Supplemental Report to the U.S. Surface Transportation Board on Capacity and Infrastructure Investment

Final Report

Laurits R. Christensen Associates, Inc.
Madison, WI

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EXECUTIVE SUMMARY

Supplemental Report to the U.S. Surface Transportation Board on Capacity and Infrastructure Investment

INTRODUCTION

The August 2008 Performance Work Statement for this supplemental report (Work Statement) calls for the analysis of long-term forecasts of freight rail demand that serve as the basis of railroad investment projections. In particular, the U.S. Department of Transportation's Freight Analysis Framework (FAF) is the foundation of the demand-side study of railroad capacity investment needs through 2035 performed by Cambridge Systematics. The Work Statement calls for the review of FAF and augmentation of FAF to permit greater incentive-based responses by economic agents and to test the sensitivity of FAF to key inputs such as fuel prices and rates.

In this report, we benchmark the FAF commodity flow forecasts against other macroeconomic forecasts and also against a number of commodity-specific forecasts to develop alternative forecast scenarios of future freight rail volumes. This benchmarking is important in two respects: the range of alternative forecasted volumes indicates the inherent uncertainty of forecasting almost 30 years into the future; and subsequent to the release of the FAF commodity flow forecasts, the U.S. economy went into a recession, which has caused downward adjustments in long-term economic forecasts. Additionally, we illustrate how responses to economic factors, such as changes in fuel prices or changes in relative prices of factors in the logistics chain, may change forecasted rail volumes.

We also analyze the 2007 Cambridge Systematics[1] (CS) study that used the FAF commodity flow forecasts to estimate the amount of infrastructure investment needed to meet the projected demand through 2035. Chapter 3 of this report provides a detailed review of the methods and conclusions of the CS study. Our analysis is limited by the fact that there are proprietary elements in the FAF and CS models, which preclude the replication or sensitivity analyses of these models. Thus, the results of

[1] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007.

the alternative forecast scenarios we present should be viewed as approximations of how the alternative scenarios would change the FAF commodity flow projections and the CS projections of railroad investment needs.

We begin this report with a synthesis of conceptual issues regarding the definition, determinants, and measurement of railroad capacity; a summary of the economic theory of investment relating to railroad infrastructure improvements; and a proposed framework for analyzing the demand for freight rail services. This report concludes with a discussion of the role for public funding of railroad infrastructure.

ES1 Railroad Capacity—Conceptual Considerations

To provide a coherent framework for analyzing railroad capacity supply, demand, and investment behavior, Chapter 2 examines the theoretical and definitional aspects of these concepts.

Railroad Capacity Definitional Issues

Railroad capacity can generally be thought of as a railroad's ability to transport volumes (in a given amount of time) over its network. The amount of capacity available from a given quantity of production inputs will be affected by factors such as technological innovations, work rules and other regulations, railroad operating practices, and learning by doing. A very important influence on railroad capacity is the existence of congestion at points in the network. While congestion can occur on mainline segments that are heavily utilized, it often occurs in terminal areas, highly crowded urban areas, ports, and other transloading facilities.[2] The multidimensional aspects of railroad capacity are illustrated by the various ways railroads can increase capacity, including running more trains, running trains faster, running trains closer together, running bigger trains, installing and improving track , technological improvements, and adding and improving staff.[3]

Economic Theory of Railroad Investment Behavior

The economic theory of investment enumerates three features that are particularly relevant for analyzing railroad infrastructure investment behavior. First, railroad infrastructure investments are often very large in scale. Second, railroad infrastructure investments are generally long-lived

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[2] Christensen Associates, *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition,* report to the Surface Transportation Board, November 2008, (Christensen Report), p. 16-1.

[3] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, pp. 27-28.

and are designed to meet freight transportation demand that is uncertain. Third, most railroad infrastructure investments are irreversible.

Lumpy and irreversible investments in markets with uncertain demand will mean that those investments will have significant option values. Thus, one would expect to see that such investments would be undertaken only if they are clearly expected to be profitable. For if demand turns out to be at the low end of future expectations, the costs associated with the sunk investments will not be recovered. Because of fluctuations in demand, railroads face significant option value associated with major infrastructure improvements. Short-run capacity shortages, which result in capacity rationing of some sort and/or service degradation, may be the economically rational response in the short-run to demand fluctuations.

In evaluating some shippers' concerns that the railroads have made insufficient investments in railroad capacity, one must consider that the relationship between railroad capacity and demand during the last few years does not necessarily indicate exploitation of railroad monopoly power. Rather, it may have been the observed outcome of the economic investment decision process.

Demand for Rail Transportation and the Logistics Chain

Freight transportation services (including rail) are combined with other logistics inputs in order to provide goods and services to final consumers in a timely fashion.[4] Some of these other logistics inputs can be used as substitutes for freight transportation, while others are complements. For example, if a firm cannot rely on fast and reliable transportation, it can still accommodate the demands of its customers by siting its warehouses closer to its customers, increasing its inventory levels so that it can respond to unexpected increases in final demand, and siting its production closer to the locations of its final demand.

The demand for freight railroad transportation and its response to different levels of congestion on a particular rail corridor is affected in very complex ways by the ability to substitute different logistics inputs for transportation, the prices of these different logistics inputs, the demand for the shipper's final goods and services, and congestion elsewhere on the network. Over time, this demand relationship will change as the firm has greater ability to reorganize its logistics operations.

[4] The relationship between transportation and inventory management was first explored by William J. Baumol and Hrishikesh D. Vinod, "An Inventory Theoretic Model of Freight Transportation Demand," *Management Science*, 14(7), March 1970, pp. 413-421.

ES2 EVALUATION OF FAF PROJECTIONS RELATIVE TO ALTERNATIVE MACROECONOMIC PROJECTIONS

While the FAF projections on which the CS study is based provide a useful scenario of what the future may possibly look like, it must be recognized that there are a number of uncertainties concerning future economic conditions and these uncertainties increase as projections reach farther into the future. Therefore, as with all long-term forecasts, these projections should not be viewed as having a high degree of precision. The Federal Highway Administration only reported a base case scenario and did not include low-growth and high-growth scenarios in the final FAF model, nor is there publicly available information on alternative growth scenarios.

Another factor that should be kept in mind when evaluating the FAF forecasts is that they were made in 2007 and at that point in time most economic forecasters were more optimistic about future economic growth than they are today. Although information is not available to determine how the forecasts used as inputs to the FAF model might have changed since 2007, we examine other publicly available forecasts to see how the unexpectedly severe recession that began at the end of 2007 has affected economic forecasters' views of the future.

Comparison of FAF to Alternative Forecasts

In Chapter 4, we illustrate the degree of uncertainty surrounding long-run forecasts by considering the forecasts of real GDP used by the Trustees of Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds (OASDI) to determine the financial positions of those trust funds. These forecasts include intermediate, low-cost (i.e., high GDP growth) and high-cost (i.e., low GDP growth) scenarios. This set of OASDI scenarios provides a benchmark against which we can demonstrate the uncertainty surrounding long-run forecasts. As shown in Figure ES-1, in the low-cost scenario, real GDP is projected to increase by 151 percent between 2002 and 2035. In contrast, real GDP is projected to increase by only 80 percent in the high-cost scenario and by 112 percent in the intermediate scenario.

In order to determine how the current economic recession is affecting economic forecasters' views of the future, we analyze macroeconomic forecasts made by the Congressional Budget Office (CBO) in both January 2007 and January 2009. Figure ES-2 compares projected real GDP growth paths from these two CBO forecasts. Using the assumptions implicit in the January 2007 CBO forecast, we project real GDP growth to increase 131% between 2002 and 2035. Using the assumptions implicit in the January 2009 CBO forecast, we project real GDP to increase only 115% during that period.

FIGURE ES-1
OASDI REAL GDP FORECASTS MADE IN 2007:
INTERMEDIATE, LOW-COST, AND HIGH-COST SCENARIOS

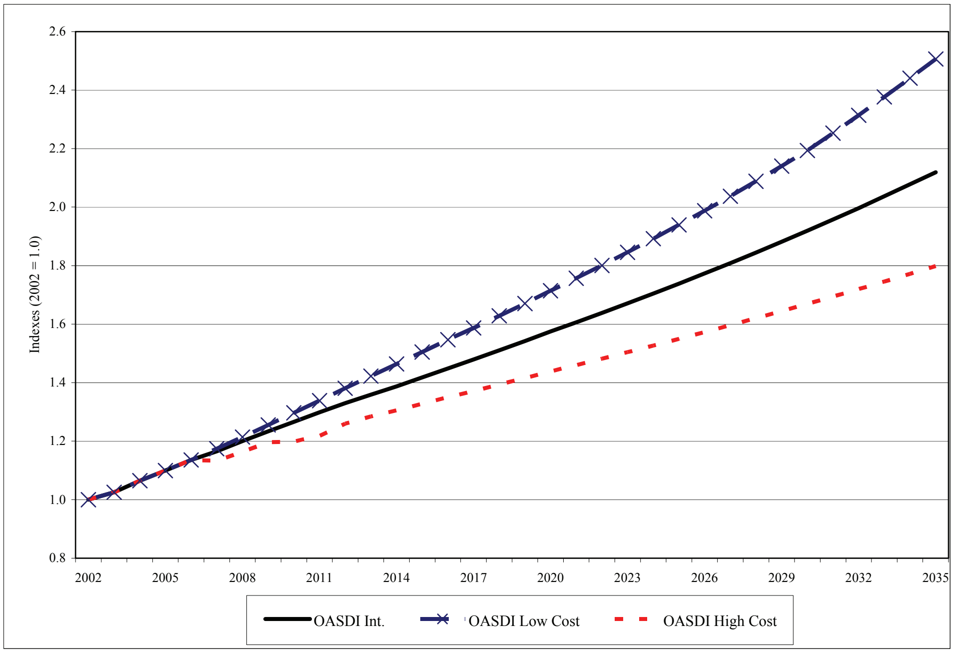
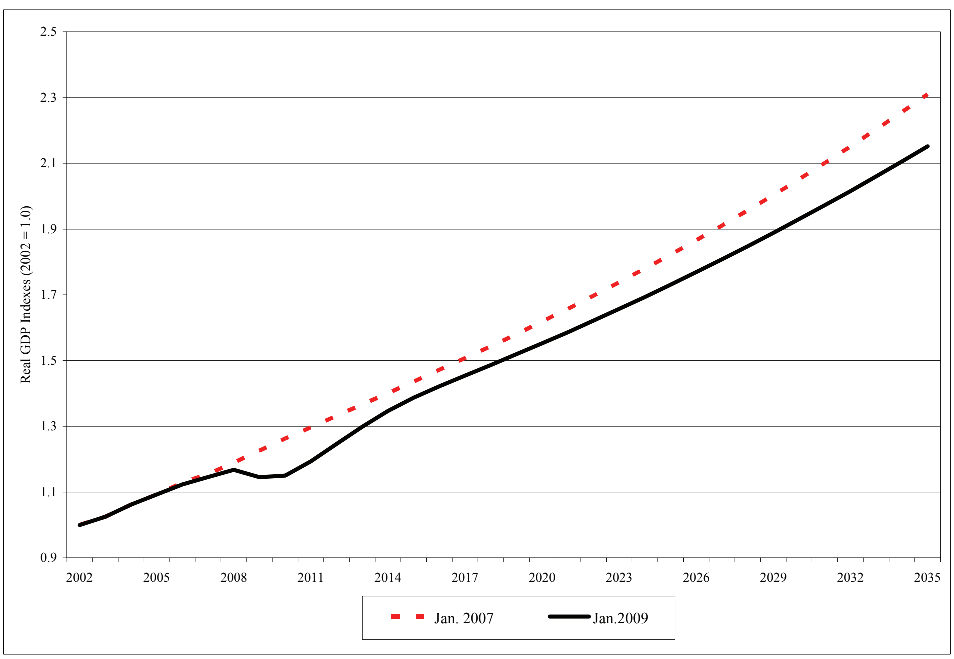


FIGURE ES-2
COMPARISON OF CBO REAL GDP FORECASTS MADE IN 2007 AND 2009



As we discuss in Chapter 4, these alternative forecasts illustrate the degree of uncertainty inherent in long-term forecasts that is not conveyed in the FAF projections. Furthermore, such uncertainty has implications for future freight railroad demand, railroad capacity needs, and the ability to fund such needs.

Changes in Rail Freight Demand Resulting from Changes in Prices and Other Factors

The CS model assumes constant modal shares by commodity and origin/destination combinations for the 2002-2035 time period. However, the potential responsiveness of demand to changes in prices should be kept in mind when evaluating long-term projections of freight transportation. Because trucking costs are more sensitive to fuel prices than are rail costs, a permanent increase in fuel prices will have a larger percentage impact on trucking prices than on rail prices, resulting in a decrease in the price of rail relative to trucking. Whether increases in fuel prices result in overall increased or decreased rail volumes depends upon the degree to which consumers view rail and truck transportation as substitutes or complements.

ES3 Evaluation of FAF Projections Relative to Select Commodity Projections

In Chapter 5 we analyze major sources of uncertainty for future rail demand and the extent to which the FAF forecasts for freight rail shipments are consistent with alternative forecasts for major commodities in the rail shipment mix. The focus of this analysis is long-term structural factors rather than declines related to the current recession. Overall, we find that the FAF model forecasts very high rail demand growth compared to current production forecasts from the Department of Energy for coal and for petroleum products (excluding gasoline and fuel oils) and from the Department of Agriculture (USDA) for grains.

The FAF forecasts assume constant modal shares by commodity and origin/destination combinations, but future rail demands also depend on the extent to which relative costs or transportation policy considerations may favor rail over other modes, especially long-haul trucking. We consider these factors along with the commodity-level forecasts for a rough quantification of a range of possible rail capacity investment needs. Summaries of two major commodity analyses from Chapter 5—coal and grains—appear below.

Coal

The Department of Energy’s Energy Information Administration (EIA) forecasts coal production, supply, and demand through 2030 using the National Energy Modeling System (NEMS). Rail is the dominant mode for long-distance coal shipments, and there are relatively few opportunities to economically substitute other transportation modes for rail. Thus, we would expect the path of rail transportation of coal to generally follow that of coal supply.

Recent NEMS runs for the EIA's Annual Energy Outlook (AEO) show significant uncertainty in long-range coal supply forecasts and, by extension, forecasts of rail shipments of coal, arising from varying long-range forecasting assumptions. Generally, the FAF model's forecasted growth in coal tonnage shipped by rail outstrips the growth in total coal production from recent EIA forecasts. The FAF forecast calls for 78 percent growth in coal rail tonnage from 2002-2030, versus 50 percent in the AEO 2007 scenario and 24 percent in the AEO 2009 scenario.

There are significant variations in forecasted coal production at the regional level, with the EIA forecasts anticipating continued westward shifts of coal production. The EIA forecasts also predict that the coal production in the Appalachian region will be below current levels for most of the forecast period through 2030.

Grains

The "cereal grains" category is the second largest in the FAF model's forecasted rail tonnage growth after coal. The FAF projects rail tonnage for grains will nearly double between 2002 and 2035, with an addition of 150 million tons. The USDA's long-term projections for major field crop production extend only through the 2017/2018 marketing year,[5] so our main consideration is whether the 10-year growth rates in FAF are reasonable. The USDA projections suggest that the forecasted rail shipment growth rates for cereal grains in the FAF model are excessive under the assumption of constant modal shares.

Capacity and Investment Implications of Commodity Forecasts

The commodity-level summaries above suggest that alternative forecasts of major components of freight rail tonnage exhibit relatively low growth during the bulk of the FAF forecast horizon. The growth rate differentials between the FAF forecasts and other commodity-specific forecasts lead to large effects on the rail traffic projections in the later FAF forecast years. Table ES-1 illustrates the effects of forecast variations

[5] U.S. Department of Agriculture, *USDA Agricultural Projections to 2017*, Long Term Projections Report OCE-2001-1, February 2008, at http://www.ers.usda.gov/Publications/OCE081/.

between the FAF and alternative sources for the four major commodity groups discussed in Chapter 5.

TABLE ES-1
EFFECTS OF FORECAST VARIATION ON RAIL TONNAGE PROJECTIONS, SELECTED MAJOR COMMODITY GROUPS

Commodity	FAF Compound Annual Growth Rate, 2002-2030	Alternative Growth Rate, 2002-2030	Alternative Growth Rate Source and/or Assumption	FAF 2035 Tons (000)	Alternative 2035 Tons (000)	Difference
Coal	2.1%	0.7%	Annual Energy Outlook 2009	1,617,892	998,077	-619,815
Cereal Grains	2.0%	1.0%	USDA field crop production forecasts, yield growth rate	304,733	214,364	-90,368
Waste and Scrap	3.1%	1.7%	FAF Average, Rail Mode	192,856	113,973	-78,883
Petroleum and Coal Products excl. Fuels	2.8%	-0.8%	Annual Energy Outlook 2009	186,573	57,139	-129,434
Total				2,302,054	1,383.553	-918,500

We use the approach developed by Burton[6] to calculate very rough estimates of the effects of alternative forecast assumptions on required rail investment. We observe that coal accounts for approximately half of the projected freight rail growth, and therefore assume that it is responsible for roughly half of the needed capacity investment. Using average length-of-haul statistics from the Carload Waybill Sample for the Appalachian, Interior, and Western regions, we calculate a rough estimate of the coal ton-mile growth implied by the FAF forecast for rail shipments of coal. We also calculate the coal ton-miles obtained by recalibrating the 2002 FAF coal traffic to the coal production growth rates by region from the AEO 2009. Using an estimate from Burton for the average incremental investment cost, we calculate the impact of the different coal forecasts on the required level of incremental investment and report our results in Table ES-2.

[6] Mark L. Burton, *Measuring the Cost of Incremental Railroad Capacity: A GIS Approach*, at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf, p. 24.

TABLE ES-2
EFFECT OF FORECAST VARIATION ON
CAPACITY INVESTMENT RELATED TO COAL

Forecast	2002 Coal Ton-Miles	2030 Coal Ton-Miles	Ton-Mile Growth	Incremental Investment Cost ($ millions)
FAF Coal Forecast	591,504	1,222,162	630,657	74,733
FAF Calibrated to AEO 2009	591,504	727,579	136,074	16,125

Note: Data in columns 2 through 4 are in millions of ton-miles.

Lower growth coal scenarios also entail lower railroad revenues and contributions in excess of marginal costs. Based on results from our competition study, the AEO 2009 scenario would reduce 2030 revenues by $8.5 billion, and the 2030 contribution by $3.6 billion (in 2000 dollars) relative to the FAF baseline.[7]

Intermodal Traffic and Truck-Rail Modal Shares

Although intermodal shipments are not readily identifiable in the FAF database,[8] it is possible to partition rail traffic between commodities commonly shipped in bulk and those likelier to be shipped in standard shipping containers or truck trailers. The FAF tonnage for the latter group of commodities is of a similar magnitude to the estimated tonnage for trailer-on-flat-car and container-on-flat-car (TOFC/COFC) shipments in the Carload Waybill Sample. Rail tonnage for this group of commodities is projected to grow at approximately the same rate as rail tonnage as a whole.

The FAF forecast actually may understate the growth in this component of rail shipments if tonnage roughly tracks trend economic growth after recovery from the current recession. The effect of growth at real GDP rates on tonnage for this component of rail would be relatively modest, but the effect on carloads (and hence train counts) would be relatively large.

The corresponding risk for intermodal shipments over the long-term appears to be on the upside of the FAF forecast, though intermodal traffic has shown substantial declines due to current economic weakness. Rail's share of long-haul shipments of commodities that are amenable to shipment in trailers and standard containers is relatively low, so shifts of moderate fractions of truck freight to the rails would have particularly large effects on rail carloads. A number of key rail corridors have seen considerable capacity-expanding investments, largely in response to increased international trade in manufactured goods, which may also be

[7] Christensen Report, p. 11-22.
[8] In particular, the tonnage for shipments using the FAF model's "Truck & Rail" mode is much lower than that for trailer and container shipments in the Carload Waybill Sample.

useful for the provision of truck-competitive services under surface transportation policies that reduce the implicit subsidies to highway transportation from unpriced negative externalities.

ES4 EXTERNALITIES AND THE ROLE OF PUBLIC FUNDING

It is a well-understood economic principle that private, profit-maximizing firms will under-invest from a social perspective when *public* benefits (i.e., positive externalities) exist, creating a demand for public participation of some form. The economic justification for public involvement (e.g., public funding of some type) in private sector investment is that the private market does not provide enough of a "good" whose social benefits exceed its private benefits—i.e., there are positive externalities (external benefits) produced by the investment.

Unlike highway projects, where public infrastructure is involved, the public funding of railroad projects involves the commitment of public funds to the infrastructure of private entities. One of the primary justifications for public involvement in railroad investment is that there is an economically inefficient level of congestion in the highway transportation network (a negative externality) that can be alleviated by encouraging a shift to more rail transportation. Therefore, the public benefit of increased rail transportation is actually a diminished level of a negative externality. Other arguments for public sector involvement in railroad infrastructure improvements are that shifting freight shipments from truck to rail transportation would lower detrimental emissions, reduce highway maintenance and security costs, increase fuel efficiency, and promote economic development.

The Role of Cost-Benefit Analysis in Assessing Publicly Funded Projects

Cost-benefit analysis is a policy evaluation tool that has been used in a variety of public investment projects to determine whether the social benefits of a public investment project outweigh its social costs, and to rank projects according to their cost effectiveness. The tools necessary to identify externalities and quantify the benefits that would result from railroad infrastructure improvement include demand models that account for shipper responsiveness to changes in prices, quality of service, and economic activity, and supply models that can be used to model the impacts of particular infrastructure investments on capacity.

The use of cost-benefit analysis that encompasses global costs and benefits is a key to targeting the most socially desirable projects. For example, it has been suggested that due to the substantial costs of highway infrastructure projects in some areas, it may be more cost-effective to reduce highway congestion through improvements in railroad infrastructure that divert some freight traffic to rail, rather than through improvements in highway infrastructure that directly increase the capacity of the highway network. In considering the relative merits of the highway versus railroad project, one must analyze both the relative costs of the two projects and the degree to which traffic would transfer from highways to rail.

Infrastructure Investment when Social Benefits are not Precisely Quantified

Although the development of a comprehensive cost-benefit analysis would be a desirable next step in improving the evaluation of railroad infrastructure projects, it is often not feasible to collect the information needed for such an analysis. This is particularly true where track has been taken out of service and other instances where detailed data on specific corridors, bridges, tunnels, and terminals are not available.

In considering whether public funding should be used for rail projects when data on corridor traffic may not exist and public benefits are not quantifiable, some decision makers have eschewed a traditional or enhanced cost-benefit analysis and developed innovative approaches in implementing public/private partnerships. The Shellpot Bridge in Delaware is a prime example. Despite not being able to precisely quantify the public benefits from restoring the Shellpot Bridge to service, Norfolk Southern Corporation and State of Delaware officials agreed to a public/private partnership to repair the bridge. The traffic volumes over the Shellpot Bridge during the 15 months following its reopening and the railroad's payments to the State of Delaware based on these volumes indicate that if rail traffic continues at a similar level, Delaware will realize an annual return of 9.75 percent on its investment in this project.[9]

Public Funding Options

Across the board investment tax credits for infrastructure improvements and expansions can encourage general investment behavior that may or may not mesh with social priorities. While general investment tax credits may not always incent private decision makers to make socially optimal decisions, such tax credits will produce positive social benefits to the extent that society determines there are generally public benefits associated with rail transportation.

On the other hand, targeted public/private partnerships can, in principle, focus on particular externalities, but these mechanisms can be complex and subject to political or bureaucratic manipulation. Public/private partnerships are employed in a number of current rail

[9] Randolph R. Resor, James R. Blaze, and David W. Campbell, "The Shellpot Bridge: A Public/Private Partnership That Worked," *Review of Network Economics*, 7(1), 2008, p. 95.

infrastructure projects—for example, the Chicago-area CREATE program and the Heartland Corridor double-stack clearance project. In some cases, the public-private partnership is an "up front" commitment of public money that is fully or partially paid back through railroad user fees of the facilities. Examples of this type of financial arrangement include the Shellpot Bridge project in Delaware, the Sheffield Flyover in Kansas City, and the Alameda corridor in Los Angeles.

Chapter 1 Contents

CHAPTER 1
INTRODUCTION TO SUPPLEMENTAL REPORT TO THE U.S. SURFACE TRANSPORTATION BOARD ON CAPACITY AND INFRASTRUCTURE INVESTMENT

INTRODUCTION

The August 2008 Performance Work Statement for this supplemental report (Work Statement) calls for the analysis of long-term forecasts of freight rail demand that serve as the basis of railroad investment projections. In particular, the U.S. Department of Transportation's Freight Analysis Framework (FAF) is the foundation of many demand-side studies of future transportation capacity needs. The Work Statement calls for the review of FAF, and also the augmentation of FAF to permit greater incentive-based responses by economic agents and to test the sensitivity of FAF to key inputs such as fuel prices and rates. The Work Statement goes on to state, "Given the high profile these projections have in policy debates regarding the state of rail capacity and what needs to be done to ensure adequate future capacity, we believe this would be an important contribution to the policy debate."[1]

In this report, we benchmark the FAF commodity flow forecasts against other macroeconomic forecasts and also against a number of commodity-specific forecasts to develop alternative forecast scenarios of future freight rail volumes. This benchmarking is important in two respects: the range of alternative forecasted volumes indicates the inherent uncertainty of forecasting almost 30 years into the future, and subsequent to the release of the FAF commodity flow forecasts, the U.S. economy went into a recession, which has caused downward adjustments in long-term economic forecasts. Additionally, we illustrate how responses to economic factors, such as changes in fuel prices or changes in relative prices of factors in the logistics chain, may change forecasted rail volumes. We also analyze the 2007 study by Cambridge Systematics[2] (CS) that used the FAF commodity flow forecasts to estimate future freight rail demand on primary corridors of the U.S. freight rail network and the amount of infrastructure investment needed to meet the projected demand through 2035.

[1] Work Statement, p. 2.
[2] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007.

Our analysis is limited by the fact that there are proprietary elements in the FAF and CS models, which preclude the replication or sensitivity analyses of these models. For example, the FAF model relies on proprietary macroeconomic forecasts to produce its commodity flow forecasts. Thus, the results of the alternative forecast scenarios we present should be viewed as illustrative approximations of how the alternative scenarios would change the proprietary forecasts used as inputs to FAF, the FAF commodity flow projections, and the Cambridge Systematics projections of investment requirements.

This report also discusses the role of public involvement in railroad infrastructure investment. The economic justification for public involvement (e.g., public funding of some type) in private sector investment is that the private market does not provide enough of a “good” whose social benefits exceed its private benefits—i.e., there are positive externalities produced by the investment. There are various approaches to public investment in railroad capacity (e.g., public-private partnerships and tax credits) and the social benefits and costs should be identified, where possible, to determine the appropriate level of public involvement.

Below, we provide a brief summary of the subsequent chapters in this supplemental report.

OVERVIEW OF CHAPTER 2

Chapter 2 is a background chapter providing a synthesis of conceptual issues that are important for understanding railroad capacity and economic investment behavior. The chapter begins with a brief summary of the analysis of railroad capacity and performance contained in our November 2008 report to the STB, and the update of this analysis that appears in the Chapter 2 Appendix. We also discuss the elusive definition of railroad capacity and the difficulties in measuring railroad capacity. To fully analyze railroad capacity and capacity constraints, we conclude that the analysis must be performed at a disaggregate level that is complex and data-intensive. However, there is a general lack of publicly available data to perform a detailed analysis without making strong assumptions that may limit the usefulness of this approach. This chapter also presents an overview of the economic theory of firm investment behavior and the demand for rail transportation as an element in a firm’s logistics decisions.

OVERVIEW OF CHAPTER 3

In Chapter 3, we provide a review and suggested extensions of the Cambridge Systematics’ 2007 study of railroad capacity and the future ability of railroads to accommodate projected demand for freight rail transportation. Our review includes a discussion of the study methodology and also FAF, on which the study’s estimate of long-term (through 2035) infrastructure investment requirements is based.

The CS study presents a landmark analysis that provides a useful tool for assessing railroad capacity issues under a given set of assumptions. Using the demand forecasts from the FAF model, this study predicts that there will be significant, system-wide capacity problems in 2035 unless substantial investments are made in railroad infrastructure. The conclusions of the CS study are sensitive to the economic projections that drive freight commodity flow forecasts, future decisions about plant locations, potential shifts among transportation modes, and changes in regional business operations.

OVERVIEW OF CHAPTER 4

In Chapter 4, we evaluate the FAF model and its forecasts. While the FAF projections provide a useful scenario for what might happen in the future, one must recognize that there is considerable uncertainty surrounding all forecasts that extend 30 years into the future. We illustrate the uncertainty in long-range forecasts with a macroeconomic forecast that not only has a “base case” projection, but also reports “high” and “low” scenarios. We note that long-range forecasting uncertainty is not reflected in the base case FAF forecasts that were used in the CS study.

