understandably be unhappy that they face higher real RPTMs notwithstanding the lower average markups. Nevertheless, our analysis suggests shippers were not, overall, facing increased railroad pricing power in the 2007-2008 period, but rather the effects of the railroads' increased input costs that were partly passed through to the RPTM.

Distribution of the Revenue/Variable Cost Ratio

The GAO[14] previously analyzed shipper captivity, in part by examining the shares of shipments generating revenues to URCS variable cost (R/VC) measures in excess of 180 percent and 300 percent as well as the changes in those shares over time. In Chapter 11 of our original report, we observed that large shares of rail traffic moving at rates below 100 percent R/VC suggested that URCS variable costs may not be well aligned with actual shipment-level cost characteristics. Nevertheless, URCS provides a cost measure independent of our econometric analysis, and based on our results we would expect the distribution of the R/VC ratio to shift downwards in the most recent years.

We computed distributions of tons and ton-miles by R/VC ratio categories from CWS data for 2001-2002, 2003-2004, 2005-2006, 2007, and 2008. See Table 5-8. The share of tons moving at revenue exceeding 180 percent R/VC dropped by two percentage points between 2005-2006 and 2008, while the share of tons below 100 percent R/VC increased by four percentage points over the same period; the share of tons exceeding 300 percent R/VC was essentially unchanged. In terms of ton-miles, we observe decreases in the shares of shipments exceeding 180 percent R/VC and 300 percent R/VC; the share of ton-miles below 100 percent R/VC increased by five percentage points. Over the entire period, the shares of high-R/VC shipments are flat-to-declining apart from an increase between the 2001-2002 and 2003-2004 periods that appears to reflect an URCS methodology change shifting average R/VC upwards for intermodal shipments.[15] Thus, URCS variable costs generally increased faster than revenues between 2005-2006 and 2008, and the R/VC measure does not (whatever its limitations) indicate increasing exercise of market power by the Class I railroads.

[14] 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.

[15] See Fig. 11-2 at page 11-26 of our original report.

TABLE 5–8
PERCENT OF TONS AND TON-MILES BY R/VC CATEGORY
2001-2008 CARLOAD WAYBILL SAMPLE DATA

	Percent of Tons by R/VC Category				
Period	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
2001-2002	16%	50%	28%	6%	34%
2003-2004	16%	50%	26%	9%	35%
2005-2006	21%	45%	25%	9%	34%
2007	23%	44%	25%	8%	33%
2008	25%	43%	23%	9%	32%

	Percent of Ton-Miles by R/VC Category				
Period	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
2001-2002	22%	56%	19%	2%	21%
2003-2004	21%	57%	17%	5%	22%
2005-2006	29%	52%	16%	4%	20%
2007	33%	50%	15%	2%	17%
2008	34%	49%	14%	3%	17%

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 (89%, 94%, and 93% of the totals, respectively). The explanatory variables in the estimated models are sets of cost-related variables, market-structure indicators, and other control factors. The results summarized in the tables of this chapter inform our discussion of selected commodities in Chapter 6, below.

The estimated effects of the cost-related variables are in line with our intuition and expectations based on past analyses of Carload 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 RPTM. 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 using 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 railroad and/or water competition. This result is in line with the underlying model of the 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). Given the railroads' requirement 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 the shippers' ability to substitute lower-cost shipment characteristics. We discuss trends in shipment characteristics further for selected commodities in the next chapter.

Our calculations of commodity-level markups show little or no evidence of markups systematically increasing for all commodities in recent years. Indeed, the sharp increases in RPTM between 2006 and 2008 observed for most commodity groups appear to be matched, if not exceeded, by railroad marginal cost increases over the same period. We obtain a similar picture from shifts in the distribution of the R/VC ratio over time: 2007 and 2008 CWS data show lower fractions of tons and ton-miles moving at rates exceeding the statutory 180 percent R/VC threshold than in the 2005-2006 period, which reflected the latest available data for our original report. The increases in RPTM observed in the later years of our current analysis thus appear to reflect cost increases rather than an increased exercise of market power by the railroads.

APPENDIX

TABLE 5–9
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	

Variable	Definition	Source[*]
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 2-digit STCC, in kilometers	Calculated using ESRI ArcView GIS
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[***]
QTR_i	Dummy variable = 1 for calendar quarter $_i$ (i = 2, 3, 4), 0 otherwise, based on waybill month	CWS, item 3
$YEAR_j$	Dummy variable = 1 for waybill $year_j$ (j = 2001-2006), 0 otherwise	CWS, item 3
$RAILROAD\_ORG_k$ ($RAILROAD\_TER_l$)	Dummy variable = 1 if originating (terminating) railroad is k (l), where k and l are indexes for 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.

TABLE 5–10
SELECTED ESTIMATION RESULTS (2003-2008 SAMPLE PERIOD)
SHIPMENT COST CHARACTERISTICS

DEPENDENT VARIABLE: LN RPTM
COEFFICIENT
(T-STATISTIC)

Commodity Group	ln TONS	ln TONSCAR	ln MILES	D_OWN	R^2
Farm Products	-0.038	-0.332	-0.569	-0.090	0.453
	(-52.276)	(-93.472)	(-196.925)	(-44.409)	
Barley	-0.028	-0.947	-0.622	-0.004	0.673
	(-7.62)	(-23.787)	(-52.686)	(-0.406)	
Corn	-0.060	-0.811	-0.714	-0.087	0.627
	(-58.85)	(-94.323)	(-151.105)	(-31.327)	
Wheat	-0.027	-0.927	-0.544	-0.030	0.599
	(-26.164)	(-99.155)	(-118.114)	(-10.213)	
Soybeans	-0.011	-0.529	-0.612	-0.112	0.504
	(-3.746)	(-37.597)	(-62.448)	(-16.565)	
Metallic Ores	-0.039	-0.777	-0.556	-0.035	0.692
	(-19.31)	(-108.82)	(-66.018)	(-5.642)	
Coal	-0.025	-0.812	-0.463	-0.112	0.456
	(-28.721)	(-87.808)	(-230.396)	(-62.536)	
Nonmetallic Minerals	-0.144	-0.346	-0.581	-0.206	0.602
	(-128.642)	(-48.892)	(-246.265)	(-80.563)	
Food Products	-0.061	-0.270	-0.584	-0.171	0.366
	(-42.039)	(-119.954)	(-200.319)	(-90.65)	
Lumber or Wood Products	-0.162	-0.346	-0.511	-0.199	0.344
	(-30.569)	(-53.116)	(-133.435)	(-45.198)	
Chemicals	-0.050	-0.229	-0.532	0.051	0.263
	(-26.947)	(-62.697)	(-234.844)	(12.24)	
Petroleum or Coal Products	-0.062	-0.468	-0.632	-0.075	0.519
	(-33.174)	(-78.174)	(-182.312)	(-13.482)	
Clay, Concrete, Glass, or Stone Products	-0.071	-0.413	-0.573	-0.130	0.499
	(-43.272)	(-117.281)	(-177.521)	(-58.049)	
Primary Metal Products	-0.086	-0.328	-0.601	-0.224	0.508
	(-55.866)	(-71.738)	(-244.787)	(-54.017)	
Transportation Equipment	0.036	-0.761	-0.738	-0.895	0.421
	(12.306)	(-197.058)	(-259.861)	(-289.99)	
Intermodal Shipments	-0.852	n/a	-0.682	0.125	0.665
	(-1898.228)		(-301.686)	(186.385)	