There have been significant changes in the U.S. economy after the FAF forecasts were released that are likely to lead to lower GDP growth in the future. Obviously, this is not a fault of the FAF model. If the macroeconomic forecasts on which the FAF commodity projections are based were to be made today, they would likely forecast lower growth that would result in lower FAF commodity flow projections. We also illustrate how factors such as changing fuel prices and the economic relationships between truck and rail transportation may affect rail volume projections. For example, if fuel prices rise significantly, there is likely to be a shift from truck to rail transportation, thus increasing freight rail demand and railroad investment requirements.

The substantial variability in macroeconomic forecasts has implications for the CS study results. We illustrate possible changes to the CS study results based on alternative macroeconomic forecasts. Since the results of the CS study are to a great extent based on proprietary information, our analysis provides only rough approximations of how alternative forecasts could affect the results of the CS study.

OVERVIEW OF CHAPTER 5

In Chapter 5 we review the FAF forecasts for coal, grains, other coal and petroleum products, and waste/scrap. These four commodity groups account for 78 percent of the projected growth of rail tonnage from 2002 to 2035 in the FAF forecast database. Overall, we find that the FAF model forecasts very high rail demand growth compared to current production forecasts for from the Department of Energy for coal and for petroleum products (excluding gasoline and fuel oils) and from the Department of Agriculture for grains. Forecast scenarios featuring high coal demand have the potential to project substantial additional railroad investment requirements; whereas Department of Energy forecasts based on current law do not fully recognize the downside risk of stringent greenhouse gas restrictions. Assuming no countervailing effects, such as a shift in freight transportation market share toward rail, the potential reductions in rail volumes relative to the FAF forecasts would be expected to materially reduce incremental investment needs, and also railroad net revenues, relative to the CS study's baseline.

The corresponding risk for intermodal shipments over the long-term appears to be on the upside of the FAF forecast, though intermodal traffic has shown substantial declines due to current economic weakness and may be expected to remain below long-term trends for some time given forecasts of a protracted economic downturn.

OVERVIEW OF CHAPTER 6

In Chapter 6, we discuss common rationales for pubic funding of railroad investment and then outline the appropriate economic framework in which the benefits and costs of railroad infrastructure projects should be evaluated. The main policy justifications for public support of freight railroad infrastructure concern the reduction of externalities of highway congestion. Other public benefits of railroad investment include reductions in highway maintenance and security costs, environmental benefits, fuel efficiency, and economic development.

We next discuss the appropriate framework for assessing costs and benefits of public investment projects. Because of the relationship of highway and rail freight transportation within a company's logistics operations that we discuss in Chapter 2, a well designed cost-benefit analysis of transportation projects would explicitly address this relationship. A multi-modal framework would fully incorporate the complementarities and the substitutability between highway and rail freight transportation, as well as safety and environmental benefits.

Alternative methods of funding public investments in infrastructure are also discussed.

Chapter 2 Contents

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CHAPTER 2
CONCEPTUAL FRAMEWORK FOR ASSESSING RAILROAD CAPACITY SUPPLY AND DEMAND

INTRODUCTION

This chapter provides a synthesis of conceptual issues regarding the definition, determinants, and measurement of railroad capacity; a summary of the economic theory of investment relating to railroad infrastructure improvements; and a proposed framework for analyzing the demand for freight rail services. Before turning our attention to these topics, however, Section 2A briefly summarizes the analysis of railroad capacity contained in our November 2008 report to the STB ("Christensen Report" or "our report") and our update of this analysis that appears in the appendix to this chapter. In Section 2B we discuss railroad capacity definitional issues that are found in the literature. Section 2C enumerates the various factors determining railroad capacity, while Section 2D describes measurement issues and the lack of publicly available data. Section 2E provides a conceptual discussion of the economic framework for investment decision-making as it relates to the freight rail industry. Section 2F discusses the role of transportation in supply-chain logistics as a driver of demand for transportation services.

2A SUMMARY AND UPDATE OF CHRISTENSEN REPORT'S ANALYSIS OF RAILROAD CAPACITY

As we discussed in Chapter 16 of our report, railroad capacity can be generally thought of as a railroad's ability to transport volumes (in a given amount of time) over its network. The amount of capacity available from a given quantity of production inputs (i.e., capital, materials inputs, and labor) will be affected by factors such as technological innovations (often embodied in capital), work rules and other regulations, railroad operating practices, and learning by doing. A very important influence on railroad capacity is the existence of congestion at points in the network.[1] This impact of congestion on the railroad network is similar to the effects of blocking or congestion that occur in communications or data networks when limited switch or router

[1] James W. McClellan, "Railroad Capacity Issues," *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007, p. 32.

capacity creates a restriction in network throughput despite the existence of virtually unlimited fiber optic capacity.[2]

Our report concluded that, based on a number of approaches, there is not a current shortage of railroad capacity in the aggregate. However, congestion at various points or corridors in the railroad network appears to be the major culprit in capacity-related performance issues over the last ten years, similar to localized congestion in other types of networks that causes reductions in output and service levels despite largely unconstrained capacity elsewhere in the network.[3]

Our primary dataset for analyzing railroad capacity and performance was the Railroad Performance Measures (RPM) weekly dataset reported by Class I railroads.[4] Our report used the terminal dwell time metric found in the RPM dataset as the principle measure for identifying network congestion. The RPM dataset also contains measures of average train speed for each railroad overall and for five different train types—i.e., intermodal, manifest, multilevel, coal unit, and grain unit. As we discussed in Chapter 17 of our report, average train speed and variations in average speed are proxies for service quality.[5]

Because of definitional changes in the RPM data during 2005, our report provided analyses of the RPM data for two distinct time periods: January 1999 through September 2005 (Period 1), and October 2005 through December 2007 (Period 2). In the appendix to this chapter, we update our tables for the latter period to include analyses of the RPM data for calendar year 2008. We observe that CN data have not appeared recently in the RPM dataset available online. Therefore, we focus on the “Big 4” Class I railroads—BNSF, CSX, NS, and UP—in our update. We find that the addition of 2008 RPM data to our Period 2 analysis does not alter the conclusion of our November study that there currently is not a shortage of railroad capacity in the aggregate.

With RPM data now available through the end of 2008, we can also examine whether the economic recession that officially began in December 2007 has had an effect on railroad congestion or performance as reflected in the RPM metrics. In the appendix to this chapter, we examine whether there is a relationship between the behavior of the RPM data and the current economic downturn. In particular, we would expect that any capacity constraints or network congestion would have eased in the last year due to the economic downturn and declines in volumes shipped by the railroads. Largely because

[2] Christensen Associates, *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition,* report to the Surface Transportation Board, November 2008, (Christensen Report), pp. 16-1 – 16-2.
[3] Christensen Report, pp. 16-30 – 16-31.
[4] Association of American Railroads, *Railroad Performance Measures,* at http://www.railroadpm.org/.
[5] Christensen Report, p. 17-19.

of these shipment reductions, we would also expect train speeds to increase and variability in speed to decrease. As described in the appendix, we find somewhat mixed support for these hypotheses despite the severity of the economic downturn. We principally attribute the inconclusive results of our analysis to the aggregate nature of the RPM data. Consistent with our assessment of the RPM data contained in our report, we believe that a more informative investigation of service and capacity issues would require data and modeling at a more disaggregate level.

2B RAILROAD CAPACITY CONCEPTS

There are a few key themes regarding railroad capacity that are apparent from Chapter 16 of our report and the broader literature. First, although a widely agreed-upon definition of railroad capacity is elusive, an important component of the definition is the consideration of factors that increase the railroads' ability to transport freight volumes. Second, and closely related, is the recognition that there are a number of factors in addition to physical infrastructure that are important in determining the railroads' ability to transport volumes and, hence, railroad capacity. Third, it is difficult to measure railroad capacity because there is a lack of publicly available data on railroad capacity metrics. We discuss these themes below and in the following two sections of this chapter.

Definition of Railroad Capacity

A number of sources indicate that there is no uniformly accepted definition of railroad capacity. However, regardless of the particular definition, an important element in the definition of railroad capacity is the ability to transport volumes on the railroad network. According to Abril et al.:

> Capacity, whose definition is a classical problem, has long been a significant issue in the railway industry. The goal of capacity analysis is to determine the maximum number of trains that would be able to operate on a given railway infrastructure, during a specific time interval, given the operational conditions.[6]
>
> Although capacity seems to be a self-explanatory term in common language, its scientific use may lead to substantial difficulties when it is associated to objective and quantifiable measures. It is a complex term that has numerous meanings and for which numerous definitions have been given. When referring to a rail context, it can be described as follows:

[6] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, p. 2.

> *"Capacity is a measure of the ability to move a specific amount of traffic over a defined rail line with a given set of resources under a specific service plan."* (Krueger, 1999).[7]

A 2008 Rand study of railroad capacity (the Rand study) states:

> To our knowledge, no universally accepted definition of rail capacity exists, but measures of capacity should be tied to the volume of freight that can be moved over a period of time across a certain distance.[8]

Theoretical vs. Practical Capacity

There is a distinction between theoretical capacity and the capacity that railroads can practically use. According to Abril et al., there are four related capacity concepts: theoretical capacity, practical capacity, used capacity, and available capacity.

- ***Theoretical Capacity*****:** [T]he number of trains that could run over a route, during a specific time interval, in a strictly perfect, mathematically generated environment, with the trains running permanently and ideally at minimum headway (i.e., temporal interval between two consecutive trains). It is an upper limit for line capacity. Frequently, it assumes that traffic is homogeneous, that all trains are identical, and that trains are evenly spaced throughout the day with no disruptions. It ignores the effects of variations in traffic and operations that occur in reality. …
- ***Practical Capacity*****:** [T]he practical limit of "*representative*" traffic volume that can be moved on a line at a reasonable level of reliability. The "*representative*" traffic reflects the actual train mix, priorities, traffic bunching, etc. If the theoretical capacity represents the upper *theoretical* bound, the practical capacity represents a more realistic measure. … It is usually around 60%-75% of the theoretical capacity, which has already been concluded by Kraft (1982). Practical Capacity is the most significant measure of track capacity since it relates the ability of

[7] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, p. 4. See also H. Krueger, "Parametric Modelling in Rail Capacity Planning," *Proceedings of the 1999 Winter Simulation Conference*, 1999, pp. 1194-2000.
[8] Brian A. Weatherford, Henry H. Willis, and David S. Ortiz*, The State of U.S. Railroads, A Review of Capacity and Performance Data*, Rand Corporation, 2008, p. 11.

a specific combination of infrastructure, traffic, and operations to move the most volume within an expected service level.

- ***Used Capacity*****:** [T]he actual traffic volume occurring over the network. …
- ***Available Capacity*****:** [T]he difference between the Used Capacity and the Practical Capacity. …[9]

A 2007 Cambridge Systematics study (the CS study) suggests that a volume-to-capacity ratio of 70 percent of theoretical capacity represents a corridor's "practical capacity."

> A rail corridor that is operating at a volume-to-capacity ratio of 0.7 … is operating at 70 percent of its theoretical maximum capacity. This is considered to be the corridor's practical capacity because a portion of the theoretical maximum capacity is lost to maintenance, weather delays, equipment failures, and other factors.[10]

Others have cited 75 percent as the practical capacity benchmark.[11]

However, a 2007 Congressional Research Service (CRS) report authored by Stan Kaplan (the CRS/Kaplan report) contends that defining [theoretical] railroad capacity and, hence, determining the percent of capacity actually used are both elusive:

> Railroad network capacity is … not a single metric, but is different for each type of traffic, and depends on the assumptions made for traffic mix, acceptable costs, and many other variables. Since the amount of capacity on a rail network is hard to pin down, the degree to which total capacity is being utilized is also "elusive."[12]

[9] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, pp. 4-5. See also E. R. Kraft, "Jam Capacity of Single Track Rail Lines," *Proceedings of the Transportation Research Forum*, 23(1), 1982, pp. 461-471.

[10] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study,* prepared for the Association of American Railroads, September 2007, p. 4-9. See Chapter 3 for additional discussion.

[11] For example, see Denver Tolliver, *Fundamentals of Freight Railroad Capacity*, PowerPoint presentation, p. 77.

[12] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, p. 35.

2C DETERMINANTS OF RAILROAD CAPACITY

Despite the absence of a widely agreed-upon definition of railroad capacity, it is generally acknowledged that there are a number of factors, in addition to physical infrastructure and inputs, that affect a railroad's ability to provide services and, thus, its capacity. This expansive notion of capacity is intertwined with the concept of productivity, which is generally defined as the amount of output that can be produced with a given amount of inputs. "Non-input" elements of capacity—e.g., operating practices—can be viewed as factors that contribute (either positively or negatively) to productivity.

The Rand study cited above provides an example of this expansive definition of railroad capacity:

> The capacity of the rail network is determined by several parameters that span the physical and operational components of the rail system. … James McClellan[,] … a rail industry consultant formerly of Norfolk Southern (NS), said that rail capacity is determined by four interrelated factors: infrastructure, motive power, operating strategies, and crews. To this, we add industry structure as a factor.[13]

Abril et al. note that:

> Railway capacity is not static. It is extremely dependent on how it is used. The physical and dynamic variability of train characteristics makes capacity dependent on the particular mix of trains and the order in which they run on the line. Furthermore, it varies with changes in infrastructure and operating conditions.[14]

These authors go on to describe a number of factors that affect railroad capacity (and productivity), placing the factors into three categories: infrastructure parameters, traffic parameters, and operating parameters.

- *Infrastructure Parameters*
  - Block and signaling system
  - Single/double tracks
  - Definition of lines, routes
  - Network effects
  - Track structure and speed limits
  - Length of subdivision

[13] Brian A. Weatherford, Henry H. Willis, and David S. Ortiz, *The State of U.S. Railroads, A Review of Capacity and Performance Data*, Rand Corporation, 2008, p. 11.
[14] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, pp. 5-8.

- *Traffic Parameters*
  - New or existing lines
  - Train mix
  - Regular timetables
  - Traffic peaking factor
  - Priority
- *Operational Parameters*
  - Track interruptions
  - Train stop time
  - Maximum trip time threshold
  - Time window
  - Quality of service, reliability, or robustness.[15]

A similar set of factors affecting railroad capacity was mentioned in the CS study. Furthermore, Table 4.2 of the CS study illustrates the interaction of the various factors determining railroad capacity included in its analysis. This table shows the CS estimates of the maximum number of trains per day that could travel over a typical freight corridor, dependent on the number of tracks, type of control system, and mix of train types.[16]

The CRS/Kaplan report notes the difficulty of defining railroad capacity and the various elements that contribute to it:

> One study broadly defines rail capacity "as the greatest possible output while maintaining a specified minimum acceptable level of service (e.g., a minimum speed). However, this kind of formulation does not address a host of complications. There are in fact no standard definitions or measures of rail system capacity. …
>
> A measure of rail system capacity is ultimately a function of the assumptions made by the analyst. The U.S. rail network has 70,000 origin-destination pairs, many routing options, and carries a wide variety of products. The carrying capacity of a section of railroad depends on the quality of the track, whether the corridor is single-tracked or double-tracked, the number and length of sidings, and the type of signaling system installed. Railroads move trains over the network at varying speeds, depending on the quality of service needed to compete with trucks or barges, the weather, maintenance programs, and the condition of the track. Capacity is also

[15] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, pp. 5-8.
[16] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study,* prepared for the Association of American Railroads, September 2007, p. 4-7.

> a function of the cost of service the railroad is willing to incur and which shippers are willing to pay. Without a consideration of cost, "the concept of capacity is meaningless."[17]

The CRS/Kaplan report further notes that "BNSF lists volume, train density, physical plant elements, and productivity as determinants of system capacity."[18] Below, we discuss some of the important determinants of the ability of railroads to move volumes of traffic over their networks.

Network Effects

The interrelatedness of railroad networks—where what happens on one segment of the network may have spillover effects on other parts of the network—is commonly referred to as network effects or network externalities. According to Abril et al., network effects can have a far-reaching impact on congestion and railroad network capacity:

> A single line cannot be considered as a fully independent part of the whole network due to crossing and overlapping lines, which can be true bottlenecks. As a consequence, the capacity of a line cannot be defined without considering what happens on the interfering lines.[19]

Related to the network effects, is the concept of cascading failures that has typically been applied to analyze outages in the electric transmission grid. A cascading failure occurs in a network when an individual network component fails, and following the failure of this component the natural dynamics of the system induce the failure of other components. In the context of railroad capacity problems, a cascading failure analysis has been used to examine Union Pacific's service issues in the late 1990s.[20]

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[17] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, p. 35 [without footnotes].
[18] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, p. 36 [without footnote].
[19] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, p. 6.
[20] David Alderson, "Cascading Failures in Infrastructure Networks," *Workshop on Large-Scale Engineering Networks*, Institute for Pure and Applied Mathematics, UCLA, April 15, 2002.

Traffic Mix and Prioritization

Other factors affecting the capacity of a rail network are the traffic mix on the network and the prioritization of certain types of traffic over other types of traffic (e.g., passenger/commuter vs. freight):

> The changing traffic mix on the rail system has also contributed to tighter capacity. There is a tradeoff between the number of coal and other bulk cargo trains running on a system versus high-speed/high-priority intermodal traffic. To compete against trucks, rail intermodal traffic must be price competitive and offer speed and timeliness. Consequently, intermodal traffic usually takes priority over coal trains (and other freight traffic). … In general, when trains of varying speeds are mixed on a rail system and the faster trains are given priority, the effective carrying capacity of the slower trains—the amount of cargo they can move over a given period of time—is reduced.[21]

The prioritization of trains is likely an important factor when a mix of train types shares service on a corridor or network. According to Abril et al., this shared usage also has an effect on capacity:

> The priorities of trains play a vital role. Train priorities decrease capacity because priority trains are given preferential treatment over lower priority trains, which results in increased delays. This basically allows the priority traffic to move as if it were the only traffic in the network. As a rule, the greater the number of priority classes, the less capacity is available.[22]

For example, intermodal trains typically have a higher priority than merchandise trains among freight trains, and passenger/commuter trains have priority over most types of freight trains.

Network Chokepoints

As we discussed in Chapter 16 of our report, a very important influence on railroad capacity is the existence of congestion at chokepoints in the network. A feature common to most network industries is that congestion at nodes and other specific network locations can often become a binding

[21] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, p. 25 [without footnotes].

[22] M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, p. 7.

constraint on the utilization of network route capacity.[23] We concluded in our report that congestion at various points or corridors in railroad networks appears to be the major culprit in capacity-related performance issues over the last ten years.[24]

James McClellan, formerly of Norfolk Southern and its predecessor companies, points out that, despite the availability of plenty of capacity on most of the network, congestion occurs at various chokepoints in the network:

> The reality is that, much of the time, plenty of capacity is available on most of the track network … However, around urban areas, key junctions, and other choke points, congestion can worsen during certain parts of the day or on certain days of the week.[25]

The impact of railroad chokepoint congestion is similar to the effects of blocking or congestion that occurs in communications or data networks when limited switch or router capacity creates a restriction in network throughput despite the existence of virtually unlimited fiber optic capacity.[26]

A study by the American Association of State Highway and Transportation Officials (AASHTO) discusses the role of network chokepoints of various types that affect the overall throughput capacity of railroad networks:

> The railways have significant physical constraints, too. These are principally in the form of critical choke points: antiquated bridges, low-ceiling tunnels, "missing" connections, outdated signal systems that cannot accommodate both high-speed passenger trains and slow-speed freight trains, single track line without adequate sidings, bridges too weak to safely carry today's heavier rail cars, and inadequate terminal capacity. These choke points reduce the overall throughput capacity of the rail system. The rail network also has significant operational constraints: railroads must interchange traffic among themselves, share right-of-way with passenger rail, and cross highway traffic at grade. The railroads also have significant business requirements: in the face of limited profitability and capitalization, they must operate as bottom-line-oriented, for-profit businesses that live or die

[23] James W. McClellan, "Railroad Capacity Issues," *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007, p. 32.
[24] Christensen Report, p. 16-31.
[25] James W. McClellan, "Railroad Capacity Issues," *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007, p. 32.
[26] Christensen Report, p. 16-2.

> by quarterly profit statements and annual investment returns. However, there is also considerable unused potential in the nation's rail system, capacity that could be reclaimed and utilized to strengthen the national freight transportation system.[27]

A U.S. Government Accountability Office (GAO) report from 2007 discusses the role of bridges and tunnels as rail chokepoints that create constraints on capacity and may result in congestion:

> Several factors contribute to congestion on freight railroad networks, including grade crossings and passenger trains, both of which can decrease freight railroad capacity and cause freight train delays. Bridges or tunnels may also cause network congestion. For example, single-track bridges and tunnels constrain capacity on double-track lines, as do low clearances that do not accommodate double-stack intermodal trains, bridges that open for marine traffic, and other structural characteristics such as sharp curves and steep grades that require slower train speeds. Deteriorated bridge and tunnel conditions can also contribute to congestion by requiring reduced train speeds, closures, and increased time out of service for maintenance. Where repairs or improvements to bridges and tunnels may not be financially viable or sufficiently profitable, railroads may institute slow orders or shut down lines and reroute traffic. In some cases, especially for Class III railroads, a bridge or tunnel closure can isolate a shipper and cripple a railroad's entire network.[28]

This GAO study provides a few examples of particular chokepoints in railroad networks that have far-ranging influences on delays and congestion throughout the network:

> Although FRA officials estimated that 10 percent or less of freight railroad congestion is attributable to capacity constraints caused by railroad bridges and tunnels, railroad officials whom we spoke with identified some key bridges and tunnels as chokepoints on their networks. For example, one chokepoint is a moveable

[27] American Association of State Highway and Transportation Officials, *Freight-Rail Bottom Line Report*, p. 52.
[28] Government Accountability Office, *Railroad Bridges and Tunnels, Federal Role in Providing Safety Oversight and Freight Infrastructure Investment Could Be Better Targeted*, Report to Congressional Requesters, GAO-07-770, August 2007, p. 16.

> bridge that is one of only a few bridges across the Mississippi River owned by a Class I railroad. According to railroad officials, during peak periods, the bridge must open up to 15 times per day for river traffic while accommodating between 65 and 70 trains per day. Each opening for river traffic generally takes an average of 25 to 30 minutes, although the bridge is sometimes open for more than an hour, causing train delays as far as the West Coast. In addition, this bridge is closed for routine maintenance for over an hour several times a week. Another chokepoint is the 1.7 mile Howard Street Tunnel … constructed in 1895 under downtown Baltimore, Maryland, which is the largest and most expensive obstacle to transporting double-stack railcars from Baltimore to Chicago. The tunnel regularly causes passenger and freight train delays in the Baltimore area and beyond because it is a single-track tunnel with insufficient clearance for double-stack railcars on a double-track main line. Grades in and curves near the Howard Street tunnel also contribute to congestion, constraining freight traffic to 25 miles per hour through the tunnel. In addition, during a fire in the tunnel in 2001, freight traffic was rerouted, resulting in 18- to 36-hour delays.[29]

Because of its location, confluence of railroads and resulting congestion, arguably, the most significant chokepoint in the U.S. railroad network is the Chicago area. The Chicago Region Environmental and Transportation Efficiency (CREATE) Program was designed to alleviate congestion in the Chicago area. In general terms, CREATE calls for: developing one passenger rail and four freight rail corridors through Chicago; building numerous grade separations and flyovers: and upgrading track, switches, and signal systems. CREATE partners include Amtrak, six of the Class I railroads, local freight and commuter rail concerns, the city of Chicago, and the U.S. DOT.[30] Because of its national significance, CREATE has federal oversight:

> One-third of America’s rail and truck cargo moves to, from, or through the Chicago region. The Chicago rail network not only serves Illinois and the Midwest, but also the rest of the United States and North America. After Illinois, the four states most economically

[29] Government Accountability Office, *Railroad Bridges and Tunnels, Federal Role in Providing Safety Oversight and Freight Infrastructure Investment Could Be Better Targeted*, Report to Congressional Requesters, GAO-07-770, August 2007, p. 17.
[30] *Progressive Railroading,* February 4, 2009.

> dependent on Chicago's rail system are California, Texas, Ohio, and New Jersey. The magnitude of the Chicago region's trade activity is such that improvements in rail efficiency can have large impacts on businesses and consumers throughout the nation. In addition, seven rail lines entering Chicago are part of the Strategic Rail Corridor Network – rail lines identified as critical to national defense. CREATE is considered so important to national infrastructure needs that an unprecedented interdepartmental team in the U.S. DOT, comprised of representatives from the FRA, Federal Transit Administration (FTA), and Federal Highway Administration (FHWA), was created to oversee it on a national level.[31]

Capacity Usage and Railroad Performance

There is a strong relationship between the amount of available railroad capacity and service performance. Rail corridors or networks where capacity is relatively tight (or that suffer from significant chokepoint issues) are also susceptible to service problems that are difficult to resolve, resulting in the railroad version of cascading failure:

> A capacity-constrained rail network may lack resiliency and have limited ability to deal with unexpected events (e.g., bad weather, mechanical failures, unexpected growth in demand). …
>
> [R]ailroad equipment has limited mobility within a system of tracks and yards that cannot be appreciably expanded or modified over the short term. Consequently, congestion on rail networks can persist for weeks or months.
>
> When a rail system is congested it loses "fluidity." As the term suggests, the system slows down. Trains are late and the railroads may be unable to carry all the traffic a shipper has contracted for or otherwise wants to move.[32]

In testimony at the STB's Ex Parte 671 proceedings, The Honorable Jeffrey N. Shane noted the impact of tight capacity on average train speed:

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[31] David Hunt, *Return on Investment on Freight Rail Capacity Improvement*, NCHRP 08-36, Task 43, April 2005, p. 2-6.
[32] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, pp. 25-26.

> While much of the system needed paring back due to redundancy and unused and light density lines, traffic on the remaining portion is moving over heavily traveled corridors. This has resulted in a reduction in system average train speed by nearly 20 percent, accompanied by network congestion and deterioration in service reliability. In 2005, for example, train velocity (train-miles per train-hour) fell to 18.6, the lowest level in 16 years. … There are some preliminary signs of a reversal in 2006.[33]

According to the CS study, as capacity usage exceeds 70 percent (the boundary between level-of-service or "LOS" grades C and D), service performance can quickly become unstable following unanticipated disruptions:

> A corridor operating at LOS C [0.4 to 0.7] will have stable train flows, ensuring that schedules can be met reliably and safely, and permitting timely recovery from service disruptions. At LOS D [0.7 to 0.8], a corridor will have stable operations under normal conditions, but service can quickly become unstable with unplanned and unanticipated disruptions. At volume-to-capacity ratios significantly greater than 0.8 (e.g., at LOS E or F), train flow rates and schedule reliability deteriorate and it takes longer and longer to recover from disruptions. To provide acceptable and competitive service to shippers and receivers, railroads typically aim to operate rail corridors at LOS C/D or better.[34]

An illustration of how network operations become more difficult at higher volume-to-capacity ratios is given by events that occurred in 2005 when high network usage meant little or no network "reserve capacity." As a result there was diminished network "fluidity" and congestion at particular locations cascaded throughout the network:

> Even now, events that once would have had little effect now cause major disruptions throughout the rail network, because there is no reserve capacity. Our experience in 2005 was a good example. West Coast storms interrupted shipments from California ports to the east, and forced

[33] Jeffrey N. Shane, Under Secretary for Policy, U.S. Department of Transportation, Statement before the Surface Transportation Board, Ex Parte 671, *Rail Capacity and Infrastructure Requirements*, April 11, 2007, p. 2.
[34] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study,* prepared for the Association of American Railroads, September 2007, p. 4-9.

> eastern carriers to hold traffic moving west; the result was filled yards and a clogged rail system. In the Powder River Basin, necessary track work and severe winter weather slowed deliver of coal to utilities.[35]

2D MEASUREMENT OF RAILROAD CAPACITY

The CRS/Kaplan report notes the difficulty of defining railroad capacity and the lack of public data to measure it:

> [M]ost of the public information on railroad capacity are anecdotal. … The unavailability of public data on rail capacity is in part because rail system capacity is difficult to measure and define.[36]

The 2007 GAO report on bridges and tunnels suggests that, while not publicly available, railroads do possess information on bridges and tunnels that are important for determining capacity and railroad investment priorities:

> Little information is publicly available on the condition of railroad bridges and tunnels, and on their contribution to congestion, but private freight railroads collect and maintain this information to varying degrees and use it to set investment priorities. This information will be increasingly important to the railroads as the demand for freight transportation grows, aggravating existing freight railroad congestion problems and further straining the railroads' infrastructure, which includes aging and expensive bridges and tunnels.[37]

While it may be difficult to develop network-wide measures of capacity, the problem is apparently more tractable for segments of the network (i.e., corridors) or particular types of traffic, and railroads possess the data for assessing this more narrowly defined capacity:

> And while the practicality (and utility) of encapsulating the capacity utilization of an entire rail system in a single

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[35] Jeffrey N. Shane, Under Secretary for Policy, U.S. Department of Transportation, Statement before the Surface Transportation Board, Ex Parte 671, *Rail Capacity and Infrastructure Requirements*, April 11, 2007, p. 3.
[36] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, p. 34.
[37] Government Accountability Office, *Railroad Bridges and Tunnels, Federal Role in Providing Safety Oversight and Freight Infrastructure Investment Could Be Better Targeted*, Report to Congressional Requesters, GAO-07-770, August 2007, p. 3.

> index number may be questionable, it is possible to define capacity for key corridors and categories of traffic for a given set of assumptions. For instance, in the past CSX has reported the degree of capacity utilization on its network for general merchandise traffic and for intermodal traffic. …
>
> Railroads estimate the current and projected capacity of parts of their systems in order to make investment decisions. …
>
> In summary, while a system-wide capacity index may be difficult or impractical to develop, corridor-specific capacity measures appear to be meaningful and feasible.[38]

However, the ability to determine capacity along specific corridors also appears to be limited by the broad nature of the determinants of railroad capacity and the corresponding lack of data for many of these determinants, as illustrated by the recent CS study:

> The capacity of rail corridors is determined by a large number of factors, including the number of tracks, the frequency and length of sidings, the capacity of the yards and terminals along a corridor to receive the traffic, the type of control systems, the terrain, the mix of train types, the power of the locomotives, track speed, and individual railroad operating practices. Complete, consistent, and current information on all these factors was not available for the study, so the capacity of the primary corridors was estimated using only the three dominant factors (e.g., number of tracks, type of signal system, and mix of train types).[39]

In our study, we mentioned an approach developed by Mark Burton for measuring railroad capacity that overcomes many of the obstacles listed above.[40] Burton notes that railroad capacity issues must be examined at a fully disaggregate level by evaluating the capacity of individual links (i.e., route segments) that form specific routes. This approach is both complex and data-

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[38] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, pp. 36-37 [without footnotes].
[39] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study,* prepared for the Association of American Railroads, September 2007, p. 4-5, fn. 15.
[40] Mark L. Burton, *Measuring the Cost of Incremental Railroad Capacity: A GIS Approach,* at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf.

intensive.[41] Burton combined railroad traffic data from the Carload Waybill Sample (CWS) with geographic information systems (GIS) infrastructure information on the U.S. railroad network and engineering cost estimates to develop traffic flows over railroad links. The CS Study performed a similar analysis. The estimated traffic flows and data on link characteristics are used to estimate an econometric model of railroad "link" capacity and incremental capacity costs.[42] With the results of his regression model, Burton was able to simulate the capacity of route segments having particular physical characteristics. He then combined his regression results with cost estimates of various capacity-enhancing additions (e.g., sidings and controls) to develop generic estimates of potential capacity improvements.

Burton acknowledges that the limitations of publicly available data required him to make strong assumptions in order to enable the analysis. The CWS data do not include details on shipment timing (other than a waybill date) or information on how shipments are formed into trains; the data also do not provide information on service-quality characteristics, notably for intermodal shipments. In practice, some relevant details on network flows will tend to be lost to factors including data aggregation or modeling limitations even to the extent that the railroads may be able to provide additional information on traffic flows and their characteristics.[43]

2E INFRASTRUCTURE IMPROVEMENTS, CAPACITY CONSTRAINTS, AND THE ECONOMIC THEORY OF INVESTMENT

In recent years, both shippers and the railroads have expressed concern about current and future capacity constraints on the railroad network. Shippers have mostly expressed concern about current capacity constraints and the reliability of rail service. Some shippers have expressed the opinion that railroads have an economic incentive to limit capacity improvements, creating capacity shortages, which allow the railroads to charge higher rates. Railroads have expressed more concern about the long-run future capacity needs and their ability to fund these needs. With a view to the railroad infrastructure requirements over the next thirty years, railroads anticipate that capacity will need to be increased considerably while they may not have the financial resources to meet these capacity needs.

[41] Mark L. Burton, *Measuring the Cost of Incremental Railroad Capacity: A GIS Approach,* at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf, pp. 1-2.
[42] Burton notes that a fundamental assumption of his analysis is that the components of the rail network were optimally suited to accommodate the observed traffic moving over them, so that the observed traffic moving over a link represented that link's capacity. See Mark L. Burton, *Measuring the Cost of Incremental Railroad Capacity: A GIS Approach,* at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf, p. 6.
[43] Railroads may possess detailed data on additional dimensions of capacity utilization, but we would expect these data to be treated as confidential. Thus, if the STB were to request the necessary data for modeling railroad capacity, it would need to come up with procedures to protect highly confidential data, much as it does with the Carload Waybill Sample.

In order to evaluate the state of railroad capacity supply, it is useful to begin with the economic theory of investment to determine the incentives that a typical firm faces when making investment decisions. Focusing on railroad infrastructure investments, the economic theory of investment enumerates three features that are particularly relevant. First, railroad infrastructure investments are often very large in scale. In some instances, it is not realistic to make these infrastructure investments incrementally because of scale economies. In other cases, the payoff to the infrastructure improvements will not be realized until the entire project is completed. Second, railroad infrastructure investments are generally long-lived and are designed to meet freight transportation demand that is uncertain. As evidenced by volume declines during the current economic downturn, railroad shipments are quite sensitive to the business cycle and unforeseen sectoral changes in the U.S. economy can have significant impacts on rail demand. Third, most railroad infrastructure investments are irreversible. Unlike investments in assets such as office buildings, automobiles, and computers, the cost associated with track-related infrastructure investment is sunk: that investment can be used to handle railroad shipments over the improved route, but it cannot be moved and used for other purposes.

Classical investment theory has long noted that in instances where an industry is growing and investments are "lumpy," i.e., can only be made in large increments, a firm can experience periods with a shortage of capacity followed by periods with excess capacity. When there is a shortage of capacity, short-run marginal costs are above long-run marginal costs. When there is an excess of capacity, short-run marginal costs are below long-run marginal costs. In a competitive industry, the firm must weigh its future revenue stream against its costs to determine the optimal timing of lumpy investments. If the industry has a shortage of capacity, prices will be determined by short-run marginal costs that are above long-run marginal costs. These prices will provide incentives for investment in the industry. On the other hand, if the industry has an excess of capacity, industry prices based on short-run marginal costs will be below long-run marginal costs and the incentives will be to reduce capacity, if that is possible.

More recent investment literature, summarized by Dixit and Pindyck,[44] shows that uncertainty of future demand and irreversibility of investment have additional implications for investment incentives. Dixit and Pindyck note that, under conditions of uncertainty when investment is irreversible, the firm must consider the option of delaying an investment instead of investing in the current period. They liken this investment opportunity to a financial call option. A call option gives the holder the right for some specified time period to purchase an asset for a predetermined price. Exercising the option is irreversible; once the option is purchased it can be resold to another investor, but the original investor cannot retrieve the option or the money spent to

[44] Avinash K. Dixit and Robert S. Pindyck, *Investment under Uncertainty*, (Princeton, New Jersey: Princeton University Press), 1994.

purchase the asset.[45] Likewise, once a firm makes an irreversible investment, it cannot reverse that investment decision. Although the asset can be resold to another firm, the value of that sale will be dependent upon the current market value of that asset, not the original purchase price. As demand becomes more uncertain, the option value of delaying an investment increases. In order for the investment to be economically profitable, the net present value of the future returns to the asset must cover both the cost of the asset and the option value. Furthermore, Dixit and Pindyck also note that the presence of an option value in and of itself does not represent a market failure that needs correction through government intervention.[46]

This investment theory framework has significant implications for evaluating the railroad industry's investments in infrastructure improvements. Lumpy and irreversible investments in markets with uncertain demand will mean that those investments will have significant option values. One would therefore expect to see that such investments would be undertaken only if they are clearly expected to be profitable. For if demand turns out to be at the low end of future expectations, the costs associated with the sunk investments will not be recovered. Furthermore, one would also expect to see the railroad industry embrace whatever cost-effective programs improve capacity utilization without large and irreversible infrastructure improvements.

In terms of evaluating some shippers' concerns that the railroads have made insufficient investments in railroad capacity, one must consider the fact that the relationship between railroad capacity and demand during the last few years does not necessarily indicate exploitation of railroad monopoly power.[47] Freight demand increased substantially in the years prior to 2008, but we have also seen substantial reductions in freight demand during this past year. Because of these fluctuations in demand, railroads face significant option value associated with major infrastructure improvements. Observed short-run capacity shortages (which need to be handled through capacity rationing) may be the economically rational response in the short-run to demand fluctuations.

2F FRAMEWORK FOR ANALYZING DEMAND FOR RAIL TRANSPORTATION

The demand for railroad freight transportation is a major component of the U.S. economy's needs for logistics services. Freight transportation services are combined with other logistics inputs such as warehouses, inventories, and information technology in order to provide goods and

[45] Avinash K. Dixit and Robert S. Pindyck, *Investment under Uncertainty*, (Princeton, New Jersey: Princeton University Press), 1994, p. 9.
[46] Avinash K. Dixit and Robert S. Pindyck, *Investment under Uncertainty*, (Princeton, New Jersey: Princeton University Press), 1994, p.19.
[47] As we demonstrated in our report, there was not an increase in the railroads' exercise of market power when capacity constraint issues became a concern in the early and mid-2000s. See Christensen Report, Chapter 10.

services to final consumers in a timely fashion.[48] Some of these other logistics inputs can be used as substitutes for freight transportation, while others are compliments. For example, if a firm cannot rely on fast and reliable transportation, it can still accommodate the demands of its customers by siting its warehouses closer to its customers (at the same time constructing warehouses with smaller capacity), increasing its inventory levels so that it can respond to unexpected increases in final demand, and siting its production closer to the locations of its final demand (once again requiring that each production site have smaller capacity). When transportation services are improved, the firm can centralize its warehouse and production operations and maintain lower overall inventory levels. Improvements in information technology can also improve the utilization of transportation services, making them more attractive relative to the use of other logistics inputs. An example of this complementary relationship was the widespread adoption of just-in-time inventory management. With just-in-time inventory management, fast and reliable transportation has been combined with information technology to reduce the need for maintaining large inventories, improving the overall efficiency of the logistics process.

Microeconomic Framework for Assessing Demand

In thinking about railroad freight transportation demand, it is important to place it in the context of providing logistics services. The Office of Freight Management and Operations section of the Federal Highway Administration (the same section that is responsible for the Freight Analysis Framework forecasts) has developed the following microeconomic model of transportation and logistics services, which is used to determine the underlying demand for freight transportation.[49] While the focus of this model is highway transportation, the model incorporates transportation over all modes.

In this framework, a freight shipment is viewed as the basic unit of transportation provided. The relevant characteristics of the shipment $S_i = S(L_i, W_i, M_i, V_i, T_i, \sigma_i)$ are:

L = the origin-destination pair of the shipment[50]
W = the shipment weight
M = the transportation mode

[48] The relationship between transportation and inventory management was first explored by William J. Baumol and Hrishikesh D. Vinod, "An Inventory Theoretic Model of Freight Transportation Demand," *Management Science*, 14(7), March 1970, pp. 413-421.
[49] *Freight Benefit/Cost Study: White Paper – Benefit-Cost Analysis of Highway Improvements in Relation to Freight Transportation: Microeconomic Framework*; presented to the Federal Highway Administration, Office of Freight Management and Operations, by ICF Consulting, HLB Decision Economics, and Louis Berger Group, February 26, 2001, at http://ops.fhwa.dot.gov/freight/freight_analysis/econ_methods/microecon_frmwk/index.htm.
[50] Arguably, one might also want to distinguish shipments by the time the shipment begins and the time it ends.

V = value added services associated with the shipment
T = the expected travel time of the shipment
σ = the variance of the expected travel time.

The relationship between logistics inputs and the level of service needed to support the firm's production and distribution operations is described by the production function Y = f(S, I, B, IT), where Y is the level of the firm's final sales; S is the vector of shipments over all origin-destination pairs, transportation modes, shipment sizes, and other shipment characteristics; I is the level of inventories maintained by the firm; B is a vector of warehouse spaces; and IT is the information input related to order processing. Based on the prices of these different shipments, inventories, warehouse capacities, information inputs, and the profit-maximizing level of final sales, the firm determines its cost-minimizing utilization of these logistics inputs. This means that the demand functions for transportation services are dependent upon all of the factors listed above.

One example of the interrelated demands for freight transportation and inventory levels can be found in the electricity generation industry. Since the early 1980s, there has been a substantial reduction in the average level of coal stocks for electricity generation. In 1980, the average level of coal stocks reflected 110 "days of burn," meaning that plants could run at their customary level for 110 days before exhausting their coal stock. Since 1980, average coal inventories at electricity generators have been cut in half, with the average level of coal stocks standing at 52 days in 2008.[51] With "day of burn" inventories at a much lower level, prompt and reliable freight transportation is essential for the effective functioning of coal power plants. But it is also the case that a power plant can respond to less reliable rail transportation by increasing its inventory levels (although one must recognize that this is not a costless change in operations for shippers and power plants). As capacity shortages emerge, a possible alternative to adding additional freight rail infrastructure would be for power plants to increase their stocks of coal. From a public policy perspective, choosing one response over the other depends upon their relative costs.

The link across capacity, congestion, and freight transportation demand is captured in this framework by the expected travel times of different shipments and the variance of these expected travel times. If congestion increases the expected travel time or its variance, the level of transportation service declines, i.e., $\partial S/\partial T < 0$ and $\partial S/\partial \sigma < 0$. In this context, if the charge for a particular shipment remains constant while the expected travel time or its variance is increased due to congestion, the quality-adjusted price of the shipment is increased, and the firm will attempt to substitute other logistics inputs for the shipment. The degree to which the demand for that particular

[51] U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*. Stan Kaplan of the Congressional Research Service graciously provided us with the data used in this analysis.

shipment responds to this increased congestion is dependent upon the elasticity of substitution between the different logistics inputs. For example, if an alternative mode of transportation is readily available and is also competitively priced, then there will be a significant response to this increased congestion and the demand function for that particular shipment will be relatively elastic.

Short Run vs. Long Run Considerations

As the Federal Highway Administration framework recognizes, the elasticity of transportation demand with respect to changes in congestion is smaller in the short run than in the long run. For example, suppose that there is a reduction in congestion levels for a particular rail corridor. In the very short run, contractual commitments and production schedules may limit the degree to which the firm can take advantage of this reduced congestion. In a slightly longer timeframe, the firm may be able to shift some of its highway transportation to this now less congested rail corridor. If the firm has multiple production sites, it might also increase production at the plant served by this corridor, while decreasing production elsewhere. The firm also might determine that expanding its final sales is profitable, further increasing production at the plant served by this rail corridor and thus increase transportation along this corridor. As many firms make similar decisions, the increase in transportation demand along the more attractive rail corridor will have a feedback effect on the congestion on that corridor (tending to offset, to some degree, the congestion improvement), while relieving congestion on other rail corridors or for other transportation modes.

In the longer run, firms may decide to relocate production operations and warehouses to make further use of that rail corridor. This will lead to further shifts in transportation utilization across modes and corridors. To the extent a railroad recognizes the increased value that reduced rail corridor congestion provides customers and consequently raises its rates, firms will make further adjustments to their logistics operations to minimize cost.

Implications for Forecasts

The demand for railroad freight transportation and its response to different levels of congestion on a particular rail corridor is affected in very complex ways by the ability to substitute different logistics inputs for transportation, the prices of these different logistics inputs, the demand for the firm’s (shipper’s) final goods and services, and congestion elsewhere on the network. Over time, this demand relationship will change as the firm has greater ability to reorganize its logistics operations. In the Appendix to Chapter 4, we review the empirical literature on rail freight transportation demand. That review indicates that the studies published to date show a wide range of elasticity estimates. Due to the complexity of the relationship between transportation and logistics, this wide range of estimates is probably not surprising. At the same time, a careful evaluation of future infrastructure needs requires a good understanding of freight transportation demand, as the Federal Highway Administration has recognized. This is an important area for future research.

CONCLUSION

The multidimensional aspects of railroad capacity are illustrated by the various ways railroads can increase capacity (and productivity). For example, according to one source, railroads have several avenues for increasing capacity, including running more trains, running trains faster, running trains closer together, running bigger trains, installing and improving track (e.g., double-track, more and longer sidings, straightening curves, and using heavier rail), technological improvements, and adding and improving staff.[52] Furthermore, attempts to increase capacity through these various elements may require increases in other aspects of the network in order to be successful. For example, increasing the size or weight of cars may also require alterations in bridges or tunnels to accommodate these increased dimensions.[53] It is apparent that the concept of railroad capacity is strongly related to factors that affect railroad performance or productivity, including the potentially far-reaching spillover effects of congestion at various points in the network. A useful characterization of the interrelated elements of railroad capacity and their effects on performance is provided by McClellan:

> Capacity is created (or destroyed) by a host of interrelated factors. Although we tend to think of capacity as an infrastructure issue, rolling stock, motive power, employees and operating strategies (e.g., size, speed, and timing of trains) are all part of the equation.
>
> In a complex network business such as railroading, all of these factors are related. Underpowered trains wreak havoc with track capacity. Too many trains running at different speeds have the same impact (which is why some railroads are taking a harder line about faster schedules for UPS and other premium intermodal customers). If yards are congested, then trains are held on

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[52] Stan Mark Kaplan, *Rail Transportation of Coal to Power Plants: Reliability Issues*, CRS Report for Congress, RL34186, September 26, 2007, pp. 27-28.
[53] Government Accountability Office, *Railroad Bridges and Tunnels, Federal Role in Providing Safety Oversight and Freight Infrastructure Investment Could Be Better Targeted*, Report to Congressional Requesters, GAO-07-770, August 2007, p. 10.

> line of road, which reduces line-of-road capacity and "burns" crew availability.[54]

In terms of evaluating some shippers' concerns that the railroads have made insufficient investments in railroad capacity, one must consider the fact that the relationship between railroad capacity and demand during the last few years does not necessarily indicate the exploitation of railroad monopoly power. In fact, during the mid-2000s when capacity tightness issues were of concern in the railroad industry, our study concluded there was no increase in the exercise of market power by railroads.[55] Because of fluctuations in demand, railroads face significant option value associated with major infrastructure improvements. The economic theory of investment says that observed short-run capacity shortages (which need to be handled through capacity rationing) may be the economically rational response in the short-run to demand fluctuations and, thus, do not represent an increased exercise of market power.

The demand for railroad freight transportation and its response to different levels of congestion on a particular rail corridor is affected in very complex ways by the ability to substitute different logistics inputs for transportation, the prices of these different logistics inputs, the demand for the firm's (shipper's) final goods and services, and congestion elsewhere on the network. Over time, this demand relationship will change as the firm has greater ability to reorganize its logistics operations.

In our opinion, the use of rough proxies, such as the RPM data, do not provide information at the appropriate level of detail to thoroughly examine capacity issues. To fully analyze railroad capacity and capacity constraints, analyses must be performed at a disaggregate level that is complex and data-intensive. However, there is a general lack of publicly available data to perform a detailed analysis without making strong assumptions that may limit the usefulness of this approach. Railroads may possess much of the data that would allow such an analysis, but these data are typically confidential. Thus, if the STB were to request such data for modeling railroad capacity, it would need to come up with procedures to protect confidentiality, much like it does with the Carload Waybill Sample.

[54] James W. McClellan, "Railroad Capacity Issues," *Research to Enhance Rail Network Performance,* Transportation Research Board, 2007, p. 32.
[55] Christensen Report, Chapter 10.

CHAPTER 2
APPENDIX: REVIEW AND UPDATE OF CAPACITY AND PERFORMANCE FINDINGS

INTRODUCTION

Chapters 16 and 17 of the Christensen Report examined capacity measurement, railroad performance, and the relationship between them. In this appendix, we provide a brief review of our findings and update some of the performance metrics presented in our earlier study. Given the current economic downturn that officially began in December 2007, we also examine how capacity and performance measures relate to the downturn.

Our primary dataset for analyzing railroad capacity and performance was the Railroad Performance Measures (RPM) dataset of weekly data reported by Class I railroads.[56] Although the RPM data are available back to 1999, in October 2005, standardized definitions were adopted, so that pre-October 2005 data are not directly comparable to post-October 2005 data.[57] Because of the definitional changes, we analyzed the RPM data for two time periods in our report: January 1999 through September 2005 (Period 1), and October 2005 through December 2007 (Period 2). Furthermore, direct comparisons of RPM measures across railroads are not necessarily meaningful.[58]

We now have an additional year of RPM data that go through the end of 2008. In this report, we update our analysis of the RPM data and focus on the latter period (i.e., Period 2) from our study. We observe that CN data have not appeared recently in the RPM dataset available online. Therefore, we focus on the "Big 4"—BNSF, CSX, NS, and UP—in our update.

A1 TERMINAL DWELL TIME

In Chapter 16 of our report, we concluded that, in the aggregate, there is not a current shortage of railroad capacity. However, as is the case for other types of networks such as electricity distribution and telecommunications, congestion at particular points in the network can have widespread impacts on output and service levels, even though there is virtually unconstrained capacity throughout the rest of the network. This type of congestion appears to

[56] Association of American Railroads, *Railroad Performance Measures*, at http://www.railroadpm.org/.
[57] Association of American Railroads, *Railroad Performance Measures*, at http://www.railroadpm.org/.
[58] Association of American Railroads, *Railroad Performance Measures*, at http://www.railroadpm.org/.

have been the major culprit in capacity-related railroad performance issues over the last ten years.[59]

The primary measure we used in our study to identify network congestion was the terminal dwell time data found in the RPM dataset. We stated in Chapter 16:

> The time railcars spend in terminals (terminal dwell time) can be considered an indicator of numerous dimensions of railroad operations. It can be thought of as a measure of capacity, a reflection of railroad operational efficiency, a contributor to performance and customer satisfaction, and a symptom of capacity constraints or network congestion. With respect to capacity or congestion, it may be the case that there is sufficient mainline capacity, but congestion at terminals creates a slowdown in railroad performance. Or increased terminal dwell time may be symptomatic of congestion elsewhere in the network.[60]

In focusing on RPM measures for the pre-October 2005 period (Period 1), we concluded in Chapter 16 of our report that while each railroad has a somewhat unique pattern, one thing that does stand out is a general increase in terminal dwell time in the 2003-04 period, followed by a decline in 2005. Moreover, individual terminals differed considerably in the variability of their dwell times, suggesting that those terminals with the longest dwell times and largest variability might be affected by capacity constraints.[61] We also concluded that increased equipment spending in recent years combined with a relatively weak economy indicates that any capacity tightness that may have existed at the beginning of this decade has likely loosened in recent years.[62]

Table 2.1 updates Table 16.3 from our report for overall railroad terminal dwell time in 2008. Given the current recession, we would expect that the lower shipment volumes would result in fewer network capacity problems, including congestion. Thus we would expect that average dwell times and the variability of dwell times would be reduced. Focusing on Period 2, we see that the 2008 average dwell time is down slightly for the two Western railroads (BNSF and UP) compared to 2007. However, compared to 2006, average dwell time in 2008 is higher for BNSF and significantly lower for UP. Both Eastern railroads (CSX and NS) have 2008 average dwell times

[59] Christensen Report, pp. 16-30 – 16-31. We also noted that the RPM dwell-time data are of limited usefulness in a number of respects. For example, they do not indicate the source of dwell-time changes, nor do they distinguish cars that are being reclassified for continuations of their trips to their ultimate destinations from cars that have reached their destinations.
[60] Christensen Report, pp. 16-10 – 16-11.
[61] Christensen Report, pp. 16-30 – 16-31.
[62] Christensen Report, p. 16-25.

that are the same as in 2007 and lower than in 2006. Variability in terminal dwell time, measured by the coefficient of variation (CV), increased noticeably in 2008 for the two Western railroads, particularly BNSF, and declined for the two eastern railroads. Comparing 2008 to 2006, the same pattern holds for the two Western railroads while it was mixed for the two Eastern railroads. It is not clear why the 2008 CVs were so high for BNSF and UP. Overall, however, there appears to be a weak relationship between the state of the economy and the average terminal dwell time and its variability.[63]

TABLE 2-1
TERMINAL DWELL TIME BY YEAR

2006-2008

Average	BNSF	CSX	NS	UP
2006	23.9	25.1	22.4	27.2
2007	24.3	23.3	21.8	25.2
2008	24.1	23.3	21.8	24.8
StdDev				
2006	0.965	1.375	1.706	1.711
2007	0.957	1.818	1.611	1.325
2008	1.763	1.311	1.465	1.714
CV				
2006	4.0%	5.5%	7.6%	6.3%
2007	3.9%	7.8%	7.4%	5.3%
2008	7.3%	5.6%	6.7%	6.9%

A2 AVERAGE TRAIN SPEED

As we discussed in Chapter 17 of our report, average train speed and its variability (measured by the CV) is a proxy for service quality, and changes in average speed represent changes in performance and service quality.[64] The RPM data allow us to calculate average train speeds across a railroad's network for different train types—intermodal, manifest, multilevel, coal unit, and grain unit. Comparisons of changes in average speed and its variability (measured by the CV) across train types provide an indication of changes in service quality for customers of these train types.[65] However, the RPM data do not allow for route-specific or corridor-specific analysis. Nor do the RPM data allow an evaluation of on-time performance or variability of performance from a shipper's perspective.

[63] An examination of individual terminal data for each of the railroads also indicates a weak relationship between the average terminal dwell time and the state of the economy, as many terminals had their highest average dwell times and greatest Period 2 coefficients of variation in 2008.
[64] Christensen Report, p. 17-19.
[65] Again, we caution that comparisons across railroads are not necessarily meaningful.

Table 2.2 summarizes the overall change in average train speed by train type between 4Q05and 4Q08 by railroad, and the overall change in terminal dwell time for this period. Table 2.2 updates information from Tables 17-2 (BNSF), 17-5 (CSX), 17-7 (NS), 17-8 (UP), and 17-10 (summary) of our report. In general, reductions in average dwell time appear to be strongly correlated with increases in average speed.

TABLE 2-2
TOTAL CHANGE IN AVERAGE TRAIN SPEED BY TRAIN TYPE

4Q08 over 4Q05

	All	Intermodal	Manifest	Multilevel	Coal Unit	Grain Unit	Dwell
BNSF	10.8%	15.3%	21.6%	14.2%	7.8%	18.4%	-12.4%
CSX	12.0%	10.2%	15.8%	17.5%	11.0%	7.5%	-20.5%
NS	5.4%	6.2%	6.1%	6.7%	13.4%	1.2%	-9.1%
UP	21.8%	27.4%	24.3%	24.0%	13.3%	21.4%	-16.6%

With the current economic recession, we would expect that average train speeds would increase and variability would decrease as railroad networks become less congested. Therefore, we would expect relatively large increases in average train speed and relatively low CVs in 2008. Tables 2.3 through 2.6 provide information by year for each of the railroads. The prediction of higher train speeds in 2008 is supported by the results for UP, which had the largest changes in its average speeds across all train types in 2008. However, the other three railroads did not post large increases in average speed during 2008. In fact, CSX had a decline in overall average speed in 2008 as well as declines in average speed for two of the five train types. Regarding variability in speed, NS was the only railroad that had its lowest CVs in 2008. Both Western railroads and CSX had their largest overall CVs in 2008, as well as for most of the train types. Therefore, the evidence regarding railroad performance does not show the expected improvement as the state of the economy deteriorated.