TABLE 5–11
SELECTED ESTIMATION RESULTS (2003-2008 SAMPLE PERIOD)
MARKET-STRUCTURE CHARACTERISTICS

DEPENDENT VARIABLE: LN RPTM
COEFFICIENT
(T-STATISTIC)

Commodity Group	ln KMWATER _ORG	RRCOMP _ORG	DLM_ORG	ln KMWATER _TER	RRCOMP _TER	DLM_TER
Farm Products	0.030	-0.021	0.005	0.012	0.041	0.091
	(27.522)	(-9.927)	(1.92)	(12.128)	(18.25)	(29.425)
Barley	0.069	-0.067	-0.038	-0.006	0.033	-0.001
	(10.62)	(-6.426)	(-2.854)	(-1.227)	(1.95)	(-0.037)
Corn	0.005	-0.009	-0.017	0.007	0.033	0.074
	(2.815)	(-3.19)	(-5.146)	(4.767)	(9.668)	(19.559)
Wheat	0.065	0.003	0.044	0.009	0.008	0.037
	(25.369)	(0.788)	(11.978)	(6.648)	(2.415)	(6.45)
Soybeans	0.040	-0.032	-0.033	0.002	0.053	0.115
	0.069	-0.067	-0.038	-0.006	0.033	-0.001
Metallic Ores	-0.014	-0.078	0.112	0.060	-0.293	-0.058
	(-2.225)	(-7.517)	(6.543)	(14.668)	(-8.924)	(-4.9)
Coal	0.020	-0.032	0.034	0.002	-0.201	0.062
	(12.916)	(-9.556)	(12.412)	(2.005)	(-94.485)	(32.696)
Nonmetallic Minerals	0.004	0.027	0.019	0.014	-0.002	0.096
	(1.971)	(5.379)	(4.961)	(12.259)	(-0.513)	(29.382)
Food Products	0.008	0.012	0.098	0.028	-0.027	0.031
	(8.856)	(7.932)	(34.913)	(34.624)	(-15.2)	(10.925)
Lumber or Wood Products	0.026	0.026	0.048	0.011	0.007	0.006
	(13.396)	(6.032)	(10.376)	(6.081)	(1.967)	(1.092)
Chemicals	0.000	-0.054	0.040	0.038	-0.039	0.101
	(-0.016)	(-29.5)	(10.741)	(39.061)	(-23.938)	(31.913)
Petroleum or Coal Products	0.027	-0.045	0.067	0.026	-0.071	0.005
	(15.382)	(-13.738)	(12.774)	(16.732)	(-22.063)	(0.931)
Clay, Concrete, Glass, or Stone Products	0.020	0.000	0.082	0.003	-0.029	0.059
	(12.843)	(0.147)	(24.889)	(2.897)	(-16.449)	(20.154)
Primary Metal Products	0.025	-0.047	-0.025	0.034	0.021	0.048
	(18.434)	(-18.585)	(-4.882)	(31.448)	(12.788)	(13.699)
Transportation Equipment	-0.002	-0.023	0.136	0.000	0.010	0.121
	(-1.21)	(-8.682)	(31.555)	(0.065)	(6.57)	(31.363)
Intermodal Shipments	0.018	0.055	-0.008	0.040	0.002	-0.047
	(53.129)	(119.77)	(-4.77)	(116.245)	(3.302)	(-24.668)

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CHAPTER 6
ANALYSIS OF SELECTED MAJOR COMMODITIES

INTRODUCTION

In this chapter, we examine recent trends in revenue per ton-mile (RPTM) and shipment characteristics measured in the Carload Waybill Sample (CWS) for coal, corn, wheat, chemicals, and intermodal shipments. We previously examined these commodities, which account for 60 percent of 2008 CWS revenue, in Chapters 12-15 of our original report. This chapter also includes comparisons of pricing model results from shorter subsamples, including 2007 and 2008 data with the results reported in Chapter 5 of this report and Chapter 11 of our original report.

6A. TRENDS IN REVENUE PER TON-MILE

Figure 6-1 shows trends in "real" RPTM from the 2002-2008 CWS[1] data for the commodities we examine in this chapter and for industry-wide RPTM (all commodities), measured as percentage changes from their respective 2001 average RPTM values. Average RPTM declined from 2001 to 2003 for intermodal and wheat shipments; average RPTM declined from 2001 to 2004 for chemicals, coal, and corn. The trough for industry RPTM also occurred in 2004. For the 2001-2008 period, coal and corn RPTM growth rates exceeded the overall railroad industry RPTM growth rate, while RPTM for chemicals, intermodal, and wheat shipments grew by smaller percentages than overall industry RPTM. Also notable is that the growth in RPTM from trough-to-peak is greater for chemicals, coal, and corn than for the industry average.

The data show substantial year-over-year increases in RPTM in 2008 for all five commodities and for the industry average. All of the commodities except intermodal shipments also exhibit increases from 2006 to 2007, though the 2006-2007 increases are less pronounced. Intermodal shipments are the only category of shipments shown that do not exhibit a substantial RPTM increase for 2007-2008 over 2005-2006, the last years of data available for our original report. The year-over-year growth rates and annual average (compound) growth rates of RPTM are presented in Table 6-1, below, along with the growth rates of marginal cost from Chapter 4, Table 4-1.[2]

[1] Annual RPTM deflated by the GDP price index.

[2] Note that the "industry" marginal cost from Table 4-1 is a weighted average of estimates for BNSF, CSX, Norfolk Southern, and Union Pacific.