TABLE 2-3
SUMMARY OF BNSF AVERAGE SPEED AND VARIABILITY

Avg	All	Intermodal	Manifest	Multilevel	Coal Unit	Grain Unit
2006	22.87	32.58	21.13	27.69	18.07	22.53
2007	23.33	34.04	21.54	28.19	19.15	23.03
2008	23.96	34.69	22.38	28.26	20.11	23.75
Change						
4Q05-4Q06	4.9%	6.7%	14.4%	11.5%	-2.1%	11.5%
4Q06-4Q07	2.0%	4.0%	-1.2%	-0.9%	12.2%	-0.3%
4Q07-4Q08	3.5%	3.9%	7.7%	3.3%	-1.8%	6.5%
Std Dev						
2006	0.59	1.61	1.00	1.20	0.63	1.02
2007	0.53	0.90	0.83	0.97	1.00	0.99
2008	0.79	1.66	1.07	1.21	0.99	1.24
CV						
2006	2.6%	4.9%	4.7%	4.3%	3.5%	4.5%
2007	2.3%	2.6%	3.9%	3.4%	5.2%	4.3%
2008	3.3%	4.8%	4.8%	4.3%	4.9%	5.2%

TABLE 2-4
SUMMARY OF CSX AVERAGE SPEED AND VARIABILITY

Avg	All	Intermodal	Manifest	Multilevel	Coal Unit	Grain Unit
2006	19.89	28.03	19.43	22.19	15.29	18.37
2007	20.78	29.37	19.98	22.81	16.66	19.27
2008	20.51	29.44	20.10	22.97	15.74	18.12
Change						
4Q05-4Q06	6.5%	3.1%	8.2%	10.4%	6.3%	4.0%
4Q06-4Q07	5.8%	5.5%	4.3%	6.5%	8.9%	8.2%
4Q07-4Q08	-0.5%	1.3%	2.6%	-0.2%	-4.1%	-4.5%
Std Dev						
2006	0.53	0.87	0.61	0.75	0.47	0.72
2007	0.82	1.10	0.90	1.30	0.61	0.90
2008	0.84	1.00	0.98	1.11	0.74	0.98
CV						
2006	2.7%	3.1%	3.2%	3.4%	3.1%	3.9%
2007	4.0%	3.8%	4.5%	5.7%	3.7%	4.7%
2008	4.1%	3.4%	4.9%	4.8%	4.7%	5.4%

TABLE 2-5
SUMMARY OF NS AVERAGE SPEED AND VARIABILITY

Avg	All	Intermodal	Manifest	Multilevel	Coal Unit	Grain Unit
2006	21.63	27.40	20.83	22.72	15.09	18.59
2007	21.58	27.66	20.51	21.95	15.64	18.30
2008	21.63	27.77	20.49	22.81	16.19	17.97
Change						
4Q05-4Q06	5.2%	4.8%	6.5%	4.5%	5.5%	7.9%
4Q06-4Q07	-0.6%	0.4%	-1.5%	-1.9%	3.9%	-4.5%
4Q07-4Q08	0.8%	1.0%	1.2%	4.1%	3.4%	-1.8%
Std Dev						
2006	0.64	0.83	0.69	0.88	0.49	1.12
2007	0.90	1.14	0.99	1.36	0.60	0.99
2008	0.53	0.66	0.62	0.81	0.52	0.72
CV						
2006	3.0%	3.0%	3.3%	3.9%	3.3%	6.0%
2007	4.2%	4.1%	4.8%	6.2%	3.9%	5.4%
2008	2.5%	2.4%	3.0%	3.5%	3.2%	4.0%

TABLE 2-6
SUMMARY OF UP AVERAGE SPEED AND VARIABILITY

Avg	All	Intermodal	Manifest	Multilevel	Coal Unit	Grain Unit
2006	21.45	25.23	19.85	22.18	20.80	20.10
2007	21.81	26.13	20.40	22.45	20.41	20.15
2008	23.47	28.69	21.93	24.43	21.98	21.87
Change						
4Q05-4Q06	6.7%	7.5%	8.9%	6.9%	2.2%	6.7%
4Q06-4Q07	1.8%	4.1%	0.6%	2.5%	1.9%	0.5%
4Q07-4Q08	12.2%	13.8%	13.4%	13.1%	8.8%	13.1%
Std Dev						
2006	0.52	0.86	0.60	0.60	0.71	0.75
2007	0.68	0.98	0.65	0.83	1.02	0.74
2008	1.27	1.93	1.26	1.49	1.15	1.14
CV						
2006	2.4%	3.4%	3.0%	2.7%	3.4%	3.7%
2007	3.1%	3.8%	3.2%	3.7%	5.0%	3.7%
2008	5.4%	6.7%	5.7%	6.1%	5.3%	5.2%

A3 IMPLICATIONS OF RPM DATA FOR RAILROAD CAPACITY AND PERFORMANCE

In addition to terminal dwell time and average train speed, the RPM dataset contains information about cars on line, which roughly proxy volumes transported. Table 2.7 summarizes annual changes in various RPM performance metrics (4Q over 4Q) by railroad from 4Q05 through 4Q08. Real GDP changes are also presented. Assuming that the cars-on-line metric is a proxy for volume, we would expect fewer cars on line as the economy worsens. This is the case for BNSF and UP, which experienced their only decline (BNSF) or largest decline (UP) in cars on line during 2008. While cars on line also declined for NS in 2008, its 2008 decline was smaller than its 2007 decline. On the other hand, CSX experienced an increase in cars on line in 2008 after declines in 2006 and 2007.

TABLE 2-7
ANNUAL CHANGES IN PERFORMANCE METRICS

2005-2008
4Q over 4Q

BNSF

	Cars on Line	Avg Speed	Dwell Time	Real GDP
05-06	3.0%	4.9%	-9.4%	2.4%
06-07	2.1%	2.0%	5.1%	2.3%
07-08	-1.0%	3.5%	-7.9%	-0.2%

CSX

	Cars on Line	Avg Speed	Dwell Time	Real GDP
05-06	-1.9%	6.5%	-16.3%	2.4%
06-07	-3.1%	5.8%	-8.0%	2.3%
07-08	1.8%	-0.5%	3.3%	-0.2%

NS

	Cars on Line	Avg Speed	Dwell Time	Real GDP
05-06	0.6%	5.2%	-8.5%	2.4%
06-07	-1.2%	-0.6%	-2.5%	2.3%
07-08	-0.7%	0.8%	1.9%	-0.2%

UP

	Cars on Line	Avg Speed	Dwell Time	Real GDP
05-06	-3.8%	6.7%	-13.2%	2.4%
06-07	-2.0%	1.8%	-1.6%	2.3%
07-08	-4.7%	12.2%	-2.3%	-0.2%

Table 2.8 updates the correlations between quarterly changes in average speed and average dwell time, and quarterly changes in average speed and cars on line from Table 17.9 of our report. It shows small negative correlations between changes in average train speed and average terminal dwell time for all years, 2006-2008, with the weakest correlation in 2008, and larger negative correlations between changes in average speed and cars on line, with the strongest in 2008. The particularly strong negative correlations between changes in average speed and changes in cars on line in 2007 and 2008 suggest the effects of a slowing economy. Generally, fewer cars on line and lower volumes indicate less network congestion and greater available capacity, thus allowing for greater speeds.

TABLE 2-8
CORRELATION WITH CHANGE IN AVERAGE SPEED ACROSS RAILROADS BY YEAR

	1Q06-4Q08	
	Avg. Dwell Time	**Cars on Line**
2006	(0.24)	(0.28)
2007	(0.41)	(0.74)
2008	(0.16)	(0.88)
06-08	(0.28)	(0.62)

Table 2.9 presents correlations between changes in average speed and the other two RPM variables, by railroad, from 1Q06 through 4Q08. The one unexpected result is the positive correlation between changes in average speed and average dwell time for UP.

TABLE 2-9
CORRELATION WITH CHANGE IN AVERAGE SPEED ACROSS YEARS BY RAILROAD

	1Q06-4Q08	
	Avg. Dwell Time	**Cars on Line**
BNSF	(0.22)	(0.74)
CSX	(0.63)	(0.74)
NS	(0.27)	(0.56)
UP	0.40	(0.42)

To more directly examine the relationship between the performance of the U.S. economy and railroad network congestion and performance, Tables 2.10 and 2.11 correlate changes in the RPM variables with changes in real GDP over the 1Q06-4Q08 period. Table 2.10 present correlations of quarterly changes in real GDP with quarterly changes in average terminal dwell time, cars on line, average speed, and the ratio of average speed to average dwell time. These correlations are for the years 2006, 2007, and 2008 across railroads. The 2008 correlations present the most interesting results. After relatively strong negative correlations for 2006 and 2007, the correlation between changes in GDP and changes in average terminal dwell time is weakly positive in 2008. The 2006 and 2007 results are puzzling as they indicate less congestion is associated with stronger economic (and presumably volume) growth. For the other two RPM indicators, 2008 witnessed strong correlations with changes in real GDP growth. Changes in cars on line had a strong positive relationship with changes in real GDP, suggesting lower real GDP growth is strongly related to lower volumes and cars on line. This is consistent with the strong negative correlation in 2008 between changes in real GDP and changes in average train speed: the lower volumes and increase in available capacity due to the economic downturn were a significant factor allowing for increased train speeds.[66]

TABLE 2-10
CORRELATION WITH CHANGE IN GDP ACROSS RAILROADS BY YEAR

1Q06-4Q08

	Average Dwell Time	Cars on Line	Average Speed	Avg. Speed / Avg. Dwell
2006	(0.42)	0.19	0.24	0.44
2007	(0.40)	0.21	0.11	0.32
2008	0.09	0.66	(0.81)	(0.58)
06-08	(0.27)	0.32	(0.24)	0.07

Table 2.11 presents correlations of quarterly changes in real GDP with quarterly changes in the RPM variables by railroad across the 1Q06-4Q08 time period. Three of the four railroads show a negative correlation between changes in real GDP and changes in average dwell time, which implies a paradoxical result that increases in economic activity lead to reductions in average dwell time. Only BNSF had a positive correlation between changes in real GDP and changes in average dwell time over this time period. Regarding the correlations between changes in real GDP and changes in cars on line and average speed, the two Western railroads—BNSF and UP—have relatively strong correlations in the expected direction (positive for cars on line, negative for speed). The two Eastern railroads—CSX and NS—have mixed and relatively weak correlations for changes in both cars on line and average speed and changes in real GDP.

[66] However, note that correlations in 2006 and 2007 between changes in real GDP and changes in average train speed are positive.

TABLE 2-11
CORRELATION WITH CHANGE IN GDP ACROSS YEARS BY RAILROAD

1Q06-4Q08

	Average Dwell Time	Cars on Line	Average Speed	Avg. Speed / Avg. Dwell
BNSF	0.13	0.79	(0.67)	(0.43)
CSX	(0.41)	(0.18)	0.02	0.27
NS	(0.52)	0.08	(0.02)	0.34
UP	(0.37)	0.85	(0.47)	(0.05)

A4 ASSESSMENT

As we discussed in our report, the RPM data are aggregate metrics that do not allow for a detailed examination of railroad capacity performance issues. To further evaluate their usefulness as predictors of capacity problems, we looked at how these measures behaved during the 2006 to 2008 period, and particularly in the recession year of 2008. We found that the RPM measures did not consistently change in the direction one would expect with a downturn in the economy. We conclude that these measures provide only rough guidance in identifying emerging capacity or service problems on the freight railroad network.

Chapter 3 Contents

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CHAPTER 3
REVIEW OF CAMBRIDGE SYSTEMATICS' 2007 REPORT: *NATIONAL RAIL FREIGHT INFRASTRUCTURE CAPACITY AND INVESTMENT STUDY*

INTRODUCTION

The U.S. Congress established the National Surface Transportation Policy and Revenue Study Commission (the Commission) in 2005 under the Safe, Accountable, Flexible, Efficient Transportation Equity Act—A Legacy for Users (SAFETEA-LU). Among its duties, the Commission was charged with "conduct[ing] a comprehensive study of… the current condition and future needs of the surface transportation system."[1] The Commission submitted to Congress its report entitled *Transportation for Tomorrow* (the Blue Ribbon Report) in January 2008. The Blue Ribbon Report recommended "the development of a strategic plan to improve the condition and performance of the Nation's surface transportation infrastructure."[2] The Commission envisioned that this strategic plan would take an integrated approach in looking at the country's infrastructure needs across all modes of surface transportation including highway, public transit, freight rail, passenger rail, intermodal, and water.

> This plan would be based on a rigorous, systematic transportation planning process incorporating a strong economic analysis component to identify the relative benefits and costs of alternative potential investments, and would serve to provide a greater understanding of the investment needs of the system as a whole.[3]

In the absence of an integrated strategic plan for the U.S. surface transportation infrastructure, the Blue Ribbon Report summarized the results of a series of analyses that were undertaken in an attempt to obtain a first approximation of the infrastructure investment needs using currently available data and analytical tools.

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[1] U.S. Code, Title 23, 101(b). See the Commission's website at http://transportationfortomorrow.org/about/.

[2] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, Volume II, p. 4-1.

[3] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, Volume II, p. 4-1.

> These [interim] analyses are intended to convey a **sense of scale** of the overall needs and facilitate discussions of alternative financing options, **but would ultimately be supplanted by the cost estimates developed as part of the recommended strategic plan**.[4]

As part of its work, the Commission requested the help of the Association of American Railroads (AAR) in conducting an analysis of the freight railroad transportation mode. In turn, the AAR commissioned a study by Cambridge Systematics (CS). In September 2007, CS published a report (the CS study) that provided an estimate of the capacity expansion needs of the continental U.S. freight railroad infrastructure through 2035.[5] The CS study concluded that infrastructure investment of $148 billion in 2007 dollars (an average of $5.3 billion per year over 28 years) would be needed to keep pace with projected demand for freight rail transportation from U.S. Department of Transportation's (U.S. DOT) Freight Analysis Framework Version 2.2 (FAF) model . In making its projection of the infrastructure investment requirement through 2035, the CS study states that the "goal was not to improve a corridor beyond the current level of service."[6] However, a comparison of the study's Figures A.2 and A.3 indicates that substantially fewer corridors would be near, at or above capacity in 2035 after the selected infrastructure improvements than in 2005.[7]

In the next section of this chapter, we provide a brief description of the FAF, which provides the forecasts of long-term freight railroad transportation demands that serve as the basis of the CS study.[8] The remainder of this chapter then provides a summary of the CS study's methods and discussions of its findings along with suggestions for possible extensions to the CS study's analysis. The CS study makes a significant contribution to the understanding of railroad capacity issues. Unfortunately, we (and any other analysts) are not able to model alternative assumptions and perform sensitivity analyses without gaining access to critical proprietary data and the model structure used in the CS study.

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[4] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, Volume II, p. 4-1 [emphasis added].
[5] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007.
[6] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-15. The CS study's estimation of the freight railroad network's current level of service is illustrated in its Figure 4.4 and Table 4.4 (p. 4-10). Although the CS study discusses its estimated distribution of corridors across various level-of-service grades, it does not state whether the current freight rail network displays adequate, excess, or tight capacity.
[7] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, pp. A-13 and A-15.
[8] A more extensive discussion of the FAF model can be found in Chapter 4 of this report.

3A FREIGHT ANALYSIS FRAMEWORK MODEL

The U.S. DOT's FAF model provides commodity demand forecasts that serve as the basis for estimating freight rail volume growth by type of train service from 2005 to 2035 in the CS model. The FAF model uses long-term growth projections for the nation's population, the U.S. economy, and international trade, to forecast demand by origin, destination, commodity, and mode for freight transportation. The U.S. DOT's model relies on forecasts of production, consumption, and trade by major industry sector as well as economic regions in the United States, North America, and the rest of the world. Forecasted changes in regional economic output over time and the input-output structure of the U.S. economy are used in modeling future commodity flows. The FAF model uses 2002 as its base year and forecasts freight traffic demands for 2010 to 2035 in five-year increments.[9] Long-term forecasts for over 40 commodity types are used to estimate future volumes of each commodity type moving among 138 economic zones on the primary corridors of the U.S. freight rail network.[10]

The FAF model's demand forecasts used in the CS study assume that the current market shares by transportation modes for each combination of commodity, origin zone, and destination zone remain constant between 2002 and 2035. Under this assumption, the use of transportation modes may only vary as a result of changes in the composition (by commodity and origin/destination) of economic activity and differences in regional growth rates. Holding the modal shares constant, even at a relatively fine level of commodity and geographic disaggregation, is restrictive as it precludes economic demand responses to changes in the relative prices of transportation modes.

In stating its objective, the CS study recognizes the uncertainties associated with long-range forecasts and other assumptions underlying its analysis, and the consequences of changes to the forecasts and assumptions:

> [T]he forecasts and improvement estimates in this study do not fully anticipate future changes in markets, technology, regulation, and the business plans of shippers and carriers. Each could significantly reshape freight transportation demand, freight flow patterns, and railroad productivity, and, thus, rail freight infrastructure needs.[11]

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[9] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-7.
[10] Issues relating to long-term economic forecasts are discussed in Chapters 4 and 5 of this report.
[11] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 1-1.

Possible Extensions. As with all long-range forecasts spanning almost 30 years, the FAF forecast used by the CS study incorporates many assumptions and judgments about economic and population growth patterns. Oftentimes, long-range forecasting analyses present a range of results, where a "most likely" or base-case outcome is bounded by "less optimistic" and "more optimistic" outcomes.[12] Given the length of the forecast period, it would have been informative if the CS study had included a range for the estimated railroad infrastructure investment needed to accommodate forecasted train volume in 2035. This study's $148 billion projected investment needed in railroad infrastructure improvements has been widely cited by stakeholders, industry analysts, and government agencies—sometimes without mentioning the caveat that unanticipated future changes in markets, technology, regulation, etc. could significantly reshape freight rail infrastructure needs.

The FAF model provides demand forecasts between 2010 and 2035 at five-year intervals, while the CS study analyzed the freight rail investment needed to meet projected demand at the end of the forecast period in 2035. The CS study reported that $5.3 billion per year ($148 billion divided by 28 years) was the average annual investment needed to meet the 2035 demand. An informative extension to the CS study results would be the forecasted stream of investment needed at five-year intervals based on the FAF model's demand forecasts at five-year intervals.

Given concerns about highway congestion and safety, long-term projected prices for diesel fuel, and environmental issues, it would have been helpful if the CS study had included one or more scenarios that assumed potential shifts in market shares across different transportation modes.[13] In addition, a scenario incorporating possible shifts in plant locations due to differential economic growth forecasts across regions as well as regional transportation network availability and costs would also provide a useful comparison to the base case analysis.[14] Presenting only a single forecast of future rail infrastructure needs—and assuming no demand responses, such as changes in modal mix or plant locations, over a 33-year time horizon—does not reflect the uncertainty inherent with any long-term forecast and thus tends to limit the usefulness of the CS study.

[12] For example, see the description of Global Insight's high-growth and low-growth forecasts supplied as alternatives to the base-case forecast for the FAF model, at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_reports/reports8/s4_highandlow.htm.

[13] See Section 3I below for a discussion of the extrapolations to the CS study's results that are found in the Commission's report.

[14] Plant relocations could be associated with either increased or decreased railroad investment needs, depending on whether the relocated plants increased or decreased the forecasted demand for rail transportation.

3B CAMBRIDGE STUDY METHODOLOGY

The methodology employed in the CS study includes the following steps:

(1) Identify the high-volume corridors of the U.S. Class I railroad network and divide these high-volume corridors into primary freight rail corridors covering 52,340 miles.[15] Establish a railroad network model identifying key corridor characteristics of the primary corridors, including number of tracks per corridor and type of signal/control system, based on the Oak Ridge National Laboratory (ORNL) Center for Transportation Analysis's Rail Network (Version 5-5) combined with the network developed by the Tennessee Department of Transportation;

(2) Estimate the current annual freight train traffic for each primary corridor of the railroad network based on the 2005 Surface Transportation Board's (STB) Carload Waybill Sample (CWS) data on loaded car movements and Uniform Rail Costing System (URCS) data on empty car movements, then estimate the number of freight trains for a day representing the 85th percentile of the maximum trains per day from the 2005 data;

(3) Estimate the current passenger train traffic on primary freight rail corridors for an average weekday based primarily on 2007 schedules;

(4) Estimate the total current corridor train volume by combining the estimates for freight trains and passenger trains;

(5) Estimate the current capacity in trains per day for archetypical rail corridors representing different combinations of number of tracks per corridor and signal/control types, based on data from Class I railroads and AAR;

(6) Compare total current corridor train volume to current corridor capacity;

(7) Estimate future freight train volume by type of train service from 2005 to 2035 based on the U.S. DOT's FAF forecasts of freight rail demand by origin, destination, and commodity;

(8) Estimate the total future train volume by combining the estimated future freight train volume and the estimated 2007 passenger train volume (that is, hold passenger train volume constant between 2007 and 2035);

(9) Compare total future corridor train volume to current corridor capacity and note where capacity shortages will arise;

[15] The CS study classifies approximately one-half of total Class I corridors, or one-third of total national freight rail corridors, as primary freight rail corridors.

(10) Identify the additional capacity needed on the primary corridors and all additional infrastructure improvements required to reliably serve the estimated future train volume;

(11) Estimate the costs of improvements to the primary corridors, including upgrades to the number of tracks per corridor and signal/control systems; and

(12) Estimate the costs for all additional infrastructure improvements, including: upgrades to Class I secondary mainline and branch line tracks as well as short line and regional railroad tracks and bridges to accommodate 286,000-pound freight cars; improvements to significant rail bridges and tunnels; and expansion of intermodal terminals, carload terminals, and service and support facilities.[16]

Important Model Assumptions.[17] The CS study's model includes the following important assumptions:

- Holds passenger rail use of freight corridors constant between 2005 and 2035[18] (pp. ES-1 and A-7).
- Estimates the capacity of primary corridors using three major factors: number of tracks, type of signal system, and mix of train type (Table 4.2 on p. 4-7).[19]

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[16] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, pp. 3-2 – 3-4 and A-1 – A-2.
[17] The CS model relies on other assumptions that are listed throughout the CS study. For example, see Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-9, for the CS model's assumption concerning empty traincar return ratios.
[18] The Commission convened a separate passenger rail committee to study the need for improvements and investments in railroad infrastructure to support passenger rail demand in the 21st Century. For a summary of the passenger rail findings, see *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, Volume II, Chapter 4. It is important to note that running multiple train types on a given railroad corridor configuration generally reduces the capacity of that corridor compared to when only single train types are using the corridor. Thus, any forecasted growth in passenger rail service on freight railroad corridors would need to be incorporated in the forecasting model for freight railroad service. It is not appropriate to separately estimate the impacts of forecasted growth in passenger service and forecasted growth in freight service on the same railroad corridors and then sum the results from the separate models.
[19] Footnote 15 of the CS study states:

> The capacity of rail corridors is determined by a large number of factors, including the number of tracks, the frequency and length of sidings, the capacity of the yards and terminals along a corridor to receive the traffic, the type of control systems, the terrain, the mix of train types, the power of the locomotives, track speed, and individual railroad operating practices. Complete, consistent, and current information on all these factors was not available for the study… (p. 4-5).

- Estimates the number of freight trains operating in 2005 on a hypothetical 85th percentile representative day, using "volume from the day representing the 85th percentile (based on volume of cars) … to scale the annual volume to a daily volume" (p. A-6) for each primary corridor (pp. A-4 to A-6).
- Defines typical number of cars/intermodal units by train service type in both Eastern and Western railroads (Table 4.1 on p. 4-3).
- Holds the assignment of commodities to train type constant between 2005 and 2035. Develops weighted averages of the forecasted commodity growth rates to forecast growth factors for each of the four train types for each origin-destination combination in the FAF model (pp. A-7 to A-9).
- Models three train-type groups to capture traffic mix (p. 4-6) and estimates average capacity of typical freight rail corridors (Table 4.2 on p. 4-7).
- Estimates a volume capacity for each primary corridor based on its actual number of tracks, type of control system, and mix of train types. Adjusts these estimated corridor capacities after reviewing the estimates with railroads participating in the study (p. 4-7).
- Defines average capacity of typical freight rail corridor combinations of tracks, controls, and mix of train types (Table 4.2 on p. 4-7, repeated in Table 6.1 on p. 6-1). Table 4.2 includes estimates of average capacity for 5-track and 6-track corridors, which are included in the study to accommodate future demand but didn't exist at the time of the study. It would be helpful to have more information about the estimated differentials between single and multiple train-type use corridors for the hypothetical 5-track and 6-track corridors. The estimates for these future corridor types look unusual relative to each other.
- Holds the number of miles included in primary rail corridors constant between 2005 and 2035. Might differential population and economic growth across regions during these three decades (a) bring about abandonment of some primary corridors, (b) cause some secondary corridors to be upgraded to primary corridors, or (c) require construction of totally new primary corridors?

The CS study's analysis relies on proprietary data, such as railroad-specific capacity tables and railroad cost estimates for expanding terminals, which are not publicly available. In addition, the CS study often reports model assumptions and results at an aggregated level, omitting more detailed input, output, and intermediate results that would be needed by other analysts to model alternative scenarios or run sensitivity analyses.

3C LEVEL OF SERVICE (LOS) GRADES AND CAPACITY CATEGORIES

The CS study classified the primary corridors in the railroad network model by their ratios of current train volume to capacity (V/C). The CS study defines six level-of-service (LOS) grades for railroads, designates a range for the volume/capacity ratio associated with each of the six LOS grades A-F, and then assigns each of the primary rail corridors to one of the LOS grades based on its volume/capacity ratio. The CS study's LOS grades and their associated volume/capacity ratios are listed in Table 3-1.

TABLE 3-1
LEVEL OF SERVICE GRADES AND VOLUME-TO-CAPACITY RATIOS

LOS Grade	Range for Volume/Capacity Ratio
A	0.0 to 0.2
B	0.2 to 0.4
C	0.4 to 0.7
D	0.7 to 0.8
E	0.8 to 1.0
F	> 1.0

The CS study states that its LOS grades correspond generally to "the LOS grades used in highway system capacity and investment requirement studies,"[20] but while highway capacity studies make use of six qualitative LOS grades (A - F) in their analyses, these studies don't inform us as to the range of volume/capacity ratios associated with each of the six LOS grades related to railroad capacity.[21] CS applies V/C ratio ranges to each of the six LOS grades and assigns the LOS grades to four broader capacity categories as shown in Table 3-2. Next, the CS study defines the volume/capacity ratio of 0.7 (at the boundary between its LOS C and LOS D grades) to be the "practical capacity" of a primary railroad corridor.[22]

[20] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 4-8.
[21] The *Montana Highway Capacity Manual* provides the following definition for LOS: "A qualitative concept that has been developed to characterize acceptable degrees of congestion as perceived by motorists." See *Montana Highway Capacity Manual*, November 2007, at http://www.mdt.mt.gov/other/traffic/external/pdf/chapter_30.pdf.
[22] The CS study goes on to state, "To provide acceptable and competitive service to shippers and receivers, railroads typically aim to operate rail corridors at LOS C/D or better." (p. 4-9) This quote implies that "practical capacity" might more broadly be defined by volume-to-capacity ratios encompassed by the LOS C/D range of 0.4 to 0.8, rather than the knife-edge value of 0.7 for this ratio. Abril et al. note that practical capacity "is usually around 60%-75% of the theoretical capacity." See M. Abril, F. Barber, L. Ingolotti, M. A. Salido, P. Tormos, and A. Lova, "An Assessment of Railway Capacity," Preprint submitted to *TRE*, April 2007, p. 5.

TABLE 3-2[23]
CAPACITY CATEGORIES, CATEGORY DESCRIPTIONS AND LOS GRADES

Capacity Category	Description of Capacity Category	LOS Grade	Range for Volume/Capacity Ratio
Below Capacity	Low to moderate train flows with capacity to accommodate maintenance and recover from incidents	A	0.0 to 0.2
		B	0.2 to 0.4
		C	0.4 to 0.7
Near Capacity	Heavy train flow with moderate capacity to accommodate maintenance and recover from incidents	D	0.7 to 0.8
At Capacity	Very heavy train flow with very limited capacity to accommodate maintenance and recover from incident	E	0.8 to 1.0
Above Capacity	Unstable flows' service breakdown condition	F	> 1.0

Possible Extensions. It is somewhat surprising that the critical LOS C grade has the broadest range of volume/capacity ratios, where the volume/capacity ratio of 0.4 at the bottom of the LOS C grade is used to represent corridors operating substantially below capacity, while the 0.7 ratio at the top of the LOS C grade is associated with primary rail corridors operating at "practical capacity." In analyzing current and, more importantly, future capacity issues, it may be helpful to revise the range of ratios associated with the six LOS grades in order to provide a better picture of the track miles that are nearing, near, and at capacity levels of service. A possible revision of LOS ranges that would provide fuller information in these important capacity categories appears in Table 3-2 Revised.

Another concern with the CS study's level-of-service grades is that the ranges of V/C ratios assigned to each LOS grade may not be equally applicable to single- and all multiple-track lines. Multiple-track main lines—especially lines with three or more tracks—are intended to be capable of handling "very heavy" train flows while accommodating maintenance and incident-recovery needs; indeed, such investments may only be economically viable when operated "near" or "at" capacity in the CS study's LOS classification.

[23] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 4.3, p. 4-8.