FIGURE 6–1
TRENDS IN "REAL" RPTM FROM ANNUAL CARLOAD WAYBILL SAMPLE DATA, SELECTED COMMODITIES AND INDUSTRY AVERAGE
2002-2008

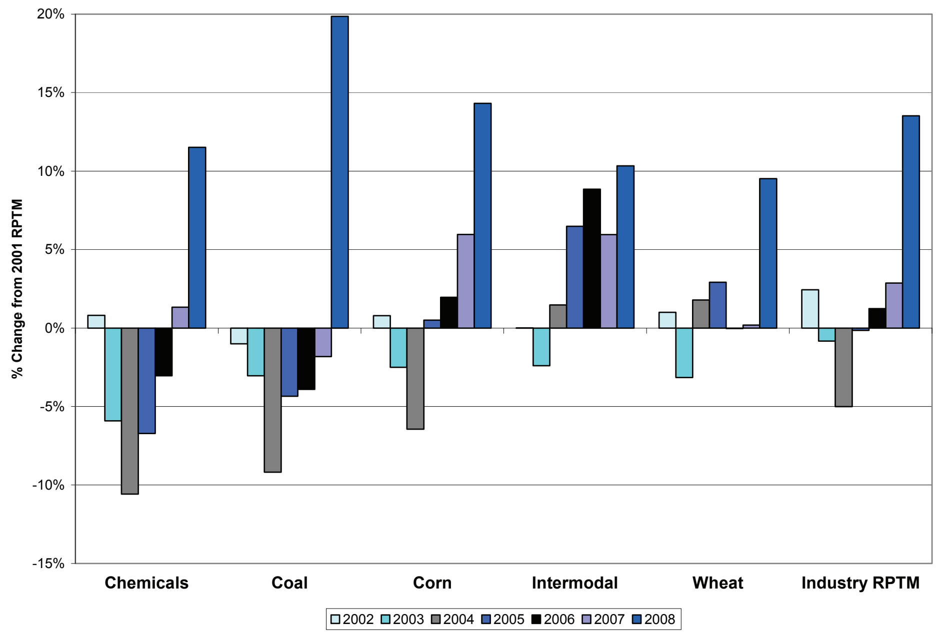


TABLE 6–1
YEAR-OVER-YEAR GROWTH RATES FOR REVENUE PER TON-MILE (RPTM) AND CLASS I INDUSTRY MARGINAL COST, 2002-2008

Commodity	2002	2003	2004	2005	2006	2007	2008	Compound Annual Growth Rate 2001-2008
Chemicals	0.8%	-6.7%	-5.0%	4.3%	3.9%	4.5%	10.1%	1.6%
Coal	-1.0%	-2.0%	-6.3%	5.3%	0.5%	2.2%	22.1%	2.6%
Corn	0.8%	-3.3%	-4.0%	7.4%	1.4%	3.9%	7.9%	1.9%
Intermodal	0.0%	-2.4%	4.0%	4.9%	2.2%	-2.7%	4.1%	1.4%
Wheat	1.0%	-4.1%	5.1%	1.1%	-2.9%	0.2%	9.3%	1.3%
All (Industry RPTM)	2.4%	-3.2%	-4.2%	5.1%	1.4%	1.6%	10.4%	1.8%
Industry MC	-2.2%	2.3%	-1.5%	11.2%	6.8%	9.6%	16.5%	5.9%

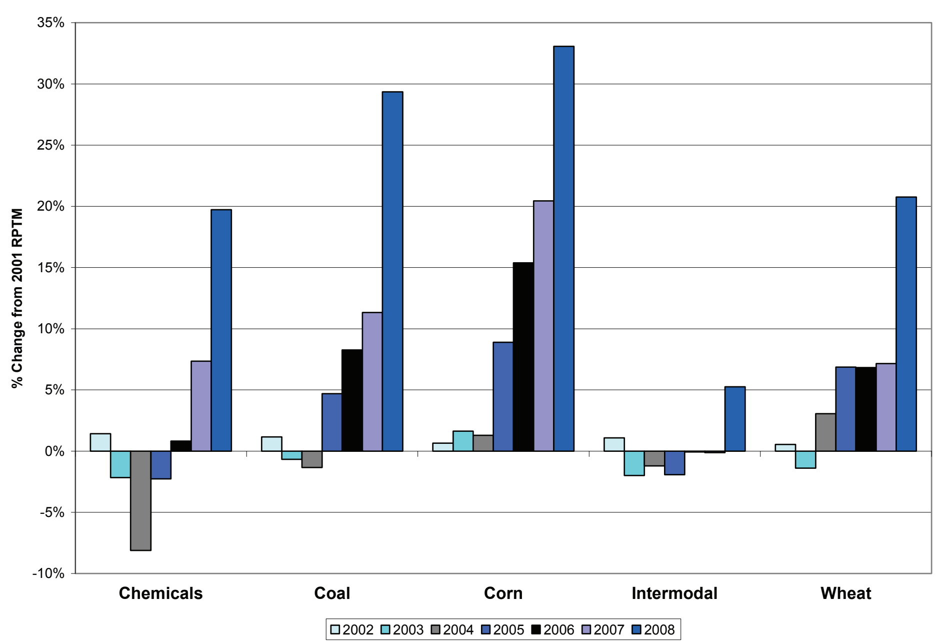
Table 6-1 shows that the coal RPTM increased particularly rapidly in 2008; the 22.1 percent year-over-year increase exceeded even the 16.5 percent increase in industry marginal cost per ton-mile. This is consistent with reports of large rate increases for some coal shippers as long-term "legacy" contracts expired. Factors such as long-term contracts may indeed aggravate certain types of "rate shocks" when they expire in high-cost years such as 2008. While rate shocks are understandably of concern to shippers, they do not in themselves imply changes in the exercise of market power by railroads.

Table 6-1 is consistent with our findings that industry- and commodity-level markups have not increased overall since our original study, in that RPTM growth has been slower than estimated marginal cost growth over longer time spans. This observation reinforces our finding, summarized in Chapter 22 of our original study, that the largest increases in the railroads' exercise of market power tended to coincide with periods of declining cost, while decreases in their exercise of market power were associated with periods of increasing cost.

The RPTM data shown in Figure 6-1 may reflect changes in commodity-level shipments and/or market characteristics that would tend to affect RPTM. Particularly for the bulk grain and coal shipments, our previous analysis showed long-range trends towards organizing shipments in more efficient forms—e.g., unit trains, heavier car loadings, and longer-distance hauls—helping to drive longer-term declines in RPTM.

The pricing model results from Chapter 5 complement this analysis by indicating trends in real revenue per ton-mile while controlling for the shipment and market characteristics included in the econometric models. That is, the YEAR dummy variables in the pricing models describe patterns of annual RPTM changes at the commodity level, holding shipment characteristics constant. Since RPTM is deflated by the price index for GDP, the resulting trend indicates changes in RPTM relative to GDP price inflation, given fixed shipment characteristics. See Figure 6-2.

FIGURE 6–2
TRENDS IN "REAL" RPTM FROM PRICING MODEL YEARLY INTERCEPTS, SELECTED COMMODITIES
2002-2008



Holding characteristics measured in the pricing models constant, the trends in Figures 6-1 and 6-2 show similar pictures of recent railroad rate increases well in excess of GDP price inflation, though the timing and magnitude of increases varies across commodities in the two figures. A notable difference is that the declines in average RPTM for chemicals and coal are less pronounced (and are absent for corn) when characteristics are held constant. As a result, except for intermodal shipments, the 2001-2008 annual average RPTM growth rates holding shipment characteristics constant exceed the growth rates of raw RPTM from the CWS, shown in Fig. 6-1, by 1.0 to 2.3 percentage points.

All of the commodities shown in Figure 6-2 exhibited increases in real RPTM in 2008, though the increasing real RPTM trend began as early as 2004 for wheat and 2005 for chemicals, coal, and corn. Intermodal shipments did not show a notably increasing real RPTM trend prior to the 2008 increase, though, as we noted in Chapter 5, data are not available on certain important intermodal shipment characteristics.

Caveats for price indexing methods such as those employed in the Producer Price Index apply here as well. 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. A comparison of Figures 6-1 and 6-2 shows that the average effects of changing shipment characteristics did substantially offset constant-characteristics RPTM increases. Shippers who did not or could not avail themselves of lower-cost shipment options would have been exposed to considerably greater above-inflation increases in RPTM.

6B. TRENDS IN SHIPMENT CHARACTERISTICS

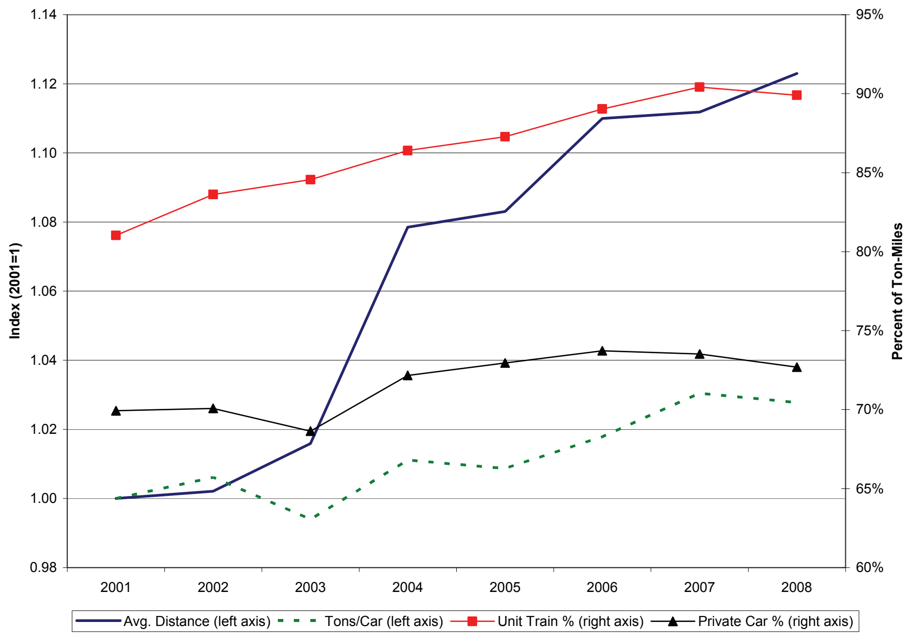
Coal

Over the 20 years prior to 2006, CWS data reported major changes in the composition of coal shipments. In large part, these changes reflected the predominance of large unit trains and increasing length-of-haul for coal shipments, driven in large part by the westward shift of coal production with the growth of Powder River Basin coal mining. However, recent data from the U.S. Energy Information Administration show stabilization in the share of east-of-the-Mississippi (mostly Appalachian) production following rapid declines in the late-1990s and early-2000s, which may limit compositional changes towards lower-cost western coal shipments.

Figure 6-3 shows trends in coal tons per car, length of haul, and the prevalence of unit train shipments (defined as 100+ carloads) and use of privately owned (non-railroad) cars for the 2001-2008 period. At the end of the period, trends towards lower-cost characteristics show signs of leveling off.

FIGURE 6–3
SELECTED COAL SHIPMENT CHARACTERISTICS

INDEXES FOR AVERAGE DISTANCE AND TONS/CAR (LEFT AXIS)
PERCENTAGES FOR UNIT TRAINS AND PRIVATE CAR OWNERSHIP (RIGHT AXIS)
2001-2008 CARLOAD WAYBILL SAMPLES



The unit train share of ton-miles was already high at 81 percent in 2001, and may have little room to increase from the 89-90 percent values of 2006-2008. The fraction of ton-miles carried in privately owned cars decreased slightly, from 74 percent in 2006 to 73 percent in 2008. Tons per car increased at an average annual rate of 0.4 percent over the entire period. Average length of haul increased slightly more than 12 percent over 2001-2008, with 11 percent of the increase occurring in 2001-2006. Between 2006 and 2008, there is relatively little change in coal shipment characteristics to offset cost increases.

Corn and Wheat

Figures 6-4 and 6-5 show for corn and wheat, respectively, tons per car, length of haul, and the fractions of unit train shipments (defined as 50+ carloads) and use of privately owned cars for 2001-2008.