TABLE 3-2 REVISED
CAPACITY CATEGORIES, CATEGORY DESCRIPTIONS AND REVISED LOS GRADES

Capacity Category	Description of Capacity Category	Revised LOS Grade	Revised Range for Volume/Capacity Ratio
Below Capacity	Low to moderate train flows with capacity to accommodate maintenance and recover from incidents	A′ B′	$0.0 \leq V/C < 0.6$ $0.6 \leq V/C < 0.7$
Near Capacity	Heavy train flow with moderate capacity to accommodate maintenance and recover from incidents	C′	$0.7 \leq V/C < 0.8$
At Capacity	Very heavy train flow with very limited capacity to accommodate maintenance and recover from incident	D′ E′	$0.8 \leq V/C < 0.9$ $0.9 \leq V/C < 1.0$
Above Capacity	Unstable flows' service breakdown condition	F′	$V/C > 1.0$

3D DISTRIBUTION OF CURRENT RAIL CORRIDORS ACROSS CAPACITY CATEGORIES

Having defined LOS grades and capacity categories for primary rail corridors, the CS study uses an engineering model to allocate current rail corridors to capacity categories. The CS study's summary of current rail volumes compared to current capacity on primary rail corridors appears in Table 3-3, which displays the estimated distribution of primary corridor mileage by capacity category and LOS grade.

As seen in Table 3-3, the CS study characterizes less than three percent of the current primary rail corridor mileage at or above capacity, with substantially less than one percent of these miles in the "above capacity" category. (According to Figure 4.4 in the CS study, the corridors that are currently above capacity are located near Chicago, Kansas City, and the Mississippi-Tennessee border.) Approximately 88 percent of primary corridor mileage is categorized as "below capacity" in LOS A through LOS C, while nine percent is "near capacity" in LOS D, based on the study's definitions of capacity categories. As mentioned in footnote 22, the CS study noted that railroads aim to operate in the range of LOS C/D or better. Table 3-3 indicates that this criterion is met by 97 percent of primary corridor miles. In reporting these results from the CS study, the Commission observed that "the Nation's freight rail network is relatively uncongested at current volumes of cargo."[24] Thus, by focusing on primary rail corridors—and abstracting from the adequacy of facilities, bridges, tunnels, and other rail corridors—it appears that the current U.S. freight rail network does not exhibit system-wide capacity

[24] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, Volume II, p. 3-15.

problems. However, as we determined in our November 2008 report (and also discuss in Chapter 2 of this report), while there may not be system-wide capacity constraints, congestion and constraints at localized points in railroad networks (including terminals, bridges, tunnels, and other facilities as well as corridors) are sufficient to create far-reaching congestion problems throughout a network.[25]

TABLE 3-3[26]
CURRENT DISTRIBUTION OF CORRIDOR MILEAGE BY CAPACITY CATEGORY AND LEVEL OF SERVICE GRADE

Capacity Category	LOS Grade	Total Corridor Mileage	Percentage
	A	9,719	19%
Below Capacity	B	15,417	30%
	C	20,683	39%
Near Capacity	D	4,952	9%
At Capacity	E	1,461	3%
Above Capacity	F	108	<1%
Totals	All	52,340	100%

<u>Possible Extensions</u>. Table 4.4 of the CS study (results replicated in Table 3-3 above) was not intended, nor is it able, to show how congestion on capacity-constrained corridors may potentially flow to other rail corridors as congestion problems on corridors with choke points lead to traffic delays on "unconstrained" corridors through the interconnectedness of the railroad network. Additionally, potential problems may arise if train crews meet their work hour limits in the middle of a run on a congested corridor and are consequently unable to work on a subsequently scheduled run, thus causing delays elsewhere in the network. The CS study includes a brief discussion of line expansion on non-primary corridors; improvements to significant rail bridges and tunnels; and projected expansion of terminals, intermodal yards, service and support facilities, and international gateway facilities in its projection of the railroad infrastructure investment required to accommodate forecasted freight railroad demand in 2035. However, there is no discussion concerning whether these other major elements of the freight railroad network were capacity-limited in the 2005-2007 time period. Further work is needed to address the current freight railroad network's ability to withstand the theoretical possibility of cascading congestion problems across interconnected rail lines and facilities. Due to the unknown potential for the spillover of congestion problems from busy corridors or facilities to other lines or structures of the railroad network, the CS study's results appearing in Table 3-3

[25] See Christensen Report, Ch. 16.
[26] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 4.4, p. 4-10.

above may suggest a misleadingly optimistic impression of the capacity availability on today's freight rail network.

3E DISTRIBUTION OF FUTURE RAIL CORRIDORS ACROSS CAPACITY CATEGORIES

Using forecasts from the FAF model to provide input for its engineering model, the CS study forecasts future volumes across the primary rail corridors and then compares the forecasted volumes for 2035 to the current capacity on these primary rail corridors. The CS study assumes that future rail volumes are demand driven[27]—with no supply-side constraints—and estimates the railroad infrastructure investment required through 2035 "to keep pace with economic growth and meet the U.S. DOT's forecast demand."[28]

The CS study makes an initial volume-to-capacity comparison for 2035 assuming no improvements to the primary rail corridors over the 2007 to 2035 timeframe. The CS study's summary of projected 2035 rail volumes based on forecasted demand for rail services compared to current capacity on primary rail corridors appears in Table 3-4, which displays the projected distribution of primary corridor mileage by capacity category and LOS grade.

TABLE 3-4[29]
2035 DISTRIBUTION OF CORRIDOR MILEAGE BY LOS GRADE, ASSUMING NO IMPROVEMENTS

Capacity Category	LOS Grade	Total Corridor Mileage	Percentage
	A	4,895	9%
Below Capacity	B	6,626	13%
	C	11,708	23%
Near Capacity	D	5,353	10%
At Capacity	E	7,980	15%
Above Capacity	F	15,778	30%
Totals	All	52,340	100%

Table 3-4 indicates that if no infrastructure improvements are made through 2035, 30 percent of primary corridor mileage will be above capacity, 15 percent will be at capacity, and 10 percent will be near capacity. According to the CS study, the resulting level of congestion would affect nearly every

[27] However, as we describe in Chapter 2 of this report, due to the lumpiness of railroad investments, there may be episodes of capacity shortages over time, which will likely result in price increases that will ration existing capacity and provide the incentives for railroads to invest in additional capacity.
[28] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. ES-1.
[29] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 5.1, p. 5-6.

region of the country and would likely shut down the national rail network"[30] Of course, the scenario portrayed in the CS study's Table 5.1 (and repeated in Table 3-4 above) mainly serves as a jumping off place for estimating the railroad investment needed to meet forecasted demand; its assumption of no improvements to primary rail corridors is not realistic given that Class I railroads invested an average of $1.5 billion per year on infrastructure expansion during the three-year period ending in 2006, and the AAR estimated that Class I railroads would spend approximately $1.9 in 2007 for capacity expansion.[31]

The CS study employed its engineering model and assumptions to determine the rail improvements needed for each primary rail corridor in order to be able to accommodate the forecasted future train volumes in 2035. The CS study's model treated corridors that are currently below capacity differently from corridors that are currently at or above capacity. [32] The CS study states:

> To avoid double-counting improvements that are currently programmed or underway, new improvements were selected to accommodate only forecast demand, not to correct current capacity shortfalls. If a corridor is below capacity today and needs additional capacity to accommodate future demand, improvements were selected to bring the volume-to-capacity ratio up to a maximum of 0.70. If a corridor is at or above capacity today and needs additional capacity to accommodate future demand, improvements were programmed to bring the volume-to-capacity ratio back to the current ratio. For example, if the current volume-to-capacity ratio of a corridor is 0.85 and the future volume-to-capacity ratio without improvements is estimated to be 1.6, improvements were made to bring the volume-to-capacity ratio back to 0.85, not to 0.70.[33]

[30] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 5-6.
[31] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 4-12.
[32] The CS study does not indicate how it treats those corridors that were slotted as "near capacity" in 2005-2007 and will need additional capacity to accommodate projected future demand through 2035. However, based on the results included in the CS study's Table 6.2, it appears likely that corridors slotted as "near capacity" based on the 2005-2007 data were treated the same as corridors slotted as "below capacity" during that time frame. As seen in Table 6.2, very few corridor miles end up in the LOS grades above LOS C after the infrastructure improvements modeled in the CS study.
[33] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 6-2.

Table 3-5 displays the results from the CS study's engineering model that programmed infrastructure improvements on primary freight railroad corridors to accommodate projected demand in 2035.

TABLE 3-5[34]
2035 DISTRIBUTION OF CORRIDOR MILEAGE BY LOS GRADE WITH MODELED IMPROVEMENTS

Capacity Category	LOS Grade	Total Corridor Mileage	Percentage
	A	4,895	9%
Below Capacity	B	15,198	29%
	C	31,036	59%
Near Capacity	D	608	1%
At Capacity	E	597	1%
Above Capacity	F	6	<1%
Totals	All	52,340	100%

Based on the results of the CS study's modeling of track improvement to accommodate the forecasted 2035 train volumes, only six corridor miles (approximately 0.01 percent) of the primary corridor mileage would be above capacity in LOS F.[35] In addition, only 597 corridor miles (one percent) would be at capacity (LOS E) and 608 corridor miles (one percent) would be near capacity (LOS D). It is worth noting that Cambridge Systematic anticipated that the 1211 miles of primary corridor mileage appearing in LOS grades D through F in Table 3-5 above would be upgraded as the result of the Class I railroads' infrastructure investment expenditures that were already planned or underway in 2007.[36] If the railroads have already implemented or planned infrastructure improvements for the corridors characterized as at or above capacity in 2005 that brings the volume/capacity ratios down to 0.7 on these corridors now or in the near future, then the investment programs modeled in

[34] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, Table 6.2, p. 6-3.
[35] As seen in the CS study's Figure 6.1 (p. 6-3), these "above capacity" six miles of primary corridor are located near Chicago. Based on a comparison of maps, it appears likely that these six miles of capacity-constrained corridor are included in the infrastructure improvement projects of the ongoing Chicago Region Environmental and Transportation Efficiency (CREATE) Program. See http://www.createprogram.org/PDF/corridors_map.pdf.
[36] As seen in the block quote above, the CS study's methodology attempted to avoid "double counting" current or planned infrastructure investments on corridors that were at or above capacity in 2005-2007. For a corridor at or above capacity in 2005-2007, the CS study's engineering model programmed only those improvement required to bring that corridor's volume/capacity ratio in 2035 back down to its 2005-2007 volume/capacity ratio. This procedure implies that CS anticipated that Class I railroads were currently implementing or had already planned infrastructure improvements to address the capacity problems on corridors that were at or above capacity in 2005-2007. It is possible that data on recent (2007-2008) or planned track infrastructure investments for the primary corridors characterized as at or above capacity in the CS study's Table 4.4 would indicate whether the capacity-limited corridors in 2005-2007 have already been or are being improved.

the CS study would result in categorizing 100 percent of primary rail corridors in LOS A through LOS C (the "below capacity" category) in 2035.[37]

Possible Extensions. According to Table 3-5 above, 59 percent of the 2035 corridor miles fall into LOS C. Given the large range of volume/capacity ratios (0.4 to 0.7) for LOS grade C, it would be informative to know how the 59 percent of 2035 corridor miles in LOS C would be distributed to the suggested LOS grades A' and B' defined in Table 3-2 Revised.

As mentioned above, the CS study indicated that railroads typically aim to operate in LOS C/D or better. According to Table 3-3, there are currently 4,952 primary corridor miles in LOS D, which is characterized as "near capacity." However, the CS study's process resulted in only 608 primary corridor miles appearing in LOS D after programmed improvements in 2035.[38] The CS study states that the maps showing the 2005 and 2035 primary corridors by LOS grade "should look similar … since the goal was not to improve a corridor beyond the current level of service."[39] However, a comparison of these two maps indicates that there are substantially more yellow (LOS D) corridors in 2005 than in 2035. Conversely, there are substantially more green (LOS A/B/C) corridors in 2035 than in 2005. Although CS suggests that the lumpiness of railroad investments may lead to the observed differences between the 2005 and 2035 maps, the cause of the differences may have more to do with the treatment of corridors that were near capacity in 2005-2007. [40]

The projected 2035 LOS distribution of primary corridors after improvements has approximately ten percent more "below capacity" primary corridor miles than the current distribution. It would be interesting to see the resulting 2035 map from a scenario that set a maximum volume/capacity ratio of 0.75 (rather than 0.7) for corridors that are currently below/near capacity today but are projected to need improvements to accommodate projected future volume. The CS study states that some corridors programmed to receive improvements in order to accommodate projected future volume end up dropping several LOS grades due to the "step-function nature of adding

[37] It seems somewhat misleading that the CS study's Table 6.2 and its description indicate that approximately two percent of primary corridors would be near/at/above capacity in 2035 after the modeled improvements. The corridors appearing in these categories are artifacts of the methods CS used in attempting to avoid double counting infrastructure improvements anticipated for the corridors that were capacity-constrained in 2005-2007.

[38] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, pp. 4-10 and 6-3. Note that if Class I railroads implemented/planned improvements on the corridors that were at/above capacity in 2005-2007, there might be close to zero primary corridor miles in LOS D in 2035 after the programmed improvements to meet projected future demand.

[39] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-15.

[40] It would be interesting to see the 2035 map that would result if the CS model treated the 2005-2007 "near capacity" corridors the same way it treated the 2005-2007 "at" and "above" capacity corridors.

capacity."[41] A sensitivity analysis that sets the maximum volume/capacity ratios at 0.01 increments above the CS study's 0.7 maximum ratio (for current corridors below capacity) would also provide valuable information concerning the range of investment needed through 2035 to meet forecasted demand. Another model extension might look directly at programmed investments that would cause a corridor to drop several LOS grades. For example, if a corridor was projected to have a 2035volume/capacity ratio slightly above 0.7 without investment, but substantially below 0.7 with investment, then no investment would be programmed for that corridor and it would remain in the acceptable LOS C/D range. The lumpiness of railroad investment projects would seem to indicate that using a knife-edge value of 0.7 for the maximum V/C ratio may be too restrictive.

3F ADDITIONAL INFRASTRUCTURE IMPROVEMENTS

In addition to the estimated improvements (adding tracks or upgrading signal control systems) required on primary rail corridors to accommodate projected freight rail demand in 2035, the CS study includes projections for the following improvements:

- Line expansion:
  - Improvements to significant rail bridges and tunnels
  - Upgrades to non-mainline Class I lines to accommodate 286,000-pound freight cars
  - Upgrades to non-Class I tracks and bridges to accommodate 286,000-pound freight cars
- Facilities expansion:
  - Expansion of carload terminals, intermodal yards, and international gateway facilities owned by railroads
  - Expansion of Class I railroad service and support facilities such as fueling stations and maintenance facilities.[42]

While the CS study provided some discussion on the methods used to estimate the needed upgrades to primary rail corridors, its treatment of these other railroad infrastructure improvements is principally a listing of the categories along with a table that breaks down the estimated cost of improvements by investment category.

3G ESTIMATED COSTS OF PROJECT IMPROVEMENTS

The CS study provides estimated costs for the following infrastructure improvement categories:

[41] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-15.
[42] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-1.

1. Line haul expansion
2. Major bridges, tunnels, and clearance
3. Branch line upgrades
4. Intermodal terminal expansion
5. Carload terminal expansion
6. Service facilities

Table 7.2[43] in the CS study presents the average unit costs used to price out line haul expansions, distinguishing rail corridors by the number of tracks and control systems.[44] The note to this table states that "[t]he actual costs of the corridors were estimated using railroad-specific capacity tables … [,]" but "… the railroad-specific cost tables were not included in this report to protect confidential railroad business information." The note goes on to say the Eastern rail corridors used higher construction cost per mile estimates because of the number of urbanized areas, hilly terrain, and numerous river crossings, while the Western rail corridors used lower cost estimates due to the flatter terrain and non-urbanized areas for some of the Western primary rail corridors. Without more disaggregated cost data than those appearing in Table 7.2, it is not possible to form a sense of the reasonableness of the estimates used in the CS study to cost out its predicted need for line haul expansion improvements.

The cost estimates for the second infrastructure category (major bridges, tunnels, and clearance) were based on individually provided estimates from the railroads participating in the study for "significant structures" identified as needing improvement by CS. The estimates provided were "not based on detailed engineering studies, and therefore only provide a rough approximation."[45] The CS study calculated average costs for major structures based on the railroads' individually provided estimates, and then developed a "significant structures cost estimate … for CN, CP and KCS by prorating the total significant structures cost by the ratio of the line haul expansion cost for these three railroads to the total line haul expansion cost."[46] The CS study doesn't include a list of the "significant structures" that it schedules for expansion to meet forecasted demand in 2035. A listing of the structures identified by CS as requiring upgrades would have provided valuable information about the potential location of chokepoints, and allowed for the

[43] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-3. This table is repeated as Table A.7 on p. A-16 of Appendix A in the CS study.
[44] Some bridges and tunnels along the primary corridors were included in the cost estimates for line haul expansions; however, the CS study provides a separate cost estimate for "major" bridge and tunnel projects.
[45] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-16.
[46] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-16.

comparison with listings of the major structures identified as capacity-limited in other current and future studies of freight railroad infrastructure.

In order to estimate the cost of branch line upgrades, the CS study updated the results of the 2000 American Short Line and Regional Railroad Association (ASLRRA) report, which identified $6.9 billion (in 1999 dollars) in costs to upgrade the track of America's short line and regional railroads to accommodate 286,000-pound loads.[47] After rebasing the ASLRRA cost estimate to 2007 dollars, subtracting the estimated costs for upgrading bridges and including an estimate from ASLRRA of $5 billion for significant structures, and subtracting the cost estimate for 2,395 miles of track "assumed to be upgraded to 286,000-pound standards between 1999 and 2007,"[48] the CS study estimated that it would cost $7.2 billion (in 2007 dollars) for upgrading short line and regional railroad track to accommodate 286,000-pound loads.[49]

Cost estimates for the last three infrastructure categories (intermodal terminals, carload terminals, and service facilities) followed a methodology similar to the approach described above for major structures. "CS provided to each study participant a table of on-point and off-point volumes by county and railroad service type for 2005 and 2035. The railroads individually provided costs (sic) estimates for expanding [each of the three infrastructure categories] to accommodate the projected growth between 2005 and 2035."[50] As with the cost estimates for major structures, the estimates of cost improvements for these three infrastructure categories individually provided by the railroads "were not based on detailed engineering studies, and therefore only provide … rough approximation[s]."[51] The CS study once again does not provide a detailed list of the projects identified for these three categories of infrastructure improvements, which would provide valuable information for other researchers and government agencies.

Table 3-6 provides the CS study's cost estimates for capital improvements to accommodate the projected demand for freight rail service in 2035, by infrastructure category and railroad classification.

[47] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-17.
[48] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-17.
[49] See page A-17 of the CS study for a fuller description of its procedures for this infrastructure category.
[50] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-19.
[51] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, pp. A-19 – A-20.

TABLE 3-6[52]
COST OF FREIGHT RAIL INFRASTRUCTURE IMPROVEMENTS TO MEET PROJECTED NEEDS IN 2035

(Millions of 2007 Dollars)

Infrastructure Category	Class I Freight Railroads	Short Line and Regional Freight Railroads	Totals
Line Haul Expansion	$ 94,750	$ 320	$ 95,070
Major Bridge, Tunnels, and Clearance	$ 19,400	$ 5,000	$ 24,400
Branch Line Upgrades	$ 2,390	$ 7,230	$ 9,620
Intermodal Terminal Expansion	$ 9,320		$ 9,320
Carload Terminal Expansion	$ 6,620		$ 6,620
Service Facilities	$ 2,550		$ 2,550
Totals	**$ 135,030**	**$ 12,550**	**$ 147,580**

As seen in Table 3-6, the total estimated cost of freight railroad infrastructure improvements to meet the projected demand in 2035 amounts to $148 billion. The annual investment needed would average $5.3 billion over the 28-year period from 2007 through 2035. Of the projected $148 billion cost estimate for infrastructure improvements, $135 billion is the projected share for Class I railroads and $13 billion is the projected share for short line and regional freight railroads. The $148 billion investment requirement is driven by forecasted demands from the FAF model, estimated current railroad network capacity, and estimated infrastructure expansion costs. In summarizing the CS study's methodology, the Commission noted, "The individual investments implicit in the projected investment levels presented in this analysis have not been subject to benefit-cost analysis."[53]

The Class I railroads anticipated in 2007 that they would be able to cover around a half of their $135 billion share of projected investment needed to meet forecasted demand in 2035. According to the CS study:

> If rail revenues grow proportionally to rail tonnage, currently forecast to increase by 88 percent by 2035, and if the railroads maintain their current level of effort for expansion, then the Class I railroads will invest cumulatively about $70 billion over the 28-year period.[54]

[52] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-2.
[53] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, Volume II, p. 4-17.
[54] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, pp. 7-5 and ES-2. Chapter 4 below discusses the ability of Class I railroads to fund investments.

Possible Extensions. More transparency in the study's methods including the use of publicly available data, and more detailed information on identified infrastructure improvement projects would be especially desirable.[55] The magnitude of the public subsidy implied by the CS results argues that the study should be replicable and that further research should be conducted on various scenarios based on alternative assumptions. Also, investment projects using public funds should, where possible, be assessed using benefit-cost analysis as suggested by the Commission.

3H ALTERNATIVE PRODUCTIVITY SCENARIO

In projecting that $148 billion ($135 for Class I railroads and $13 for other railroads) in infrastructure improvements would be needed to accommodate the projected demand for freight rail services in 2035, the CS study assumed that future needs would be met "by using current technology and existing rail corridors."[56] The CS study recognizes that "there are alternative futures that could, and eventually should, be examined."[57] Although the CS study did not attempt to present alternative scenarios based on a host of alternative assumptions, it did include "a preliminary estimate … of the potential cost savings from productivity improvements."[58]

Based on the railroads' anticipated productivity improvements, CS re-estimated its model assuming a 0.5 percent productivity improvement per year over the 28-year period from 2007 to 2035. In Section 7.2, the CS study notes that this alternative productivity scenario "would reduce capacity expansion needs in many corridors, reducing the cost of [investment] across all railroads from $148 billion to about $121 billion."[59] The CS study also notes how the reduction in required investments would be distributed across railroad classes.

> The Class I freight railroads' share for infrastructure expansion would be reduced from $135 billion to $109 billion, a savings of $26 billion. The short line and regional freight railroads' share of capital expenditures

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[55] The CS study projects that the total Class I investment requirement through 2035 averages $4.8 billion annually, with an anticipated average annual investment of $2.5 billion from Class I railroads and a gap averaging $2.3 billion per year.

[56] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-4.

[57] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-4.

[58] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-4.

[59] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-4. The CS study includes the following footnote: "Productivity improvements are only applied to line costs, not to terminals, yards, facilities, etc." p. 7-4.

would be reduced from $12.6 billion to $12.3 billion, a savings of about $0.3 billion.[60]

Looked at another way, the gap between the projected amount needed for Class I infrastructure expansion and the estimated amount that Class I railroads anticipate they could generate for infrastructure investments would be reduced from $65 billion ($135 billion minus $70 billion) to $39 billion ($109 billion minus $70 billion). In other words, under this alternative productivity assumption, the gap between projected infrastructure needs and projected investment generated by the railroads is reduced by 40 percent. Over the 28-year study period, this productivity scenario reduces the average annual gap from $2.3 billion to $1.4 billion.

Possible Extensions. Given the significant impact of the 0.5 percent per year productivity scenario, it would be desirable to know the impacts of scenarios that assumed both less optimistic and more robust productivity gains than the single productivity scenario reported.[61]

3I EXTRAPOLATIONS OF THE CS MODEL PRESENTED IN THE BLUE RIBBON REPORT

The Blue Ribbon Report reviewed the current status of and future investment requirements for all modes of the surface transportation system in the United States, including the results of the CS study on projected freight rail investment needs to meet forecasted demand. The Commission further requested that CS conduct analyses to supplement the CS study by modeling the impact of changes to the railroad's market share of freight transportation between 2005 and 2035.[62] The Blue Ribbon Report included the results of several scenarios assuming different market shares in terms of the average annual investment required over the 28-year period. Table 3-7 presents the results of the market-share scenarios requested by the Commission.[63]

[60] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-4.
[61] Improvements in technology can be embodied in alternative productivity scenarios. Chapter 4 of this report discusses the Class I railroads' historical levels of productivity growth.
[62] The Commission also requested that CS extrapolate the results of its study to project the investment needed in freight railroad infrastructure through 2055. The result of this extrapolation appears in *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, p. 4-18.
[63] The Commission refers to this analysis of changes in the railroad's market share as an extrapolation of the analysis in the CS study. It does not seem likely that this extrapolation includes the modeling of demand response. See the discussion in *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, pp. 4-16 – 4-18.

TABLE 3-7[64]
IMPACT OF CHANGING RAILROAD MARKET SHARE ON AVERAGE ANNUAL FREIGHT RAIL INVESTMENT REQUIREMENTS

Market Share Scenario	Rail Ton-Miles in 2035 (trillions)	Avg. Annual Investment Required ($ billion)
Reduce Current Market Share	2.46	$3.9
Maintain Current Market Share[65]	2.75	$5.3
Increase Market Share 5%	2.89	$5.7
Increase Market Share 10%	3.03	$6.0
Increase Market Share 20%	3.30	$7.1

As can be seen in Table 3-7, the CS study forecasts that a 20 percent increase in the railroads' market share of freight transportation would result in a 34 percent increase in the projected average annual freight rail investment requirement. Over the 28-year analysis period, the projected railroad investment requirement would increase from $148 billion to $198 billion. Since the 20 percent increase in the railroads' market share would be accompanied by a corresponding decrease in trucking's market share, the average annual highway capacity investment requirements would decrease. The Blue Ribbon Report states that "the impacts of these modal shifts would vary widely depending on the specific corridors in which they occur."[66] The results from the scenarios assuming different market shares illustrate the impact of the CS model assumption of no shift in market shares, and provide insight into the sensitivity and nonlinearity of the CS study's model.

3J POSITIVE TRAIN CONTROL

In recent years, various legislative proposals have been introduced before Congress that would require, among other provisions, Positive Train Control (PTC) on our nation's rail corridors. On October 16, 2008, President Bush signed into law the Rail Safety Improvement Act of 2008 (Public Law 110-432). The PTC provision in this act requires that all Class I railroads, as well as intercity passenger and commuter railroads, install PTC on main line tracks by Dec. 31, 2015.

This legislation requires substantial investment in PTC technology by Class I railroads over the next seven years that was not fully anticipated at the time of the CS study. When the CS study projected that a primary corridor would need to be expanded to meet the forecasted demand for rail service in 2035, it always selected line upgrades that included Centralized Traffic Control

[64] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, p. 4-17.
[65] The "Maintain Current Market Share" scenario is the case described in the CS study.
[66] *Transportation for Tomorrow,* Report of the National Surface Transportation Policy and Revenue Study Commission, December 2007, p. 4-18.

and Track Control Systems (CTC-TCS).[67] It is possible that the newly mandated PTC upgrades could be substituted for the CTC-TCS upgrades included in the CS model. Therefore the cost of implementing PTC would be partially offset by the cost of the CTC-TCS upgrades scheduled in the CS study. However, it is not possible to assess the impact of the legislated PTC requirement on the CS study's results since the CS study does not indicate a timeline of infrastructure investments through 2035, nor does it indicate the share of Class I railroad miles that would have upgraded control systems in 2035.

Descriptions of the benefits from installing PTC generally mention that these controls can increase the capacity of existing railroad lines.[68]

> FRA in its *Five-Year Strategic Plan for Railroad Research, Development, and Demonstrations* ...[stated,] In addition to providing a greater level of safety and security, PTC systems also enable a railroad to run scheduled operations and provide improved running time, greater running time reliability, higher asset utilization, and greater track capacity.[69]

Similarly, the CS study's description of CTC and TCS states that these systems "increase capacity."[70] An earlier study concluded that advanced train dispatching systems also "have the potential of improving general freight service over and above the effects on line operations alone," as more efficient terminal operations are also likely to result.[71] One railroad industry analyst suggested that following the mandated implementation of PTC, the volume/capacity ratio indicating "practical capacity" may be in the range of 0.8 to 0.85. Thus the new mandate to install PTC on all Class I railroads by 2015 is likely to have offsetting impacts on projected railroad investment requirements in the CS study: (a) increased investments to cover PTC installations on all Class I railroads, and (b) decreased investments associated with defining "practical capacity" at a volume/capacity ratio above 0.7.

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[67] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. A-14.

[68] The U.S. Federal Rail Administration submitted a report to Congress in 2004 at the request of the House and Senate Committees on Appropriations for updated information on the benefits and costs of PTC systems. See U.S. Department of Transportation, Federal Rail Administration, *Benefits and Costs of Positive Train Control*, August 2004, at http://www.fra.dot.gov/downloads/safety/ptc_ben_cost_report.pdf.

[69] U.S. Department of Transportation, Federal Rail Administration, *Benefits and Costs of Positive Train Control*, August 2004, pp. 29-30.

[70] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 4-5.

[71] Carl D. Martland and Michael E. Smith, "Estimating the Impact of Advanced Dispatching Systems on Terminal Performance," prepared for the *Transportation Research Forum,* October 11-13, 1989.