Figure 6–4
Selected Corn Shipment Characteristics

Indexes for Average Distance and Tons/Car (left axis)
Percentages for Unit Trains and Private Car Ownership (right axis)
2001-2008 Carload Waybill Samples

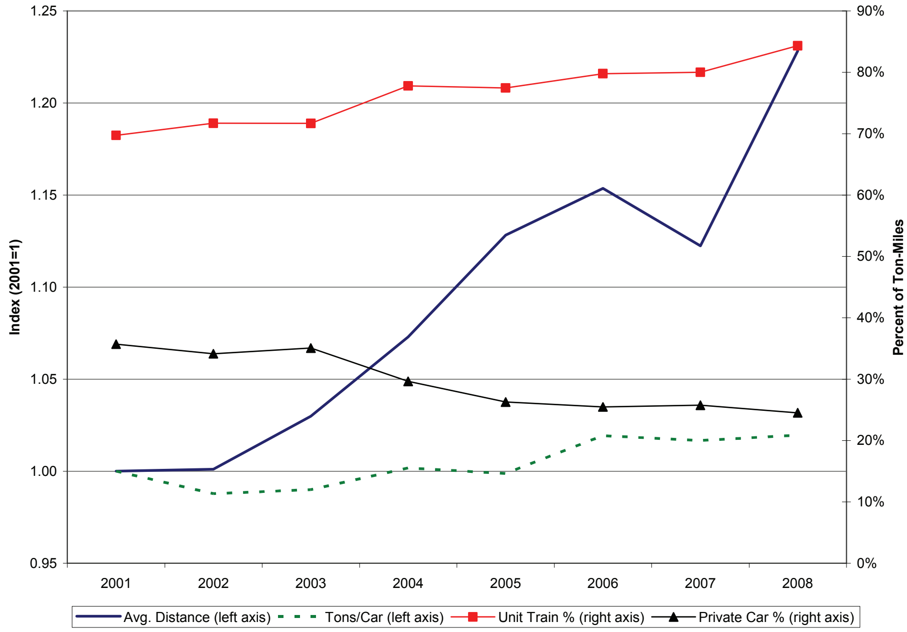
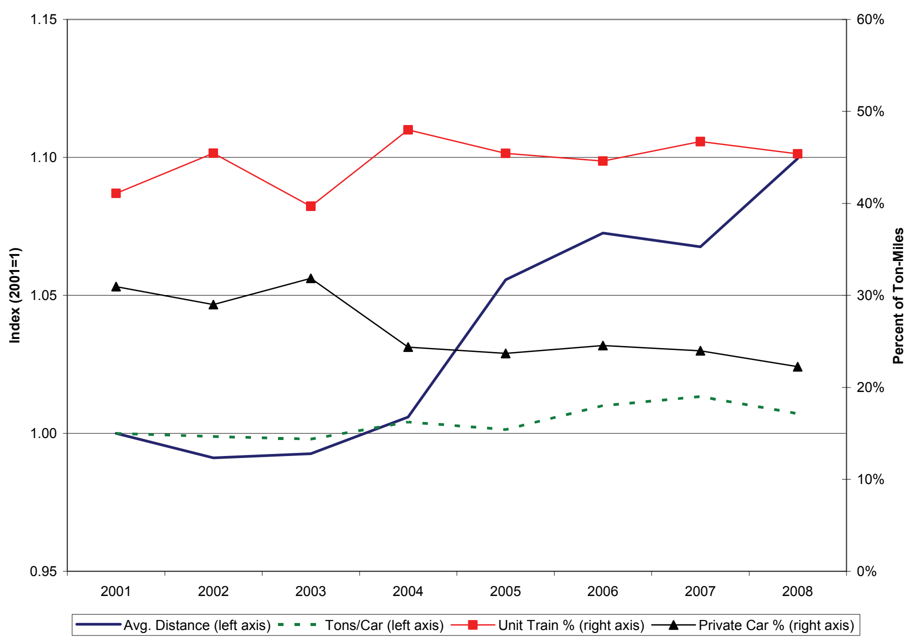


Figure 6–5
Selected Wheat Shipment Characteristics

Indexes for Average Distance and Tons/Car (left axis)
Percentages for Unit Trains and Private Car Ownership (right axis)
2001-2008 Carload Waybill Samples



For corn, average length of haul, tons per car, and the fraction of ton-miles in 50+ car shipments increased from 2001 to 2008; the fraction of ton-miles using private cars declined. Tons per car and the fraction of ton-miles in private cars were flat from 2006-2008, though. Average length of haul for wheat shipments also increased, private car use decreased as a fraction of ton-miles, and there was a slight increase in average tons per car. Fifty-plus carload shipments of wheat increased in 2008 relative to 2001, but were flat to slightly declining from 2004 to 2008. The variations in length of haul correspond in part to changes in rail deliveries of grain to ports.[3] From 2006 to 2008, reported rail deliveries to Pacific Northwest ports increased; those deliveries would involve relatively long hauls. The 2006-2007 decline in length of haul may be consistent with a decrease in total rail deliveries to ports from 2006 to 2007, related to a decline in rail shipments to Gulf Coast ports.

Based on the coefficients on ln MILES in Table 5-3, observed length-of-haul increases explain most of the difference between the observed growth rates of RPTM and the estimated growth rates of RPTM for constant-characteristics shipments—2.1 percentage points (out of 2.3) for corn and 0.8 (out of 1.4) for wheat.

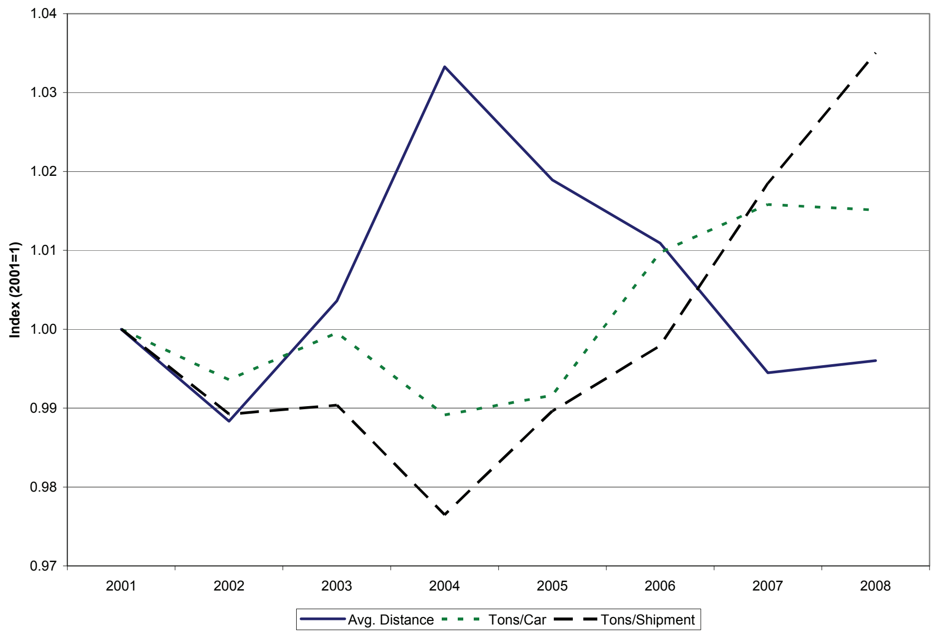
Chemicals

Figure 6-6 shows trends in tons per car, length of haul, and tons per shipment for chemical shipments from 2001 to 2008. As with coal, corn, and wheat (above), chemical tons per carload are slightly higher in 2006-2008 than in 2001-2005. Average length of haul is largely unchanged over the full 2001-2008 period and slightly lower in 2008 than in 2006. Average shipment tonnage increases 3.5 percent overall, with the net increase over 2001 occurring from 2006 to 2008. There is little in the way of shifts towards more favorable cost characteristics for chemical shipments to offset increases in generic costs.

[3] See U.S. Department of Agriculture, Agricultural Marketing Service, "Grain Transportation Report," December 25, 2008, page 4, at http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5074559&acct=graintransrpt (accessed January 4, 2010). A caveat is that USDA describes the port data as "incomplete as it is voluntarily provided."

FIGURE 6–6
SELECTED CHEMICAL SHIPMENT CHARACTERISTICS

INDEXES FOR AVERAGE DISTANCE, TONS/SHIPMENT, AND TONS/CAR
2001-2008 CARLOAD WAYBILL SAMPLES



Intermodal Shipments

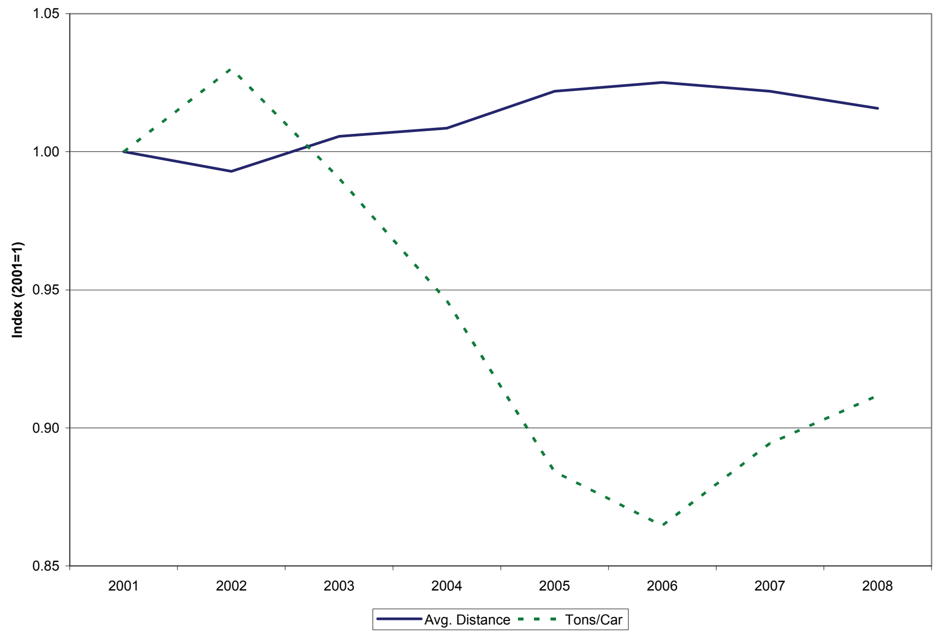
Figure 6-7 shows trends in tons per car and length of haul for intermodal (COFC/TOFC) shipments from 2001 to 2008. Average length of haul increased slightly overall, but was essentially flat from 2006 to 2008. Tons per car decreased from 2001 to 2008, but increased from 2006 to 2008. The longer-range trend had been declining tons per intermodal carload going back to 1991.[4] The observed shift towards lower tons per carload would tend to increase RPTM by one percent per year, other things equal, according to the pricing model results.

As we noted in Chapter 5, CWS data have important limitations for intermodal shipments, in that actual shipment size (number or weight of containers or trailers on a single train) and use of costly higher-quality service offerings are unobserved.

[4] See Fig. 15-3 in our original report, at page 15-4.

FIGURE 6–7
SELECTED INTERMODAL SHIPMENT CHARACTERISTICS

INDEXES FOR AVERAGE DISTANCE AND TONS/CAR
2001-2008 CARLOAD WAYBILL SAMPLES



6C. PRICING ANALYSIS

In this section, we examine pricing model results for evidence of major shifts in pricing behavior in the latter part of our analysis period. For this purpose, we estimated our pricing models for shorter panels including 2006-2008 and 2007-2008, in addition to the 2001-2008 and 2003-2008 panels for which we reported results in Chapter 5.

Coal

Table 6-2 shows estimated coefficients and t-statistics for cost-related variables in the coal pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels.[5] The later panels exhibit a weaker effect of shipment distance (MILES) on RPTM, and stronger effects for both total shipment size and average tons per car. The coefficient on D_OWN indicates the effective discount for using shipper-owned railcars. While the coefficient on this variable is lower (in absolute value) for the 2006-2008 and 2007-2008 panels as compared to 2001-2008, longer average

[5] Note that the R-squared and sample size (N) values in Table 6-2 (and subsequent tables for other commodities) are based on the same regressions as the corresponding market-structure results in Table 6-3 (*et seq.*). The dependent variable for these regressions is ln RPTM.

hauls and slightly larger car loading leave the implicit average rental per car relatively unchanged.

TABLE 6–2
COEFFICIENTS ON COST-RELATED VARIABLES, COAL PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
ln MILES	-0.478	-0.429	-0.425
	(-275.6)	(-138.9)	(-111.7)
ln TONS	-0.006	-0.051	-0.041
	(-8.3)	(-22.8)	(-14.8)
ln TONSCAR	-0.863	-0.940	-1.002
	(-105.7)	(-62.9)	(-49.1)
D_OWN	-0.115	-0.095	-0.088
	(-73.3)	(-36.4)	(-27.6)
R-squared	0.45	0.47	0.46
N	274,228	97,651	63,501

Table 6-3 shows estimated coefficients and t-statistics for market-structure variables in the coal pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. The major feature of the coal shipments' market-structure results in our original report was a strong response of RPTM to the presence of railroad competition in the destination county (coefficient on RRCOMP_TER); this result is also present, if not slightly stronger, in the later panels. The models also indicate a small response to railroad competition at the origin county (RRCOMP_ORG), though in the later panels the effect is concentrated in the coefficient on DLM_ORG, a dummy variable indicating the presence of exactly one railroad serving the origin county. The effects of distance to water are also relatively small, while the effect is stronger for distance to water at the origin for the 2001-2008 and 2006-2008 sample periods. For the 2007-2008 sample period, the distance to water effect at the origin is somewhat weaker, and the distance to water effect at the destination is stronger, than in the earlier periods.