Possible Extensions. Given the passage of the Rail Safety Improvement Act of 2008, it would be useful to model an alternative scenario that assumed the investment needed to fully implement PTC technology by the end of 2015, along with a timeline of acceptable volume/service ratios that would increase from the current 0.7 ratio used in the CS study to 0.8 or 0.85 for 2016 through 2035, and possibly starting earlier than 2016 for some corridors.

CONCLUSION

Forecasting capacity needs thirty years into the future is, at best, an imprecise and difficult project. Using the demand forecasts from the U.S. DOT's FAF model, the CS study predicts that there will be significant, system-wide capacity problems in 2035 unless substantial investments are made in railroad infrastructure. The CS study presents a landmark analysis that provides a useful tool for assessing railroad industry capacity issues under a given set of assumptions. It develops a methodology and engineering model to estimate the investment requirements in lines and structures to avoid projected capacity constraints in 2035.

In Section 1.0 of the study, Cambridge Systematics noted that the forecasts it relied upon did not fully anticipate all changes that could significantly reshape freight transportation demand and, thus, freight rail infrastructure investment needs. Despite this caveat, the study provided only a point estimate of the investment needed to accommodate forecasted rail volume demand in 2035, rather than a range of values for future investments to reflect low-growth and high-growth scenarios as well as the base case.

In Section 7.2, the CS study provided the results of one alternative scenario that allowed for 0.5 percent per year productivity growth in the railroad industry. The discussion in this section states that the assumed productivity improvements would reduce the projected cost of infrastructure expansion from $148 billion to about $121 billion, noting that the Class I railroads savings would be $26 billion.

However, the Executive Summary of the CS study does not mention the $121 billion estimate. Rather it focuses on the $148 billion projected as the cost of infrastructure expansion under the strict assumption of no productivity growth in the railroad industry. The CS study adds the Class I railroad's estimated $26 billion savings in infrastructure expansion costs from the productivity scenario to the $70 billion investment for Class I railroads projected in Section 7.3.[72] In its Executive Summary, the CS study then describes this sum of approximately $96 billion ($26 billion plus $70 billion) as the amount that "[T]he Class I railroads anticipate that they will be able to

[72] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. 7-5.

generate …"[73] Although the gap of $39 billion between the Class I railroads' projected investment requirement and investment ability is the same whether the $26 billion in productivity savings is subtracted from the base case $148 billion investment requirement or added to the $70 billion investment ability, we think it would have been more appropriate if the Executive Summary had mentioned the $121 billion result as the projected investment requirement assuming productivity savings.

The conclusions of the CS study are sensitive to the economic projections that drive freight commodity flow forecasts, future decisions about plant locations, potential shifts among transportation modes, and changes in regional business operations. While the results of the CS study may be illustrative, they cannot—nor could any study based on a 28-year forecast of population growth and economic activity—provide a precise forecast of capacity needs almost three decades into the future. To illustrate this point, we can consider the steep increases in fuel prices during the first half of 2008 followed by more recent decreases in fuel prices, and the differential impacts of the current recession across U.S. regions and industries with especially dire predictions for the U.S. auto industry. With the CS study's use of auto train service as one of its four train types, uncertainties regarding the economic health of the U.S. auto industry have a very visible link to the model's structure. Given the inexact nature of long-range economic forecasts, it would have been very helpful if the CS study had provided some details about the forecasted commodity growth rates that drive demand for freight railroad traffic, and results for low-growth and high-growth scenarios to establish a range around its base case result. Furthermore, since the FAF projections are available at five-year intervals, some of the forecast uncertainty could be alleviated by having railroad investment projections done at these shorter-term intervals.

[73] Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, prepared for the Association of American Railroads, September 2007, p. ES-2.

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CHAPTER 4
A MACROECONOMIC VIEW OF LONG-TERM FREIGHT RAIL DEMAND FORECASTS

INTRODUCTION

The CS study developed a long-run projection of railroad capacity investment needs based on projections of freight rail commodity flows through the year 2035. These commodity flow projections came from the U.S. DOT's Freight Analysis Framework 2.2 (FAF) model, which was developed by Global Insight, Inc. for the Federal Highway Administration.[1] Global Insight describes the process used in making its projections as a "top-down, bottom-up process," where forecasts of macroeconomic trends are combined with more detailed projections of economic trends for different regions and industries to arrive at the final commodity flow forecasts. These forecasts do not formally incorporate the impact of infrastructure capacity constraints of any kind (e.g., rail, highway, and port) on freight demand, nor do they model changes in transportation modal choice based on changes in prices for the different transportation modes.

In this chapter, we evaluate the FAF model and its forecasts at a macro level. In particular, we compare the FAF forecasts to other macroeconomic forecasts. We discuss the uncertainty that is inherent in forecasts, particularly as projections reach farther out in the future, and the implications of that uncertainty. We then provide some illustrations of how forecast uncertainty could affect projected Class I railroads' capacity investment requirements and funding ability. Finally, we illustrate how rail freight demand and forecasts of this demand are likely to change with changes in factors such as relative transportation prices and fuel prices.

4A CONSIDERATIONS IN EVALUATING THE FAF MODEL

While the FAF projections provide a useful scenario of what the future may possibly look like, it must be recognized that there are a number of uncertainties concerning future economic conditions and these uncertainties increase as projections reach farther into the future. Therefore, as with all long-term forecasts, these projections should not be

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[1] Global Insight, Inc., *Methodology for the Freight Analysis Framework-2: Forecasts of Inter-regional Commodity Flows*, Report Number S8, Contract # DTFH61-01-C-00182, Battelle Memorial Institute, May 29, 2007, at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_reports/reports8/index.htm.

viewed as having a high degree of precision. The lack of precision is largely due to the fact that making projections of economic growth thirty years into the future requires making strong assumptions, which may or may not come to fruition.

In its report, Global Insight recognized the uncertainty surrounding its projections and developed low-growth and high-growth forecasts, along with its base case forecast, for the Federal Highway Administration. Unfortunately, the low-growth and high-growth scenarios were not included in the final FAF model, nor is there publicly available information on those alternative scenarios.[2] Furthermore, since the Global Insight model is proprietary, one cannot evaluate the macroeconomic assumptions or the assumptions underlying the industry and regional projections. Therefore, it is not possible to use the published information to estimate what Global Insight's low-growth and high-growth scenarios might have been and the implications for the FAF forecasts.

Another factor that should be kept in mind when evaluating the FAF forecasts is that they were made in 2007 and at that point in time most economic forecasters had more optimistic forecasts of future economic growth than they have today. Although information is not available to determine how Global Insight's forecasts might have changed in the interim, we can examine other publicly available forecasts to see how the unexpectedly severe recession that began at the end of 2007 has affected economic forecasters' views of the future.

In evaluating the FAF projections, it is important to consider how future changes in prices or service levels may affect the demand for rail freight transportation. As discussed in Chapter 2, freight rail demand is a function of its price, the speed and reliability of its service, and relative prices of other transportation modes and other inputs in the logistics chain. While the CS study estimates how much infrastructure will be needed to meet exogenously determined increases in demand, that analysis could be turned around to determine how existing capacity would be rationed among shippers if scarcity arises. This rationing can occur either through increases in rail rates or decreases in the quality of service or both, as both will have an impact on rail demand. An additional consideration in making projections of rail freight demand is the fact that rail and truck transportation are substitutes for some shippers (e.g., short-haul carload shipments) and complements for other shippers (e.g., intermodal shipments). Therefore, increases in the price of truck transportation or deterioration in truck transportation service quality will have either a positive or negative impact on rail transportation, depending on the

[2] In response to our request for greater detail, we were told by the Federal Highway Administration that it does not maintain any more detail on the high-growth/low-growth scenarios than what has been included in the documentation available at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_reports/reports8/index.htm.

particular circumstances. The overall impact depends on the relative proportions of substitute and complementary relationships.

One factor that can potentially have a large impact on the future demand for freight transportation and its modal mix is the price of fuel. To the extent that fuel costs represent a larger percentage of input expenditures in the trucking industry than the rail industry, increases in the price of fuel will have a relatively larger impact on the price of truck transportation than the price of rail transportation. The resulting increase in the price of rail transportation will have an unambiguously negative impact on rail freight demand, but the resulting increase in the price of truck transportation will have a more uncertain impact on the demand for rail transportation, depending upon whether truck and rail transportation modes are substitutes or complements for the shippers. In the case where truck and rail are substitutes for each other, increases in fuel prices will presumably result in a modal shift to more rail transportation.

4B Comparison of FAF Projections with CBO and OASDI Forecasts

In this section, we conduct a macroeconomic analysis of the FAF commodity flow projections to provide information that can be helpful in evaluating those projections. The purpose of this analysis is not to discredit the FAF projections, but rather to show the uncertainty surrounding those projections and their sensitivity to unexpected changes in projections of future economic factors.

We first compare the FAF projections of rail freight growth with two sets of long-run economic forecasts that are publicly available. The first is the long-run forecast of the U.S. economy conducted by the Congressional Budget Office (CBO). The second is the long-run forecast conducted by the Trustees of Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds (OASDI). The OASDI forecast is also useful in that it includes both low-cost (i.e., high economic growth) and high-cost (i.e., low economic growth) scenarios. This provides a benchmark against which we can demonstrate the uncertainty surrounding long-run forecasts.

Our comparisons show that the commodity flow projections from the FAF model generally do not increase as rapidly as the projections of real economic growth, measured by real Gross Domestic Product (GDP), made by the CBO and OASDI Trustees. This difference in growth rates is consistent with an analysis of historical data, which shows freight tons typically grow slower than GDP. For example, between 1990 and 2006, freight tons grew an average of 2.0 percent per year and real GDP grew at an average of 2.9 percent per year. Part of this difference in growth rates is due to the fact that the composition of GDP is much broader (e.g., it includes services) than the commodities projected by the FAF model.

We next look at how recent economic performance has affected the long-run view of the future. We compare the CBO's current economic forecasts with forecasts it made in 2007. From this comparison we conclude that Global Insight would likely have made lower projections of freight commodity flows for 2035 if their projections were made in 2009 instead of 2007. To illustrate this point, in a recent statement before the U.S. House of Representatives, Lance R. Grenzeback, Senior Vice President of Cambridge Systematics, indicated that the current recession would cause the projected volumes formerly expected in 2035 to be delayed three to five years.[3]

Comparison of FAF Projections to CBO and OASDI Forecasts of Real GDP

To put the FAF commodity flow projections in the context of macroeconomic forecasts that were being made concurrently, we compared the FAF projections to the CBO projections that were released in January of 2007 and the OASDI projections that were made in May of 2007. Each year, the CBO makes ten-year projections of real GDP growth. For the last five years of the analysis, the CBO assumes that economic growth will match its expected long-term growth in potential output for the economy. In order to project what those long-term expectations mean for real GDP growth through 2035, we extrapolate from the January 2007 CBO ten-year forecasts through 2017 using the expected long-term growth in potential output that CBO adopted at that time to project real GDP through 2035.

The OASDI Trustees make long-run forecasts of real GDP through the year 2085 and, therefore, no extrapolation is necessary when making a comparison to the FAF forecasts. Each year the OASDI Trustees make a low-cost (i.e., high GDP growth), a high-cost (i.e., low GDP growth), and an intermediate forecast. For purposes of comparison with the FAF projections, we use the OASDI intermediate forecast. Figure 4-1 compares the FAF commodity flow projections with the CBO and OASDI real GDP forecasts that were published in early 2007. Two indexes of FAF projections are shown in this figure. The first index represents the total tons of freight shipped via railroads. The second index represents the total tons of freight shipped by any mode of transportation.

[3] Lance R. Grenzeback, *Freight and Passenger Rail: Present and Future Roles, Performance, Benefits, and Needs*, Testimony before The Subcommittee on Railroads, Pipelines, and Hazardous Materials, Committee on Transportation and Infrastructure, U.S. House of Representatives, January 28, 2009, p. 4.

FIGURE 4-1
COMPARISON OF FAF COMMODITY FLOW PROJECTIONS WITH 2007 CBO AND OASDI FORECASTS OF REAL GDP

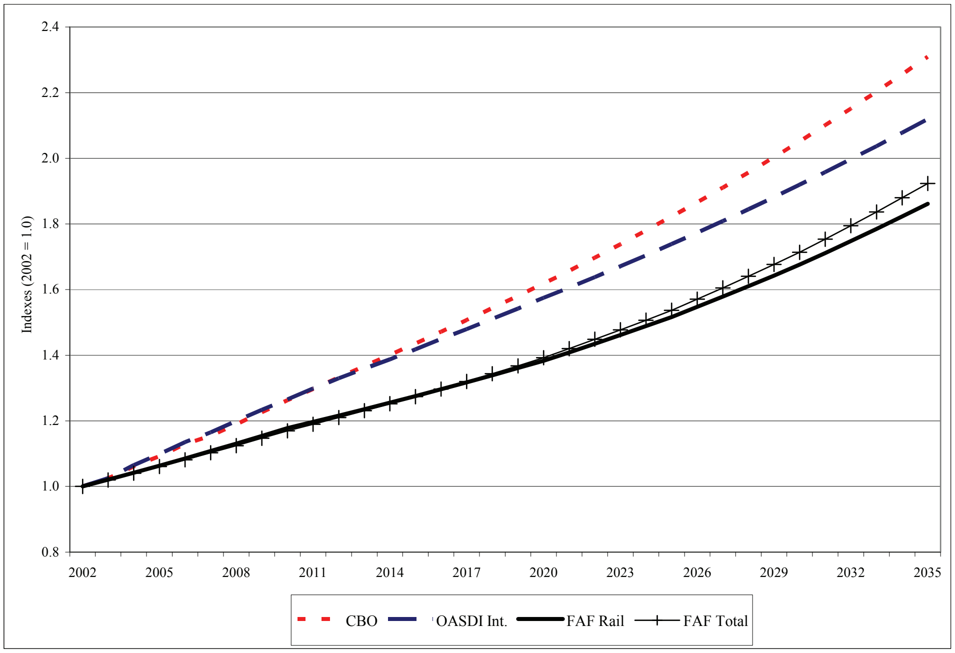


Figure 4-1 shows that the FAF projection of total freight tons increases by 92 percent and that of freight rail tons increases by 86 percent between 2002 and 2035. During this period, the CBO projected real GDP to grow 131 percent while the OASDI intermediate forecast projects real GDP increasing by 112 percent. It is not clear how much of the differences between these real GDP forecasts and the FAF commodity flow forecasts is due to differences in the mix of economic activity included in each index, or simply because of the difference in sources. A more appropriate comparison would have been between the Global Insight real GDP forecast and the FAF forecasts. However, the Global Insight macroeconomic forecast on which the FAF forecasts are based is not publicly available.

Future Uncertainty Not Accounted for in FAF

As mentioned above, Global Insight recognized that there was a considerable degree of uncertainty in its long-run projections. However, the extent of this uncertainty cannot be discerned from available information. In the documentation of its model, Global Insight refers to its alternative high-growth and low-growth freight projections in addition to its base-case projections that are publicly available. We inquired with the Federal Highway Administration about these alternative projections, but were told that these projections were not available.

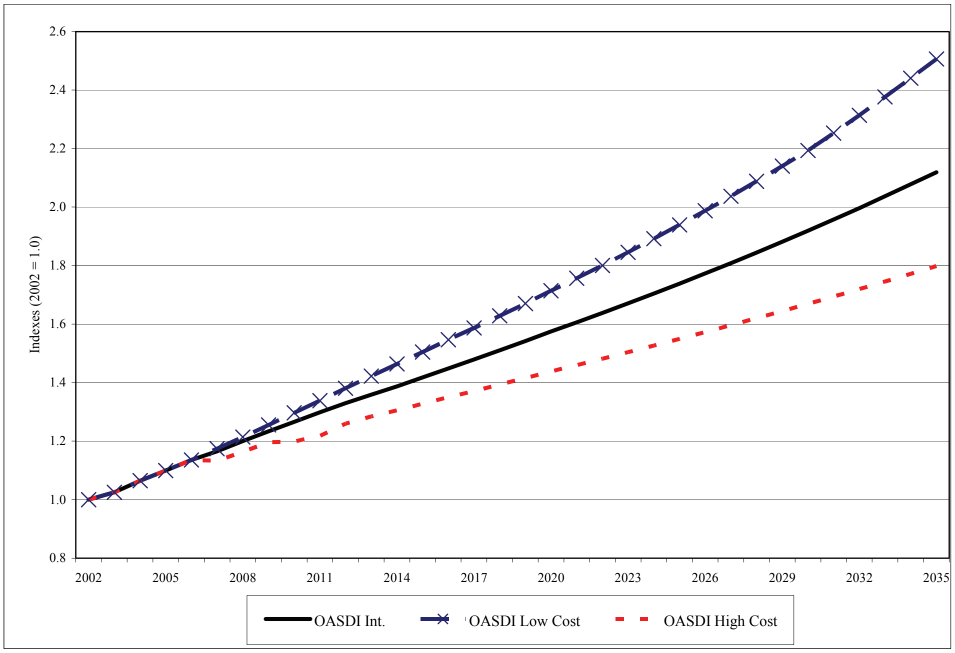
Although there is insufficient information available to determine what these alternative projections are, Global Insight does report that for total nonfarm employment, the high-growth scenario shows 2035 employment levels 18 percent higher than the base-case scenario, while the low-growth scenario shows employment levels 15 percent below the base-case scenario. The differences are substantially larger for the manufacturing sector, where the high-growth scenario shows employment levels in 2035 that are 30 percent above the base-case scenario, while the low-growth scenario shows employment levels that are 20 percent below the base-case scenario.[4] These alternative employment projections suggest that there is likely wide variation in the commodity flow projections, which would have significant implications for the projected amount of rail infrastructure investment required in the future.

Additional information to gauge how large the uncertainty concerning long-run commodity flow projections might be is given by the three real GDP scenarios forecasted by OASDI Trustees. The OASDI forecasts are built up from forecasts of productivity growth, employment growth, and changes in average hours worked per employee. Using alternative assumptions for all three components leads to the alternative OASDI forecasts of real GDP. Figure 4-2 shows the forecasts of real GDP through 2035 for the low-cost (high GDP growth), intermediate, and high-cost (low GDP growth) scenarios.

In the low-cost scenario, real GDP is projected to increase by 151 percent between 2002 and 2035. On the other hand, real GDP is projected to increase by only 80 percent in the high-cost scenario. This suggests that forecasts going out thirty years into the future are highly sensitive to the assumptions made and likely have a high degree of uncertainty. Again, this comparison implies that the commodity flow projections through 2035 and the resulting estimate of the rail infrastructure investment requirements have a high degree of uncertainty.

[4] Global Insight, Inc., *Methodology for the Freight Analysis Framework-2: Forecasts of Inter-regional Commodity Flows*, Report Number S8, Contract # DTFH61-01-C-00182, Battelle Memorial Institute, May 29, 2007, p. 19, at http://ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_reports/reports8/index.htm.

FIGURE 4-2
OASDI REAL GDP FORECASTS MADE IN 2007:
INTERMEDIATE, LOW-COST, AND HIGH-COST SCENARIOS

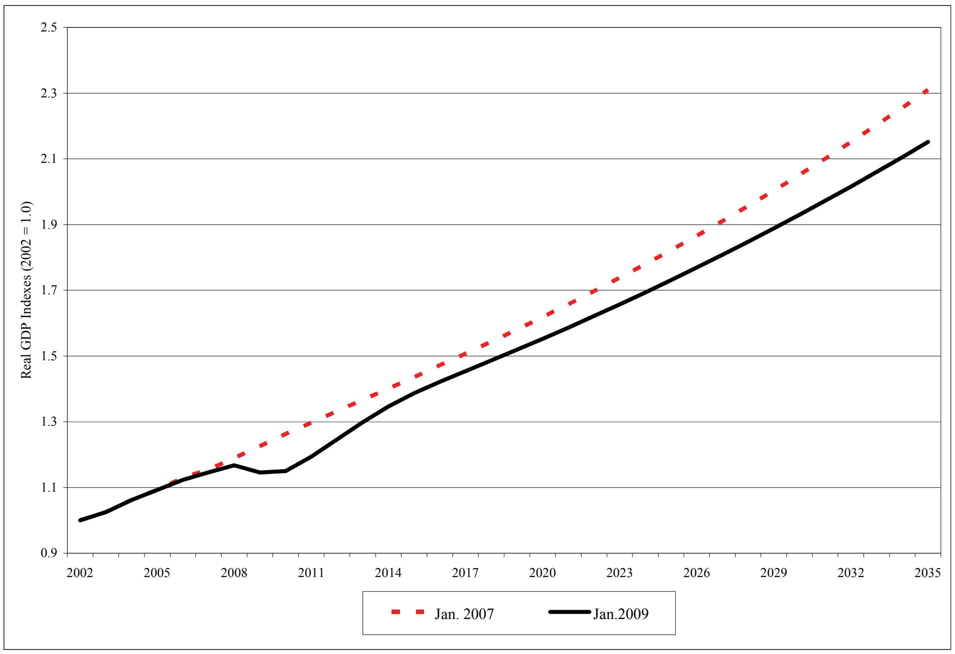


Recent Changes in the Economy Likely to Affect Future FAF Projections

Another consideration in evaluating the long-term FAF projections is the fact that significant changes in the economy lead forecasters to make significant revisions to their forecasts. This has been particularly true during the past two years, when the U.S. economy fell into a significant recession whose magnitude was unforeseen by many forecasters. The resulting impact on long-run economic forecasts can be seen by comparing the economic forecasts that the CBO made in January of 2007 with the forecasts it made in January of 2009. Figure 4-3 compares the CBO forecasts made in these two periods. The chart compares projected real GDP relative to its level in 2002. As mentioned above, the CBO does not make explicit forecasts beyond a ten-year period, so we extrapolate the CBO forecasts to 2035 using their forecasted growth in the long-run economic growth potential.

Figure 4-3 shows that the January 2007 projection of real GDP increases 131 percent between 2002 and 2035. Eleven months after this forecast was released in January of 2007, the U.S. economy entered a recession, and the CBO now forecasts lower levels of real GDP into the future.[5] The current forecast shows real GDP increasing 115 percent between 2002 and 2035. Were the Global Insight and FAF projections to be updated today, we would expect to see a similar decline in forecasted growth from their long-run projections made in 2007. As discussed above, Mr. Grenzeback of Cambridge Systematics has recently indicated that the current economic situation would delay forecasted 2035 freight rail volumes by three to five years.[6]

FIGURE 4-3
COMPARISON OF CBO REAL GDP FORECASTS MADE IN 2007 AND 2009



4C FORECAST UNCERTAINTY AND IMPLICATIONS FOR FUTURE RAILROAD INFRASTRUCTURE INVESTMENT NEEDS AND RAILROAD ABILITY TO FINANCE INVESTMENTS

In this section, we illustrate the potential impact of the various forecast scenarios discussed earlier in this chapter on future railroad investment requirements, using the CS study's Class I total of $135 billion as a benchmark. The variability and uncertainty in the macroeconomic forecasts of real GDP have implications for commodity flow projections

[5] One should note that the CBO forecasts do not incorporate any potential fiscal stimulus package that had not yet been enacted into law. With a fiscal stimulus package, the January 2009 forecast would probably not be as pessimistic.
[6] Lance R. Grenzeback, *Freight and Passenger Rail: Present and Future Roles, Performance, Benefits, and Needs*, Testimony before The Subcommittee on Railroads, Pipelines, and Hazardous Materials, Committee on Transportation and Infrastructure, U.S. House of Representatives, January 28, 2009, p. 4.

and the resulting amount of railroad investment requirements. We also discuss the implications for the financing of that investment. However, because we do not have access to model and forecast details for the FAF or the CS estimates of future railroad investment, it must be stressed that our analysis merely illustrates the potential impact of changes in the macroeconomic climate on future railroad capacity needs and investment. In performing this analysis, we employ the CS study's assumptions of railroads maintaining their financial ability to fund investments, no modal shifts over time, and the closely related assumption that there is no economic response to changing prices (e.g., fuel prices) that would affect relative demands for various modes of freight transportation.

Illustration of the Impact of Economic Uncertainty on Future Class I Investment Needs

Table 4-1 summarizes the average annual growth and total growth from 2002 to 2035 of the various real GDP forecasts and the FAF freight rail projections discussed in this chapter.

TABLE 4-1
SUMMARY OF REAL GDP AND FREIGHT RAIL FORECASTS

	Avg Annual Growth	Total Growth, 2002-2035
2007 CBO real GDP	2.5%	131.0%
2009 CBO real GDP	2.3%	115.2%
OASDI Int. real GDP	2.3%	111.9%
OASDI Low Cost real GDP	2.8%	150.6%
OASDI High Cost real GDP	1.8%	79.8%
FAF Rail	1.9%	86.1%

To illustrate the potential impact of changes in real GDP forecasts on the FAF freight rail forecasts and resulting estimates of the railroad investment needed (under the CS model's assumptions), we first compute ratios of the OASDI high-cost and low-cost scenarios to the OASDI intermediate forecast of real GDP, and of the 2009 CBO forecast to the 2007 CBO forecast of real GDP. These ratios are then applied to the FAF rail freight forecasts to illustrate the potential impact of different real GDP forecast scenarios on commodity flow projections. The ratios are computed on the cumulative growth projections through 2035 since the focus of the CS study is on cumulative freight rail demand projections and railroad investment through 2035. We then use these results to approximate the possible impact of these alternative forecasts on the railroad investment requirement forecasted in the CS study. At best, this ratio analysis provides a rough approximation of the relationship between forecasted real GDP growth and future railroad capacity and investment needs, using the CS study's forecasts as a starting point. Because we do not know the details of the models that generated the various forecasts, this analysis should be interpreted as providing illustrative examples of how forecast uncertainty or changes in forecasts would affect the projected railroad capacity and investment needs reported in the CS study.

Table 4-2 shows the ratios of the alternative real GDP forecasts to the "base" OASDI intermediate and 2007 CBO forecasts, and the application of these ratios to the cumulative FAF freight rail growth projection of 86.1 percent through 2035. The OASDI low-cost and high-cost scenarios imply a wide range of possible freight rail volume growth through 2035 that is not apparent from the point estimate of 86.1 percent reported in the CS study. A range similar to this would presumably have resulted if the FAF projections incorporated the alternative Global Insight high-growth and low-growth scenarios. The 2009 CBO scenario illustrates the possible effects on commodity flow projections of the recent downturn in economic activity and the incorporation of that information in more recent forecasts.

TABLE 4-2
ILLUSTRATION OF POSSIBLE EFFECTS OF ALTERNATIVE REAL GDP FORECASTS ON FREIGHT RAIL VOLUME GROWTH PROJECTED IN FAF

	Total Real GDP Growth, 2002-2035	Ratio to Base Forecast	Resulting Freight Rail Growth, 2002-2035
OASDI Int. (Base)	111.9%		
OASDI Low Cost	150.6%	1.35	115.9%
OASDI High Cost	79.8%	0.71	61.4%
2007 CBO (Base)	131.0%		
2009 CBO	115.2%	0.88	75.7%

Table 4-3 illustrates the possible effects of the alternative real GDP forecasts on the CS study's projected Class I investment needs of $135 billion through 2035. Since we do not know the details of how the $135 billion was computed, we simply adjust the CS study result by the ratios of alternative forecasted cumulative real GDP growth to the respective base cases. Again, this analysis serves as an illustration of the likely variation and uncertainty of all long-range forecasts that must be considered in evaluating the results of these forecasts. Furthermore, the 2009 CBO forecast serves to illustrate how unforeseen events can significantly change the path of future economic growth.

Finally, it is important to repeat our caveat from above that these calculations only illustrate the possible effects of uncertainty on the future freight rail volumes modeled in FAF and Class I investment needs forecasted in the CS study. Since we do not have access to key models and data that were used to estimate the results of the CS study, we cannot perform an actual analysis of forecast uncertainty on the CS study results. We also note that our illustrative examples are not meant to diminish the role of the CS study as a vision of future Class I capacity and investment needs.