TABLE 6–3
COEFFICIENTS ON MARKET-STRUCTURE VARIABLES, COAL PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
DLM_ORG	0.035	0.056	0.061
	(15.2)	(13.0)	(11.7)
RRCOMP_ORG	-0.019	-0.001	0.010
	(-7.0)	(-0.2)	(1.5)
DLM_TER	0.056	0.060	0.059
	(33.8)	(21.4)	(17.2)
RRCOMP_TER	-0.189	-0.234	-0.234
	(-104.5)	(-73.0)	(-59.3)
ln KMWATER_ORG	0.028	0.016	0.011
	(21.2)	(6.9)	(3.8)
ln KMWATER_TER	0.002	0.002	0.008
	(2.2)	(1.4)	(5.7)

Corn and Wheat

Table 6-4 shows estimated coefficients and t-statistics for cost-related variables in the corn pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. The effect of length-of-haul is larger and of tons per carload is smaller in the later panels than with the 2001-2008 panel, but both effects are relatively strong, along the lines of our previous results for 2001-2006. The effects of shipment size (TONS) and car ownership are consistent across the sets of results.

TABLE 6–4
COEFFICIENTS ON COST-RELATED VARIABLES, CORN PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
ln MILES	-0.690	-0.752	-0.752
	(-162.9)	(-119.0)	(-88.4)
ln TONS	-0.060	-0.060	-0.061
	(-64.6)	(-44.5)	(-34.3)
ln TONSCAR	-0.814	-0.720	-0.707
	(-102.3)	(-59.0)	(-48.8)
D_OWN	-0.089	-0.091	-0.087
	(-36.1)	(-24.2)	(-17.2)
R-squared	0.59	0.66	0.65
N	41,715	15,766	9,881

Table 6-5 shows estimated coefficients and t-statistics for market-structure variables in the corn pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. Increasing the number of serving railroads at the origin county modestly reduces RPTM, other things equal, but the additional effect of having exactly one serving railroad at the origin county (DLM_ORG) is to reduce RPTM.[6] At destination, RPTM is higher for a single serving railroad (DLM_TER), though the marginal effects of increasing the number of effective competitors (RRCOMP_TER) are positive. The effects of distance to port facilities are small and in some cases statistically insignificant. Since much of the Corn Belt is in relatively close proximity to navigable stretches of the upper Mississippi, Missouri, and Ohio Rivers, and barge transportation will tend to be the low-cost option, we expect that 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 serve to relax modal competition constraints on railroad pricing.

TABLE 6–5
COEFFICIENTS ON MARKET-STRUCTURE VARIABLES, CORN PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
DLM_ORG	-0.021	-0.017	-0.015
	(-7.0)	(-3.9)	(-2.7)
RRCOMP_ORG	-0.015	-0.009	-0.013
	(-6.1)	(-2.6)	(-2.7)
DLM_TER	0.071	0.088	0.091
	(21.3)	(17.4)	(13.5)
RRCOMP_TER	0.029	0.054	0.059
	(9.9)	(11.9)	(9.5)
ln KMWATER_ORG	0.005	0.003	0.004
	(2.9)	(1.5)	(1.3)
ln KMWATER_TER	0.010	0.006	0.004
	(7.0)	(3.0)	(1.4)

Table 6-6 shows estimated coefficients and t-statistics for cost-related variables in the wheat pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. The effects of length-of-haul, shipment size, and tons per car are relatively stable. The estimated RPTM discounts for use of privately owned cars is smaller in the 2006-2008 and 2007-2008 panels versus the 2001-2008 panel, but remain statistically significant.

Table 6-7 shows estimated coefficients and t-statistics for market-structure variables in the wheat pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. The main feature of our previously reported results was a very strong positive effect of the distance from the origin to

[6] This result is somewhat counterintuitive, but, as we noted in our original report, it is possible that regulatory intervention, or the prospect thereof, may lead railroads with local monopolies to cede some of their pricing power.

port facilities on RPTM. Thus, wheat shipments originating in insular areas tend to face much higher RPTMs than similar shipments originating in areas with better water access. In the 2006-2008 samples, the effects remain strong for wheat relative to other commodities, but are much smaller than our previous estimates; the result appears to be sensitive to the inclusion of data from the earlier years (especially 2001-2002) of the full panel. We observe higher RPTM for shipments originating or terminating in counties with a single serving railroad (coefficients on DLM_ORG and DLM_TER); other railroad competition effects are small and sometimes insignificant.

TABLE 6–6
COEFFICIENTS ON COST-RELATED VARIABLES, WHEAT PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
ln MILES	-0.562	-0.570	-0.576
	(-129.3)	(-90.9)	(-75.1)
ln TONS	-0.023	-0.028	-0.030
	(-23.3)	(-21.4)	(-18.4)
ln TONSCAR	-0.941	-0.920	-0.907
	(-97.7)	(-82.0)	(-71.7)
D_OWN	-0.040	-0.029	-0.025
	(-14.3)	(-7.5)	(-5.2)
R-squared	0.55	0.67	0.69
N	30,318	11,955	8,039

TABLE 6–7
COEFFICIENTS ON MARKET-STRUCTURE VARIABLES, WHEAT PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
DLM_ORG	0.030	0.066	0.062
	(8.5)	(13.4)	(10.3)
RRCOMP_ORG	-0.010	0.014	0.015
	(-2.7)	(2.6)	(2.3)
DLM_TER	0.018	0.052	0.044
	(3.2)	(6.3)	(4.2)
RRCOMP_TER	-0.005	-0.008	-0.008
	(-1.5)	(-1.7)	(-1.3)
ln KMWATER_ORG	0.098	0.044	0.039
	(42.5)	(12.3)	(8.8)
ln KMWATER_TER	0.003	0.010	0.011
	(2.2)	(5.5)	(5.5)

Chemicals

Table 6-8 shows estimated coefficients and t-statistics for cost-related variables in the chemicals pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. Effects of length of haul and shipment size on RPTM are similar across the sample periods. The effect of tons per carload increases in the later periods, though this has little practical effect for typical shipments given the small variations in average car loadings over the periods. The coefficient on D_OWN, which indicates an unexpected premium for the use of privately owned railcars in the full sample, has a negative sign in the later periods (and is statistically significant in the 2007-2008 panel) indicating that the effective car rental rate is positive. We continue to suspect that these results may be driven by confounding effects involving unmeasured shipment characteristics. The coefficients in the later periods on D_HAZARD, a dummy variable indicating shipments with hazardous materials, indicates an increase in RPTM premiums for hazardous materials shipments.

TABLE 6–8
COEFFICIENTS ON COST-RELATED VARIABLES, CHEMICALS PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
ln MILES	-0.526	-0.538	-0.543
	(-261.4)	(-174.0)	(-146.6)
ln TONS	-0.048	-0.053	-0.052
	(-28.6)	(-22.2)	(-18.8)
ln TONSCAR	-0.205	-0.299	-0.304
	(-64.1)	(-57.3)	(-48.3)
D_OWN	0.063	-0.007	-0.022
	(17.7)	(-1.0)	(-2.5)
D_HAZARD	0.119	0.146	0.142
	(58.3)	(46.8)	(37.6)
R-squared	0.24	0.30	0.31
N	327,149	127,461	85,048

Table 6-9 shows estimated coefficients and t-statistics for market-structure variables in the chemicals pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. Chapter 14 of our original report showed that increased railroad competition at both origin and destination tended to lower RPTM for chemicals in the 2001-2006 panel and split-period samples. We find similar railroad competition effects in the panels including 2007 and 2008 data. Access to port facilities at the origin has no significant effect on RPTM, but RPTM increases with the destination's distance to the nearest port facility. With chemical manufacturing concentrated near waterways (e.g., the Gulf Coast of Texas, Delaware River), access to water facilities at the destination appears to be the more binding constraint on the pricing of chemical shipments by railroads.

TABLE 6–9
COEFFICIENTS ON MARKET-STRUCTURE VARIABLES, CHEMICALS PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
DLM_ORG	0.045	0.019	0.029
	(13.7)	(3.7)	(4.7)
RRCOMP_ORG	-0.058	-0.058	-0.063
	(-36.0)	(-22.6)	(-20.3)
DLM_TER	0.091	0.104	0.099
	(33.1)	(23.3)	(18.2)
RRCOMP_TER	-0.043	-0.044	-0.050
	(-29.6)	(-19.4)	(-18.2)
ln KMWATER_ORG	0.001	0.003	0.002
	(0.6)	(1.8)	(1.2)
ln KMWATER_TER	0.037	0.038	0.035
	(43.6)	(27.8)	(21.4)

Intermodal Shipments

Table 6-10 shows estimated coefficients and t-statistics for cost-related variables in the intermodal shipments pricing models for the 2001-2008, 2006-2008, and 2007-2008 panels. Effects of shipment distance and tons per carload[7] are similar across the sample periods. The positive coefficient on D_OWN indicates that shipments in non-railroad containers or trailers pay higher RPTM, other things equal, than those shipped in railroad-owned equipment.

TABLE 6–10
COEFFICIENTS ON COST-RELATED VARIABLES, INTERMODAL PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
ln MILES	-0.650	-0.678	-0.660
	(-331.1)	(-209.3)	(-168.4)
ln TONSCAR	-0.846	-0.865	-0.872
	(-2096.9)	(-1337.2)	(-1063.4)
D_OWN	0.104	0.164	0.160
	(177.3)	(151.3)	(117.7)
R-squared	0.66	0.66	0.65
N	2,487,122	1,017,999	663,136

Table 6-11 shows estimated coefficients and t-statistics for market-structure variables in the intermodal shipments pricing models for the

[7] Note that since intermodal containers and trailers are recorded as single-carload shipments in the CWS, tons per carload and tons per shipment are identical in the CWS data.

2001-2008, 2006-2008, and 2007-2008 panels. The coefficients on variables indicating railroad competition generally imply higher RPTM in the presence of multiple serving railroads at origin and destination, but again we caution that the lack of service quality indicators limits the analysis of intermodal shipments' pricing characteristics. Shorter distances to port facilities tend to reduce the RPTM for intermodal shipments. In our earlier qualitative research, we heard that some intermodal shippers use their ability to choose ports in order to exert price pressure on both railroads and ports.

TABLE 6–11
COEFFICIENTS ON MARKET-STRUCTURE VARIABLES, INTERMODAL PRICING MODELS

SELECTED SAMPLE PERIODS
(T-STATISTICS IN PARENTHESES)

Variable	2001-2008	2006-2008	2007-2008
DLM_ORG	-0.006	-0.029	-0.039
	(-4.0)	(-12.8)	(-14.3)
RRCOMP_ORG	0.050	0.065	0.065
	(115.3)	(108.9)	(89.3)
DLM_TER	-0.037	-0.031	-0.027
	(-22.0)	(-12.1)	(-8.7)
RRCOMP_TER	-0.003	0.013	0.016
	(-6.0)	(14.8)	(14.4)
ln KMWATER_ORG	0.020	0.014	0.009
	(67.6)	(29.0)	(15.3)
ln KMWATER_TER	0.043	0.034	0.031
	(141.4)	(71.1)	(52.5)

6D. INFERENCES FOR COMPETITION

The pricing model results using only recent CWS data generally show that RPTM for major commodity groups responds to observed shipment cost characteristics similarly to our previous results. As a rule, lower-cost shipment characteristics translate into lower RPTM, as we would expect. The effects of market-structure variables are mixed. Increasing railroad and modal competition often is associated with decreased RPTM, but we only observe signs of more vigorous railroad price competition (in the sense that much of the railroads' markup may be competed away) for coal shipments. The availability of modal competition from water transportation is a factor in some cases, notably intermodal shipments and wheat shipments. The pricing models do not suggest any wholesale shifts in pricing behavior that would exacerbate "captive shipper" problems.

We observe shifts in shipment characteristics offsetting increases in "generic" railroad costs for coal, grains, and chemicals; however, the main observed cost-related characteristic for intermodal shipments—tons per carload—actually decreased, which would tend to increase shipment costs. In recent years, though, a number of cost-reducing shipment trends, including fractions of unit trains and car loading for bulk shipments, showed relatively little improvement. To some extent, this may reflect current engineering limits (e.g., in railcar empty and gross weights). The upshot is that many shippers may have lacked the ability to modify their shipment characteristics to offset increases in the railroads' generic costs, which were driven primarily by the spike in fuel prices in recent years. Thus, while shippers have been exposed to increasing RPTMs after 2004, it appears that costs rather than markup factors are largely the culprits.