TABLE 4-3
ILLUSTRATION OF POSSIBLE EFFECTS OF ALTERNATIVE REAL GDP FORECASTS ON CLASS I INVESTMENT NEEDS FORECASTED IN THE CS STUDY

	Total Real GDP Growth, 2002-2035	Ratio to Base Forecast	Resulting Class I Investment Needs, 2002-2035
OASDI Int. (Base)	111.9%		
OASDI Low Cost	150.6%	1.35	$ 181.7
OASDI High Cost	79.8%	0.71	$ 96.3
2007 CBO (Base)	131.0%		
2009 CBO	115.2%	0.88	$ 118.7

Implications for the Funding of Future Class I Investment Needs

The CS study states that of the projected $135 billion of cumulative Class I investment needs through 2035, $96 billion can be funded by the railroads, leaving a funding gap of $39 billion. The $96 billion from Class I railroads consists of $70 billion that the railroads can fund through increased earnings from revenue growth and higher volumes, and $26 billion resulting from productivity improvements of 0.5 percent per year. However, as described in Chapter 3, the $26 billion of productivity improvements is really a reduction in required investment. That is, with the 0.5 percent per year of forecasted productivity gains, cumulative Class I investment needs can be reduced by $26 billion from $135 billion to $109 billion.[7]

Not only will variations in projected real GDP growth have an impact on projected Class I capacity and investment needs, but such variations will presumably also affect the railroads' ability to fund investments. The CS study assumes railroad earnings will be sufficient to fund their stated share of investment, but reductions in forecasted real GDP can be assumed to cause reductions in projected railroad earnings. Table 4-4 continues with the illustrative scenarios from above (complete with caveats) as it assumes the ability of Class I railroads to fund

[7] The CS study does not document how the 0.5 percent per year productivity growth projection was determined.

investment is proportionate to the ratios of the alternative forecasts to the base-case forecasts—i.e., earnings are scaled proportionately to maintain railroad funding ability. As a starting point, the analysis assumes the $96 billion of funding ability from the CS study. Thus, it includes the $26 billion “contribution” of the 0.5 percent per year anticipated productivity growth. Although, as we mention above, this $26 billion is actually a reduction in investment requirements, it is included as a funding source here to be consistent and comparable to the CS study results. Table 4-4 also shows adjustments to the funding gap, computed as the difference between the forecasted investment needs in Table 4-3 for the particular forecast scenario and the projected Class I funding ability in Table 4-4. It should be noted that despite reductions in forecasted railroad investment needs due to lower real GDP projections, a funding gap still exists because of reduced projected railroad earnings implied in the CS study. Also, since the alternative funding abilities are based on the 0.5 percent productivity assumption, changes in future productivity growth would have an impact on these projections.[8]

TABLE 4-4[9]
ILLUSTRATION OF POSSIBLE EFFECTS OF ALTERNATIVE REAL GDP FORECASTS ON PROJECTED CLASS I FUNDING ABILITY ESTIMATED IN THE CS STUDY

	Total Real GDP Growth, 2002-2035	Ratio to Base Forecast	Resulting Class I Funding, 2002-2035	Resulting Class I Funding Gap
OASDI Int. (Base)	111.9%			
OASDI Low Cost	150.6%	1.35	$ 129.2	$ 52.5
OASDI High Cost	79.8%	0.71	$ 68.4	$ 27.8
2007 CBO (Base)	131.0%			
2009 CBO	115.2%	0.88	$ 84.4	$ 34.3

4D CHANGES IN RAIL FREIGHT DEMAND RESULTING FROM CHANGES IN PRICES AND OTHER FACTORS

Another factor that must be kept in mind when evaluating long-term projections of freight transportation is the responsiveness of demand to changes in prices. The appendix to this chapter summarizes a review of the literature on rail freight transportation demand. That review shows evidence that increases in the prices of rail freight transportation lead to reductions in shipments, though the elasticities of demand vary by

[8] These alternative scenarios also retain the CS study’s assumption of no change in rail’s market share of freight transportation by commodity and origin/destination combinations.
[9] This table is designed to show the variability of possible outcomes due to the uncertainty of future economic growth projections; it should not be viewed as providing reliable estimates of the actual funding gap.

industry. The review also shows that economic studies have conflicting evidence on the relationship between the price of truck transportation and the utilization of rail transport. Some of the studies listed show that truck and rail transportation are substitutes for each other, so that an increase in the price of truck transportation will lead to an increase in rail transportation. Other studies show that they are complements, so that an increase in the price of truck transportation will have a negative impact on both truck and rail transportation. Furthermore, it is likely that these relationships vary by commodity and location.

An important question that arises concerning transportation is the impact of potential fuel price increases on rail transportation. Since permanent increases in fuel prices will ultimately have an impact on both the price of rail transportation and truck transportation, the ultimate outcome is not obvious. Because trucking costs are more sensitive to fuel prices than are rail costs, a permanent increase in fuel prices will have a larger percentage impact on trucking prices than on rail prices, resulting in a decrease in the price of rail relative to trucking. Thus, an increase in fuel prices may have opposing effects on the volume of rail shipments. Whether increases in fuel prices result in overall increased or decreased volumes depends upon the degree to which consumers view rail and truck transportation as substitutes or complements. If these two transportation modes are "strong substitutes," then volume shifting from trucking more than offsets the volume decrease from rail shippers and rail volumes increase overall. If rail and trucking are "weak substitutes," then the decrease in volume by rail shippers is only partially offset by shifting volumes from trucking. And if rail and trucking are complementary modes of transportation, then the decline in rail volumes is exacerbated as truck-based rail traffic also decreases.

From our review of the literature on price elasticities, we find a reasonable range of the own-price elasticity for rail transportation is from -0.4 to -1.0. For the cross-price elasticity of rail volume with respect to the price of trucking, we believe the reasonable range is from -0.4 to +0.4. Thus, we conclude that a ten percent increase in fuel prices would result in rail volume changes between -1.3 percent and +0.3 percent.

Table 4-5 provides an illustrative analysis of the impact of a ten percent increase in fuel prices on rail volume. We use representative elasticities found in our literature review. We also assume that fuel represents about seven percent of rail costs and about fourteen percent of trucking costs. These cost shares are consistent with industry data published by the Bureau of Economic Analysis, our econometric analysis of the railroad industry described in our November 2008 study, and 10-K filings by various trucking firms. Thus, for a permanent ten percent increase in fuel prices, we estimate that rail transportation prices will increase about 0.7 percent (i.e., 7% × 10%) and truck transportation prices will increase about 1.4 percent (i.e., 14% × 10%).

TABLE 4-5
IMPACT ON RAIL VOLUMES RESULTING FROM A TEN PERCENT INCREASE IN FUEL PRICES

		Own-Price Elasticity of Demand for Rail			
		-0.4	-0.6	-0.8	-1.0
Cross-Price Elasticity of Demand	-0.4	-0.8%	-1.0%	-1.1%	-1.3%
	0.0	-0.3%	-0.4%	-0.6%	-0.7%
	0.4	0.3%	0.1%	0.0%	-0.1%

Consider the case where the own-price elasticity for rail transportation is -0.8 and the cross-price elasticity of rail transportation with respect to the price of truck transportation is +0.4. The reduction in rail transportation due to the increase in rail rates is exactly offset by the substitution of freight transportation from trucking to rail due to the increase in truck transportation prices ((-0.8 × 7% × 10%) + (+0.4 × 14% × 10% = 0%)).

Similar analyses can be done for changes in the prices of other transportation inputs. It is important to note that the changes in input prices and the resulting changes in transportation prices in our analysis are changes in real rather than nominal prices (i.e., net of inflation).

CONCLUSION

While the FAF projections provide a useful scenario for what might happen in the future, one must recognize that there is considerable uncertainty surrounding all forecasts that extend thirty years into the future. This uncertainty is not reflected in the base-case FAF forecasts that were used in the CS study. Furthermore, there have been significant changes in the U.S. economy after the FAF forecasts were released that are likely to lead to lower real GDP growth in the future. Were Global Insight to make long-run projections today, it is likely that its results would show lower projected growth, which would result in lower FAF commodity flow projections.

In this chapter, we have illustrated how future uncertainty and changing economic conditions might affect the results of the CS study regarding its projection of railroad investment requirements under the assumptions of the CS model. We also illustrated how factors such as changing fuel prices and the economic relationships between truck and rail transportation may affect projections of rail volumes and, in many cases, could result in higher projected freight rail demand growth. However, since the results of the CS study are based largely on proprietary models and data, our examples are only rough approximations of how these various considerations could affect the results of the CS study.

CHAPTER 4 APPENDIX: OWN-PRICE AND CROSS-PRICE ELASTICITIES OF DEMAND

Price elasticities measure the collective response of decision makers in response to changes in economic factors such as prices. Of particular interest in this report is how freight transportation consumers' demand for rail services responds to changes in the price of rail and trucking services.

The *own-price elasticity* of demand measures the percentage response of rail service consumers (shippers) to a one-percent change in the price of rail services. The own-price elasticity of demand is negative, reflecting the law of demand that more is consumed at lower prices, other things the same. Elasticity of absolute value greater than one, indicating a more than proportional response to a price change, is classified as elastic whereas elasticity of absolute value less than one is classified as inelastic.

The *cross-price elasticity* of demand for rail with respect to the price of trucking services indicates how rail consumers respond, in percentage terms, to a one-percent change in the price of trucking services. A positive value for the cross-price elasticity indicates consumers use rail and trucking as substitute services, while a negative cross-price elasticity of demand implies complementarity in consumption. It should be noted that the cross-price elasticity of demand for rail with respect to trucking prices is a distinct concept from the cross-price elasticity of demand for trucking with respect to rail prices, although both measures are indicative of the substitute/complement relationship between these two transportation services.

Freight transportation is an input into production processes of shippers, rather than a final good or service. This view of rail and trucking transportation as inputs leads to two related, but distinct elasticity concepts. *Output-constant* elasticities reflect shipper responses as they move to minimize the cost of producing a given level of output. The output-constant demands for transportation services are theoretically derived from the minimum cost function, which is a function of the output level and the prices of inputs, including transportation services.[10] The own-price elasticity is then the log-derivative of an input demand with respect to that input's price. The cross-price elasticity of demand is the log-derivative of an input demand with respect to the price of another factor. Thus, the own-price and cross-price, output-constant elasticities of demand are second derivatives (direct and cross partial derivatives) of the shipper's minimum cost function.

[10] Shepherd's lemma states that the cost-minimizing demand for an input is the derivative of the minimum cost function with respect to the input's price.

Output-adjusted elasticities have an additional component that captures the response that occurs because shippers change production levels in response to a change in an input price. Output-constant elasticities reflect shippers' responses as they move to maintain maximum profits from producing and selling outputs. The output-adjusted demand for transportation services is theoretically derived from the maximum profit function, which is a function of the prices of outputs and inputs, including transportation services.[11] Log derivatives of the profit-maximizing input demands with respect to the inputs' prices yield the output-adjusted elasticities. Thus, the own-price and cross-price, output-adjusted elasticities of demand are second derivatives (direct and cross partial derivatives) of the shipper's maximum profit function.

It is noted that cost-minimization is a "necessary but not sufficient condition" for profit maximization. Consequently, the output-constant elasticity is one of two components of the corresponding output-adjusted elasticity. The other component captures the change in input usage due to output changing. For own-price elasticities, the output-adjustment component typically reinforces the output-constant component. That is, an input's price increase results in less usage as other inputs are substituted to produce the same output level. However, the change in the input price also causes the optimal output level to decrease, which induces a corresponding decrease in all input usage.[12]

EMPIRICAL EVIDENCE ON THE PRICE ELASTICITY OF DEMAND

Numerous studies have estimated price elasticities for freight transportation. Oum, Waters, and Yong provide the most comprehensive review of the empirical literature.[13] They find that differences in variable definitions, time periods and locations analyzed, the degree of aggregation, control for intermodal competition, and econometric specifications result in a wide range of values for own-price elasticities of demand. These differences make a comparison across studies difficult.

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[11] Hotelling's lemma states that the profit-maximizing demand for an input is the derivative of the maximum profit function with respect to the input's price.

[12] The typical case reflects a "normal input" such that increased output requires increased usage of the input. There is a theoretical possibility of an "inferior input" whose usage decreases as output increases. However, in this strange case an increase in the price of the inferior input shifts down marginal cost and induces output expansion. So, even in the inferior input case, the output-adjustment effect reinforces the output-constant effect.

[13] See Tae H. Oum, W. G. Waters, II, and Jong Say Yong, *A Survey of Recent Estimates of Price Elasticities of Demand for Transpor*t, Working Paper 359, The World Bank, January 1990. Other elasticity surveys include Chris Clark, Helen Tammela Naughton, Bruce Poulx, and Paul Thoma, *A Survey of the Freight Transportation Demand Literature and a Comparison of Elasticity Estimates*, IWR Report 05-NETS-R-01, Institute for Water Resources, U.S. Army Corps of Engineers, Alexandria, VA, January 2005; and Australian Bureau of Transport Economics, *Transport Elasticities Database, 2001*, at http://dynamic.dotars.gov.au/bte/tedb/index.cfm.

Nevertheless, Oum and colleagues do provide a methodical synthesis of 50 rail and 26 trucking studies to construct a “most likely range” for output-adjusted own-price elasticities of demand.[14] The studies synthesized have analysis periods in the 1970s and 1980s. While there are specific estimates of elasticity ranges for the major commodity groups, there are no estimates for intermodal rail traffic as it was not as prevalent as it is today.

To develop our range of own-price elasticity for rail transportation, we started with the most likely range for the major commodity groups from Oum, Waters, and Yong. We then calculated the weighted average of the upper and lower bounds using each commodity’s 2007 share of ton-miles. This aggregating resulted in a range of -0.3 to -0.8. We then adjusted this range to recognize the growth of intermodal traffic that has occurred since the underlying studies were conducted. We believe that the demand for rail by intermodal traffic is relatively elastic because intermodal shipments involve a competing mode of transportation. The intermodal share of rail ton-miles had grown to over six percent by 2007. Consequently, we believe the likely range for output-adjusted own-price elasticity of demand for rail services is -0.4 to -1.0.

There is a much smaller body of evidence on the cross-price elasticity of demand for rail transport with respect to trucking prices, and this evidence is more difficult to synthesize. Oum, Waters, and Yong find that the cross-price elasticities are specific to market situations and the degree of data aggregation. Consequently, they suggest caution when attempting to generalize about cross-price elasticities. Nonetheless, we reviewed the cross-price elasticity estimates presented in Oum, Waters, and Yong,[15] recognized the growth of intermodal in the subsequent years, and created a rough range of -0.4 to +0.4 for the aggregate cross-price elasticity of demand for rail with respect to the price of trucking services. The fact that this range is centered at zero reflects the opposing attributes of substitution and complementarity between these two freight transit modes.

[14] See Table 3 in Tae H. Oum, W. G. Waters, II, and Jong Say Yong, *A Survey of Recent Estimates of Price Elasticities of Demand for Transport*, Working Paper 359, The World Bank, January 1990.
[15] See Table 5 in Tae H. Oum, W. G. Waters, II, and Jong Say Yong, *A Survey of Recent Estimates of Price Elasticities of Demand for Transport*, Working Paper 359, The World Bank, January 1990.

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CHAPTER 5
COMMODITY-LEVEL SOURCES OF FREIGHT RAIL GROWTH

INTRODUCTION

General economic conditions to a certain extent determine demand for transportation services including freight rail services. However, the paths of aggregate demand and freight rail demand can diverge substantially as the composition of rail freight is disproportionately linked to specific sectors, most notably coal. In this chapter, we review the U.S. DOT's Freight Analysis Framework Version 2.2 (FAF) forecasts for coal, grains, other coal and petroleum products, and waste/scrap. These four commodity groups account for 78 percent of the projected growth of rail tonnage from 2002 to 2035 in the FAF forecast database. The FAF does not fully identify intermodal shipments; in lieu of an intermodal shipment measure, we examine a collection of commodities that are likelier to be shipped by rail in containers or trailers.

Our purposes are to identify major sources of uncertainty for future rail demand and to determine the extent to which the FAF forecasts for freight rail shipments are consistent with alternative forecasts that bear on key commodity flows in the rail shipment mix. The focus of this analysis is long-term structural factors rather than declines in commodity production and associated transportation demand related to the current recession. Overall, we find that the FAF model forecasts very high rail demand growth compared to current production forecasts from the Department of Energy for coal and for petroleum products (excluding gasoline and fuel oils) and from the Department of Agriculture (USDA) for grains. The range of alternative forecasts is very broad, especially for coal shipments. Forecast scenarios featuring high coal demand have the potential to project substantial additional railroad investment requirements; whereas Department of Energy forecasts based on current law do not fully recognize the downside risk of stringent greenhouse gas restrictions.

The FAF forecasts assume constant modal shares by commodity and origin/destination combinations, but future rail demands also depend on the extent to which relative costs or transportation policy considerations may favor rail over other modes, especially long-haul trucking. Since rail's share of long-distance freight transportation—for commodities other than the major bulk commodities—is relatively low, it is possible to greatly increase intermodal carloads by putting relatively small shares of interstate freight truckloads on the rails.

We recalibrate the FAF coal transportation forecasts to recent Department of Energy forecasts in order to provide a rough quantification of the potential effects on coal ton-miles, investment requirements, and railroad revenues. Since the CS study does not provide sufficient detail to replicate its investment requirement model, we apply a linear extrapolation of capacity incremental cost estimates from Burton to indicate the rough magnitude of the effects.[1]

Table 5-1 shows the commodity mix (based on tonnage) for domestic rail shipments in the FAF database for the 2002 base period and the 2010-2035 forecasts.

Not surprisingly, coal shipments are by far the largest commodity component of rail tonnage in 2002, and represent a majority of forecasted rail tonnage growth through 2035. Indeed, the FAF forecast anticipates coal tonnage increasing somewhat faster than rail-mode tonnage as a whole. Other commodities typically shipped in bulk[2] round out the other high-tonnage categories in the FAF forecast, with grain shipments in a distant second place. Commodities likelier to be containerized for shipment (including truck trailers) will account for much higher shares of carloads than tons; intermodal shipments are not readily identified in the FAF database. However, the FAF tonnage for commodities that would be expected to involve higher fractions of intermodal shipments grows at approximately the same rate as total rail traffic and somewhat faster than rail traffic excluding coal.

[1] Mark L. Burton, *Measuring the Cost of Incremental Railroad Capacity: A GIS Approach*, at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf.
[2] In the FAF model's Standard Classification of Transported Goods, the other commodities typically shipped in bulk include Cereal Grains, Coal and Petroleum Products - not elsewhere classified, Waste/Scrap, Gravel, Fertilizers, Basic Chemicals, Nonmetallic Mineral Products, Other Agricultural Products, Nonmetallic Minerals, Animal Feed, Natural Sands, Metallic Ores, Gasoline, Fuel Oils, and Logs.

TABLE 5-1
FREIGHT RAIL COMMODITY MIX FROM FAF DATABASE, DOMESTIC SHIPMENTS

(THOUSANDS OF TONS)

Commodity	2002	2010	2015	2020	2025	2030	2035
Coal	815,957	982,521	1,073,851	1,178,216	1,298,085	1,448,059	1,620,667
Cereal grains	154,364	171,113	188,499	209,165	235,716	268,191	304,733
Coal & petroleum products-n.e.c.	74,481	97,223	107,981	121,545	138,921	160,522	186,573
Waste/scrap	65,910	65,601	80,710	97,666	123,262	153,750	192,856
Gravel	83,913	130,813	135,810	140,403	146,738	151,543	155,894
Fertilizers	85,743	77,077	76,941	75,154	74,291	73,655	72,404
Other foodstuffs	41,204	48,808	52,653	57,249	63,331	70,947	79,270
Basic chemicals	65,280	69,184	69,194	69,266	69,464	69,621	69,899
Nonmetal min. prods.	35,294	46,459	51,276	56,255	61,671	66,804	71,327
Other ag. prods.	26,312	31,758	38,727	42,940	52,955	60,124	71,048
Wood prods.	46,794	46,116	48,977	52,009	53,780	55,627	57,862
Base metals	40,746	44,537	46,262	47,780	50,502	53,858	57,243
Plastics/rubber	27,894	32,917	36,021	39,394	42,787	46,212	49,837
Nonmetallic minerals	31,158	38,581	40,449	43,309	43,709	45,451	46,894
Newsprint/paper	29,108	30,186	32,285	33,943	35,547	37,202	39,005
Animal feed	21,259	24,285	26,102	28,255	30,913	34,177	37,679
Natural sands	22,727	31,359	31,337	31,184	30,725	30,494	30,380
Milled grain prods.	11,244	12,835	13,877	15,258	17,030	19,173	21,438
Motorized vehicles	11,762	10,485	11,301	12,165	14,206	16,351	18,504
Alcoholic beverages	6,184	10,215	11,707	13,117	14,304	15,181	15,827
Metallic ores	31,522	34,449	30,860	26,433	20,957	14,696	7,351
Chemical prods.	5,214	6,009	6,784	7,891	9,511	11,729	14,491
Transport equip.	5,093	6,492	6,948	7,592	9,334	11,164	13,281
Gasoline	6,993	9,946	10,052	9,970	10,162	10,544	11,488
Fuel oils	5,731	6,968	7,549	8,148	9,023	10,122	11,851
Articles-base metal	4,661	5,683	6,107	6,595	7,325	8,222	9,240
Unknown	4,169	3,618	4,167	4,793	5,741	6,992	8,605
Machinery	1,517	1,919	2,267	2,807	3,588	4,627	5,936
Mixed freight	840	1,050	1,222	1,455	1,757	2,141	2,606
Paper articles	968	1,043	1,139	1,236	1,321	1,406	1,488
Misc. mfg. prods.	443	498	603	753	980	1,292	1,708
Logs	1,441	1,011	977	1,011	1,051	1,087	1,189
Printed prods.	662	691	739	796	853	907	960
Meat/seafood	415	512	558	621	704	805	887
Electronics	545	517	528	539	572	619	642
Pharmaceuticals	399	256	284	319	367	428	497
Furniture	265	258	277	294	322	356	394
Textiles/leather	485	425	387	354	323	296	273
Building stone	10	3	3	3	3	3	3
Precision instruments	1	0	0	0	0	0	0
Total	1,768,709	2,083,421	2,255,410	2,445,883	2,681,834	2,964,377	3,292,228
Total excl. Coal	952,753	1,100,900	1,181,558	1,267,666	1,383,748	1,516,318	1,671,561

As of the writing of this report, the ultimate depth and length of the economic recession that began in December 2007 are matters of speculation. Minutes of the January 27-28 meeting of the Federal Open Market Committee (FOMC) indicate that economic conditions deteriorated sharply between the December and January FOMC meetings, and suggest growing expectations that the downturn will be severe and protracted.[3] High-frequency measures of rail traffic such as the AAR's carload statistics show sharp year-over-year downturns in many commodity categories. Notably, coal rail traffic remains relatively close to its levels from the peak of the economic cycle.[4] If coal traffic continues to show less cyclical variability than other commodities—particularly imported manufactured goods and export goods[5]—then the recession's effect on railroad traffic would be expected to disproportionately involve rail corridors (and associated terminal facilities) serving ports, some of which are in the midst of capacity expansion programs predicated on growth in foreign trade (especially container) volumes. Therefore, it must be kept in mind that the current economic downturn would add further uncertainty to the analyses presented in this chapter.

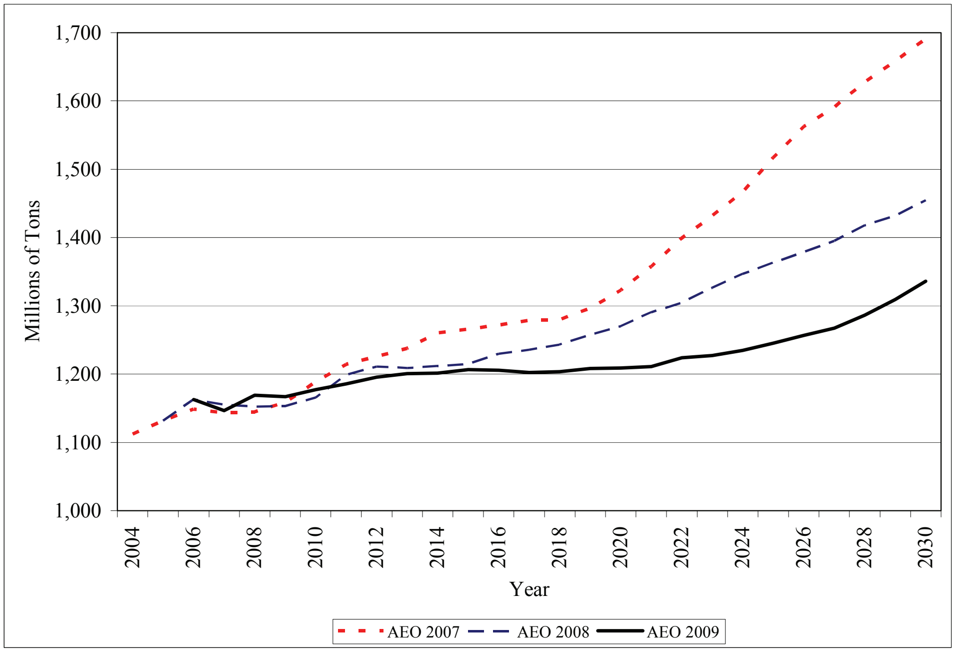
5A COAL

U.S. demand for coal is derived primarily from coal's use as a fuel for electricity generation. In 2006, the electric power sector accounted for 92 percent of coal use in the U.S., with other industrial uses and coke accounting for most of the remainder. The growth in coal demand therefore depends primarily on electricity demand growth and coal's share in the fuel mix for electricity generation. The Department of Energy's Energy Information Administration (EIA) forecasts coal production, supply, and demand through 2030 using the National Energy Modeling System (NEMS). Rail is the dominant mode for long-distance coal shipments, and there are relatively few opportunities to economically substitute other transportation modes for rail. Thus, we would expect the path of rail transportation of coal to generally follow that of coal supply.

Recent NEMS runs for the EIA's Annual Energy Outlook (AEO) have shown significant uncertainty in long-range coal supply forecasts and, by extension, forecasts of rail shipments of coal, arising from varying long-range forecasting assumptions. Coal forecasts through 2030 from the 2007-2009 AEOs are shown in Figure 5-1, below.

[3] Federal Open Market Committee, Minutes of January 27-28, 2009, at http://www.federalreserve.gov/monetarypolicy/fomcminutes20090128.htm.
[4] Association of American Railroads, "2008 U.S. Rail Freight Traffic Fourth-Highest in History, but Down Sharply in December and the Fourth Quarter," January 8, 2009, at http://www.aar.org/sitecore/content/Home/AAR/Pressroom/PressReleases/2008/12_WTR/010809_HighestInHistory.aspx.
[5] The decline in freight rail traffic has been led by motor vehicles and materials used in construction and industrial production.

FIGURE 5-1
REFERENCE CASE FORECASTS FOR U.S. COAL PRODUCTION, AEO 2007-2009



The major drivers of the AEO coal forecast variability are long-range economic growth assumptions and market anticipation of possible greenhouse gas (GHG) regulations. The "reference case" for the AEO 2008 reduced the assumed average annual economic growth rate by 0.4 percent versus the AEO 2007. For the AEO 2009, the reference case reflects the addition of a "cost of capital penalty" to "represent the implicit cost being added to GHG-intensive projects to account for the risk that they may have to purchase allowances or make other investments in the future to offset GHG emissions."[6] There is some degree of coal supply growth in each of the three forecast scenarios, but the two successive AEO forecast revisions remove 355 million tons from the 2030 coal production forecast. As an indicator of the scale of the forecast revisions, total 2007 coal production in the Appalachian region was 377.8 million tons.[7] The low coal growth scenarios provide insufficient coal production to meet the long-range FAF forecast of coal shipments: the 1,336 million tons of 2030 production in the AEO 2009 forecast is well below the 2030 FAF forecast of 1,448 million tons of coal shipped by rail.[8]

[6] U.S. Department of Energy, EIA, *Annual Energy Outlook 2009, Early Release*, presentation of December 17, 2008, at http://www.eia.doe.gov/oiaf/aeo/pdf/aeo2009_presentation.pdf.
[7] U.S. Department of Energy, EIA, *Coal Production and Number of Mines by State and Mine Type*, Report No.: DOE/EIA 0584 (2007), released September 2008, at http://www.eia.doe.gov/cneaf/coal/page/acr/table1.html.
[8] In the 2002 base year for the FAF database, 74 percent of coal production is shipped by rail.

Even the AEO 2009 coal scenario does not indicate all of the downside risk to coal shipments from potential future environmental regulations, since the AEO forecasts are based on current law at the time of the forecast. Thus, the AEO forecasts assume that tax credits for solar and wind power will expire as scheduled, even though policy has been to renew the credits.[9] This would tend to increase the forecast for future coal-fired generation capacity relative to a forecast that assumed renewal of the credits in line with current policy. More significantly, GHG caps would likely require much more significant substitution away from coal-fired electricity generation than is provided by the capital cost premium for GHG-intensive technologies in the AEO 2009.

Generally, the FAF model's forecasted growth in coal tonnage shipped by rail outstrips the growth in total coal production from recent EIA forecasts. Since rail's modal share for coal shipments is already high in the major coal-producing regions, there is little room for compositional changes that would allow rail shipment growth to greatly outpace production growth under the FAF assumptions. The FAF forecast calls for 78 percent growth in coal rail tonnage from 2002-2030, versus 50 percent in the AEO 2007 scenario (higher economic growth, lower GHG-related costs) and 24 percent in the AEO 2009 scenario (lower economic growth, higher GHG-related costs).

There are significant variations in forecasted coal production at the regional level, with the EIA forecasts anticipating continued westward shifts of coal production. The EIA forecasts also predict that the coal production in the Appalachian region will be below current levels for most of the forecast period through 2030. Forecast variability is greatest for the Northern Great Plains region, including Powder River Basin (PRB) production, which has accounted for the bulk of recent U.S. coal production growth. Rail's modal share for PRB coal is especially high, since the region's remoteness from navigable waterways and points of use limit the use of water and truck modes.[10] The average length of haul for PRB coal shipments is much higher than that for other coal-producing regions, so the PRB forecast variability is also a major driver of future output variability (carloads and ton-miles) for the western Class I railroads. However, AEO forecasted increases in coal production in the Interior region[11] are not mirrored in the FAF forecasts.

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[9] Subsequent to the NEMS run for AEO 2009, certain renewable energy tax credits were extended from 2010-2012 to 2013-2014. See Section 1101 of the American Recovery and Reinvestment Act of 2009, 111th Congress, at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h1enr.pdf.

[10] For instance, some PRB coal shipments are transported to waterway terminal facilities with an initial rail leg.

[11] The Interior region includes western Kentucky, Illinois, Indiana, Iowa, Missouri, Mississippi, Kansas, Oklahoma, Arkansas, Texas, and Louisiana.

Appalachian Region

Figure 5-2 shows the relative paths of the FAF rail shipment forecast for coal originating in the Appalachian region and the region's forecasted production from the 2007-2009 AEO revisions. The FAF forecast anticipates 2030 tonnage will be 10 percent over 2007 levels, whereas the recent AEO forecast scenarios call for production declines between 2 percent and 15 percent, with the 2009 reference scenario calling for a decline of 10 percent between 2007 and 2030. Ten percent of 2007 rail traffic for Appalachian coal is approximately 33 million tons.

FIGURE 5-2
COMPARISON OF AEO PRODUCTION AND FAF RAIL TONNAGE COAL FORECASTS, APPALACHIAN REGION

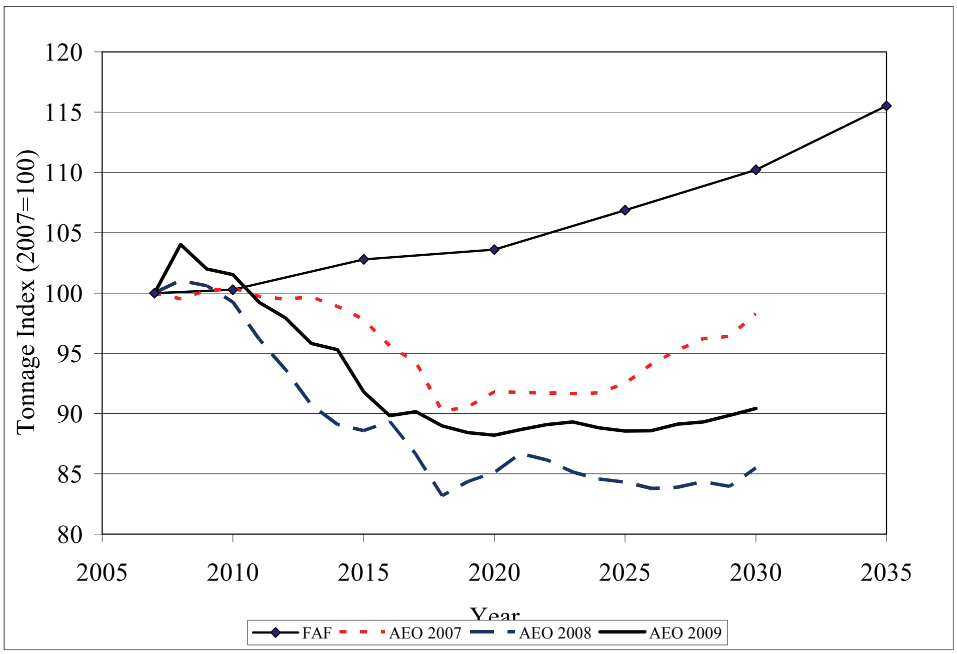
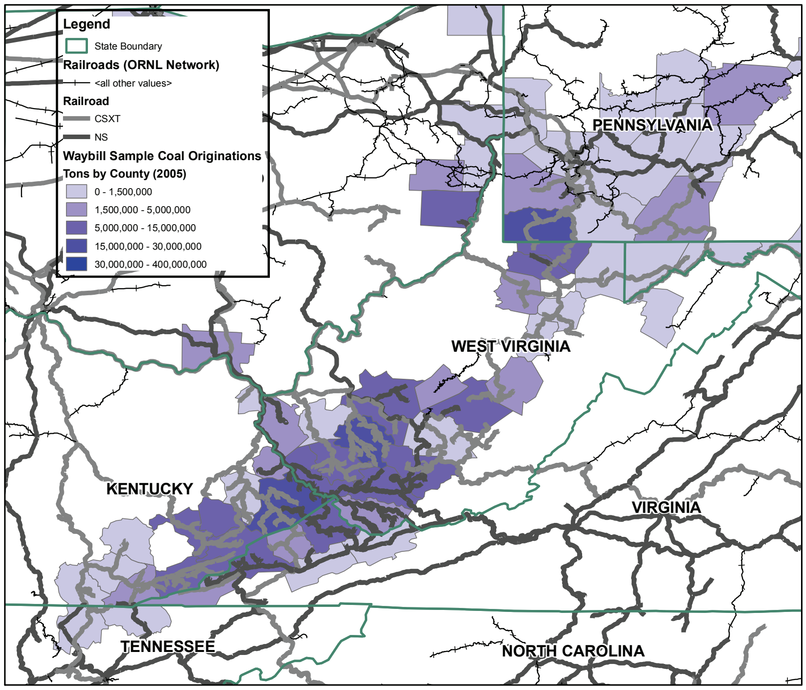


Figure 5-3 shows coal originations by county from the Carload Waybill Sample (CWS) and rail routes for the Appalachian region. Appalachian coal routings are relatively diverse, so modest increases or decreases in aggregate shipment tonnage may not tend to create or relieve major bottlenecks. Nevertheless, much of the region is served by single-track lines, and so could be subject to capacity constraints should production shift away from existing multiple-track main lines, notably within southwestern West Virginia.

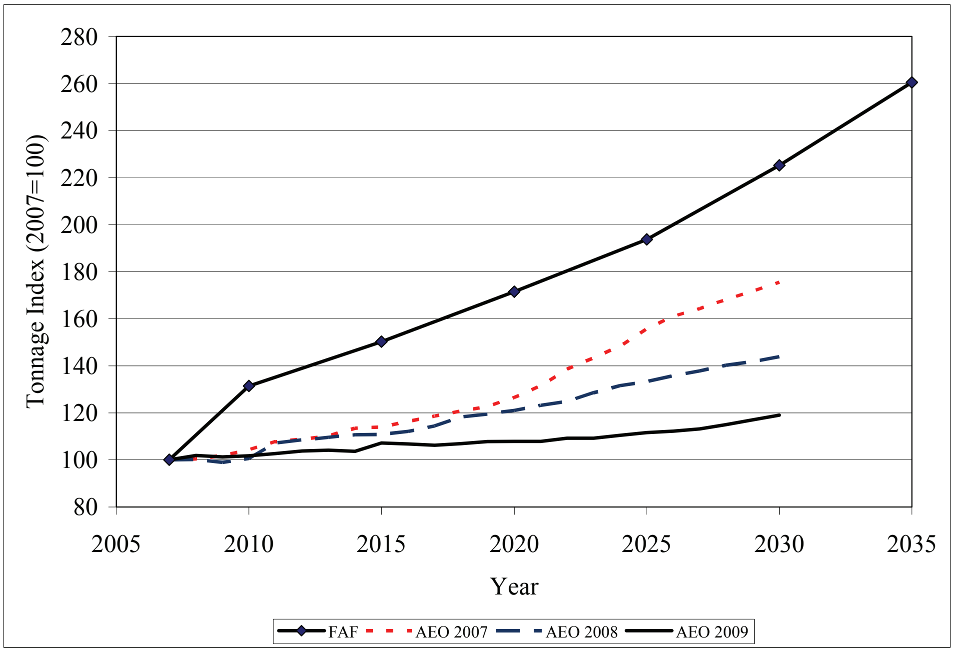
FIGURE 5-3
APPALACHIAN COAL ORIGINATIONS BY COUNTY AND RAIL ROUTES



Western Region

Figure 5-4 compares the FAF forecast for western coal rail shipments with the AEO coal production forecasts. The FAF forecast calls for coal rail shipments originating in the western region to rise to 225 percent of the 2007 level by 2030. The AEO 2007 forecast called for a still very substantial 75 percent increase in coal production between 2007 and 2030, but subsequent scenario revisions have reduced the forecasted production increase to 20 percent between 2007 and 2030 in AEO 2009. In the 2009 scenario, essentially all of the net production increase for western coal is in the northern Great Plains region which includes the PRB; the 2007 and 2008 scenarios include a positive contribution from other western coal and faster PRB production growth. The NEMS methodology tends to fill incremental electricity demands with the low-cost fuel source, which has been PRB coal. Thus, lowering assumed economic growth rates (and hence electricity demand growth) and increasing the cost of coal relative to other fuel sources combine to markedly reduce PRB coal production growth. Since the region's geography is inhospitable to other transportation modes, we would expect PRB coal production and rail tonnage trends to track each other closely.

FIGURE 5-4
COMPARISON OF AEO PRODUCTION AND FAF RAIL TONNAGE COAL FORECASTS, WESTERN REGION

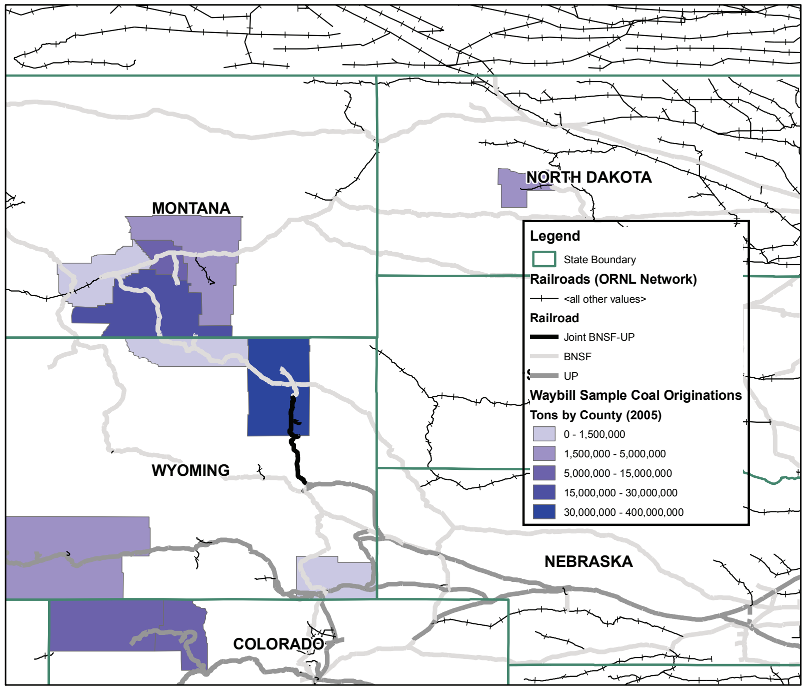


The bulk of Western coal production originates in the PRB region. Figure 5-5 shows PRB originations in the CWS and the main rail routes in the region. Coal rail traffic is highly concentrated on the BNSF-Union Pacific Joint Line and routes branching from this joint line.

The 2009 coal forecast has considerably different implications for required PRB freight rail investments as compared to the 2007 and 2008 forecasts. In 2008, rail construction was underway pursuant to recommendations from a 2006 study to increase the BNSF-UP Joint Line's capacity to 409 million tons, and design work was scheduled for a subsequent phase of expansion to 455 million tons; a final phase would provide for 490-500 million tons of capacity with construction of a fourth main track south of the Bill, Wyoming, yard.[12] The BNSF-UP Joint Line carried 359 million tons of coal in 2007, so a 20 percent increase from 2007-2030 would result in the line carrying 431 million tons in 2030. Under the lower AEO 2009 coal growth scenario, not all of the currently planned joint line capacity expansion would be necessary to serve projected 2030 coal shipment needs. Under the AEO 2007 growth scenario, in contrast, the joint line coal shipments could exceed 500 million tons by the early 2020s and over 600 million tons in 2030. The higher-growth coal scenarios would also likely lead to capacity constraints on some route segments that carry large quantities of PRB coal.

[12] Union Pacific Railroad, Presentations for STB Rail Competition Study, April 2008.

FIGURE 5-5
POWDER RIVER BASIN COAL ORIGINATIONS BY COUNTY AND RAIL ROUTES

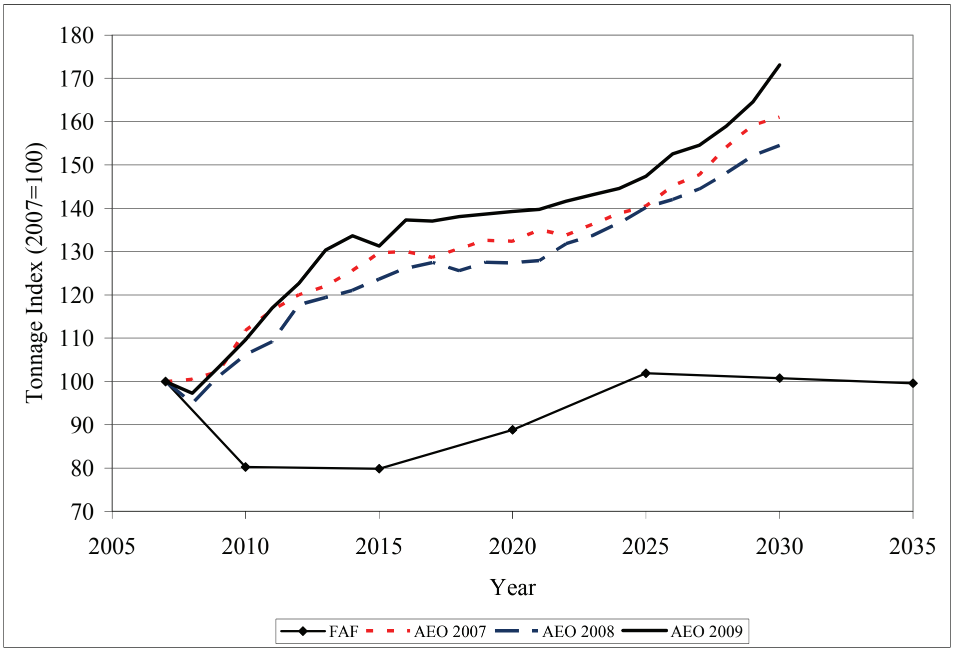


Interior Region

Figure 5-6 shows AEO coal production forecasts and FAF rail tonnage trends for coal for the Interior region. In contrast to the Appalachian and Western regions, the production forecasts are for considerable growth—if from low levels compared to Appalachian and PRB production—while the FAF forecast is for essentially flat rail tonnage of coal shipments originating within the Interior region. The production growth forecast for the Interior region is also robust compared to the AEO forecast scenarios, with a range of 54 to 74 percent growth over the 2007-2009 reference scenarios. The AEO 2009 scenario would call for approximately 37 million additional tons of rail shipments of Interior region coal annually in 2030, extrapolating from the FAF database using AEO 2009 production growth rates.

Interior region coal shipments have a relatively short average length of haul, and a lower modal share for rail, so substituting Interior coal for Appalachian or Western coal would tend to reduce overall rail tonnage and ton-miles. This owes to the region's proximity to navigable waterways and local use of the resource.[13] Nevertheless, current rail traffic for Interior coal appears to be served in part by relatively low-density, single-track lines that may require upgrades to carry significant additional coal traffic; capacity requirements derived from the FAF forecasts would not necessarily capture these needs.

FIGURE 5-6
COMPARISON OF AEO PRODUCTION AND FAF RAIL TONNAGE COAL FORECASTS, INTERIOR REGION



5B GRAINS

The "cereal grains" category is the second largest in the FAF model's forecasted rail tonnage growth after coal. The FAF projects rail tonnage for grains will nearly double between 2002 and 2035, with an addition of 150 million tons. The rail tonnage is projected to grow 22 percent between 2010 and 2020, and an additional 28 percent between 2020 and 2030. The USDA's long-term projections for major field crop production extend only through the 2017/2018 marketing year,[14] so our

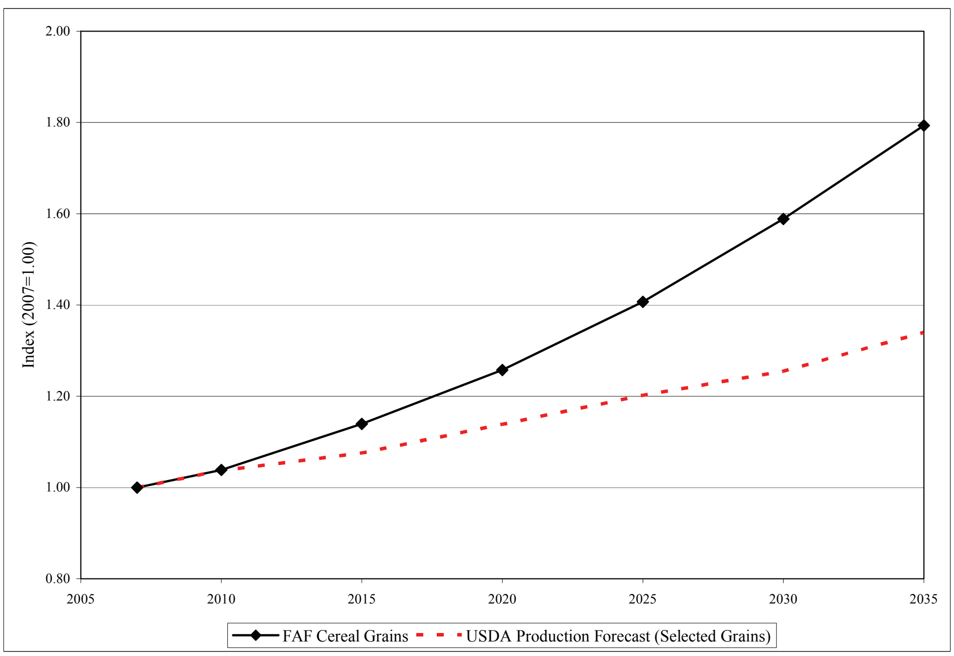
[13] For example, the Illinois "Clean Coal Portfolio Standard Law" of January 2009, is intended to "put Illinois coal to work to produce electricity and substitute natural gas." See Illinois Attorney General, *AG Madigan Thanks Coalition That Worked Together on Clean Energy Law*, Press Release, January 12, 2009, at http://www.illinoisattorneygeneral.gov/pressroom/2009_01/20090112C.html.

[14] U.S. Department of Agriculture, *USDA Agricultural Projections to 2017*, Long Term Projections Report OCE-2001-1, February 2008, at http://www.ers.usda.gov/Publications/OCE081/.

main consideration is whether the 10-year growth rates in FAF are reasonable. The USDA projections suggest that the forecasted rail shipment growth rates for cereal grains in the FAF model are excessive under the assumption of constant modal shares.

Grain production growth in the USDA forecasts is driven primarily by increasing crop yields. In the absence of large amounts of unutilized fertile land in the U.S., total crop acreage is expected to be relatively constant. The projected 10-year growth in production from 2007/2008 to 2017/2018 (the final marketing year in the current long-range forecast) for six major grains[15] is 10 percent. The USDA forecasts that crop yields will increase on the order of 1 percent per year over the forecast horizon. We would expect production potential for very long-range forecasts to follow yield growth. In Figure 5-7, we show the relative trends of FAF rail tonnage of cereal grains versus the USDA forecasts. We extrapolated the USDA forecasts from the 2017/2018 crop mix using the final forecasted rates of yield growth.

FIGURE 5-7
FAF RAIL TONNAGE FOR CEREAL GRAINS VERSUS USDA FORECAST



Since the USDA's forecasts involve stable yield growth and relatively constant total amounts of land under production, we do not consider the estimated growth of grain tonnage hauled by rail in the FAF forecast to be well-founded. We note that cereal grain tonnage hauled by

[15] Corn, sorghum, barley, oats, wheat, and soybeans.

truck increases at similar rates in the FAF model, so that forecast is also likely to be considerably overstated.

5C Waste and Scrap Materials

The "waste and scrap" commodity category includes metal scrap, ashes, and chemical wastes. The FAF database shows essentially flat tonnage of waste and scrap materials between 2002 and 2010 (the 2010 figure represents a slight decline), and very rapid growth in rail shipments of waste and scrap after 2010. As a result of the post-2010 growth, rail shipments of waste and scrap are projected to increase by 127 million tons, or 193 percent, from 2002 to 2035.

The pattern of slight decline from 2002 to 2010 followed by very rapid growth after 2010 raises the possibility that the waste and scrap growth represents an anomalous result from the proprietary Global Insight commodity forecasts underlying the FAF database, particularly insofar as the pattern is mirrored (though applied to a larger base) for the truck mode.[16]

Historical data indicate that some components of the waste and scrap commodity group have grown rapidly in the past, notably coal combustion products as measured by the American Coal Ash Association.[17] However, there is no reason to expect total coal ash production to grow faster than coal combustion, the rate of which is insufficient to produce the forecasted growth in ash. The other major component of this category by tonnage is scrap metal. The most recent U.S. Geological Survey statistics (2006)[18] show that the recycling of a collection of metals, including iron and steel, aluminum, copper, and lead, actually declined slightly from 2002 to 2006, from 75 million tons to 72 million tons, despite considerable increases in the market values of recycled metals. The quantity of scrap metal generated in the U.S. does not have an obvious price response or a clear correlation with domestic economic growth. However, over the same period, scrap metal exports increased from 11.7 million tons to 20 million tons. Increases in scrap material exports may be significant beyond their gross weight as the movements would involve port facilities that may already be congested. Overall, though, we see little evidence to support the magnitude of the increase in waste and scrap tonnage in the FAF forecasts.

[16] There appear to be other such anomalies underlying the FAF database. For example, truck transportation of "precision instruments" is projected to grow from 18 million tons in 2002 to 471 million tons in 2035.

[17] American Coal Ash Association, *1966-2007 CCP v. Production*, at http://www.acaa-usa.org/associations/8003/files/1966-2007_CCP_Svy_Prod_and_Use_Charts(As%20of%2012-29-08).pdf.

[18] U.S. Geological Survey, *Minerals Yearbook 2006*, at http://minerals.usgs.gov/minerals/pubs/commodity/recycle/myb1-2006-recyc.xls.

5D Coal and Petroleum Products (Other Than Gasoline and Fuel Oils)

The category for coal and petroleum products "not elsewhere classified"—notably, excluding gasoline and fuel oils—is projected to exhibit rapid growth relative to rail tonnage as a whole in the FAF model. The 2.8 percent compound annual growth rate is projected to add 112 million tons of domestic rail shipments between 2002 and 2035. As with coal, Department of Energy forecasts from NEMS are available for the petroleum products that comprise the bulk of this category. Recent NEMS runs do not support the forecasted FAF growth rate for this category. The AEO 2009 scenario features negative growth rates (-0.8 percent on average) for liquefied petroleum gases and a residual category of petroleum products excluding gasoline and fuel oils. The AEO 2007 scenario, featuring higher forecasted demand for petroleum products, featured annual average growth rates of 0.7 percent and 0.1 percent, respectively, for liquefied petroleum gases and other petroleum products. Thus a reasonable range of growth for this category, based on recent energy forecasts, would be within 20 million tons of its 2002 level; under such circumstances, at least 90 million tons of projected rail shipments in this FAF category would not materialize as of 2035.

5E Capacity and Investment Implications of Commodity Forecasts

The forecasted annual growth rates for freight rail tonnage in the FAF—1.9 percent for the rail mode in total, and 1.7 percent for freight rail tonnage excluding coal—are not self-evidently inconsistent with real GDP growth at faster rates (see Chapter 4). However, the commodity-level review above suggests that, notwithstanding considerable forecast variability, major components of freight rail tonnage are expected to exhibit relatively low growth during the bulk of the FAF forecast horizon. The growth rate differentials between the FAF forecasts and other commodity-specific forecasts lead to large effects on the rail traffic projections in the later FAF forecast years. Table 5-2 illustrates the effects of forecast variations between the FAF and alternative sources for the four major commodity groups discussed above.

Over the 2002-2035 time period, the FAF forecast calls for an increase in freight rail tonnage of just over 1.5 billion tons for all commodities. Alternative forecasts for the four largest commodities by tonnage could reduce total FAF domestic rail tonnage growth by 60 percent, led by more modest projected growth for energy-related commodities. Our analysis does not imply that the commodity-level forecasts underlying FAF were inherently flawed; rather they may be seen as reflecting expectations for faster growth in coal and petroleum products that prevailed until recently.[19] However, future rail traffic under the FAF assumptions is notably susceptible to the path of coal production.

TABLE 5-2
EFFECTS OF FORECAST VARIATIONS ON RAIL TONNAGE PROJECTIONS, SELECTED MAJOR COMMODITY GROUPS

Commodity	FAF Compound Annual Growth Rate, 2002-2030	Alternative Growth Rate, 2002-2030	Alternative Growth Rate Source and/or Assumption	FAF 2035 Tons (000)	Alternative 2035 Tons (000)	Difference
Coal[20]	2.1%	0.7%	Annual Energy Outlook 2009	1,617,892	998,077	-619,815
Cereal Grains	2.0%	1.0%	USDA field crop production forecasts, yield growth rate	304,733	214,364	-90,368
Waste and Scrap	3.1%	1.7%	FAF Average, Rail Mode	192,856	113,973	-78,883
Petroleum and Coal Products excl. Fuels	2.8%	-0.8%	Annual Energy Outlook 2009	186,573	57,139	-129,434
Total				2,302,054	1,383,553	-918,500

As we noted in Chapters 3 and 4, the process by which growth in rail traffic was translated into rail investment requirements by Cambridge Systematics (CS) is not replicable. However, there is some literature that attempts to estimate average incremental costs for rail capacity investments. We use the approach developed by Burton[21] to calculate very rough estimates of the effects of alternative forecast assumptions on required rail investment. An interesting feature of Burton's analysis is that average incremental costs of capacity investments (i.e., per ton-mile) have much less variation than specific project costs. In fact, Burton's average incremental cost yields investment funding requirements of the right order of magnitude for the FAF-based CS investment forecast.

Using average length-of-haul statistics from the Carload Waybill Sample for the Appalachian, Interior, and Western regions, we calculate a rough estimate of the coal ton-mile growth implied by the FAF forecast for rail shipments of coal. We also calculate the coal ton-miles obtained by recalibrating the 2002 FAF coal traffic to the coal production growth rates

[19] We reiterate that the differences are due to structural considerations and not the current recession.
[20] Coal from the Appalachian, Interior, and Western regions.
[21] Mark L. Burton, *Measuring the Cost of Incremental Railroad Capacity: A GIS Approach*, at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf, p. 24.

by region from the AEO 2009. We use Burton's mean of $0.1185 per ton-mile as the average incremental investment cost.[22] (See Table 5-3.) The linear extrapolation from traffic growth is not intended to capture the details of rail infrastructure investment, but rather to show the order of magnitude of the traffic variations across scenarios. The coal ton-mile growth in the FAF scenario is consistent with an investment requirement in the tens of billions of dollars. As coal accounts for half the FAF rail tonnage growth, the CS investment estimate does not appear to be unreasonable for the FAF scenario. However, the large potential variations in coal traffic alone would tend to drive correspondingly large variations in investment requirements.[23]

TABLE 5-3
EFFECT OF FORECAST VARIATION ON CAPACITY INVESTMENT RELATED TO COAL

Forecast	2002 Coal Ton-Miles	2030 Coal Ton-Miles	Ton-Mile Growth	Incremental Investment Cost ($ millions)
FAF Coal Forecast	591,504	1,222,162	630,657	74,733
FAF Calibrated to AEO 2009	591,504	727,579	136,074	16,125

Note: Data in columns 2 through 4 are in millions of ton-miles.

Of course, lower growth coal scenarios also entail significantly lower railroad revenues and "contributions."[24] Based on results from our competition study, the AEO 2009 scenario would reduce 2030 revenues by $8.5 billion, and the 2030 contribution by $3.6 billion (in 2000 dollars) relative to the FAF baseline.[25]

For any specific corridor, capacity-related investment needs would tend to follow a step function. Over some ranges, additional rail traffic can

[22] This is the $0.00395 annual cost per ton-mile reported in Burton's Table 10 multiplied by the 30-year assumed life of the investments. See Mark L. Burton*, Measuring the Cost of Incremental Railroad Capacity: A GIS Approach*, at http://www.njrati.org/files/research/papers/adobe/TPUG-01.pdf, pp. 18; 24.

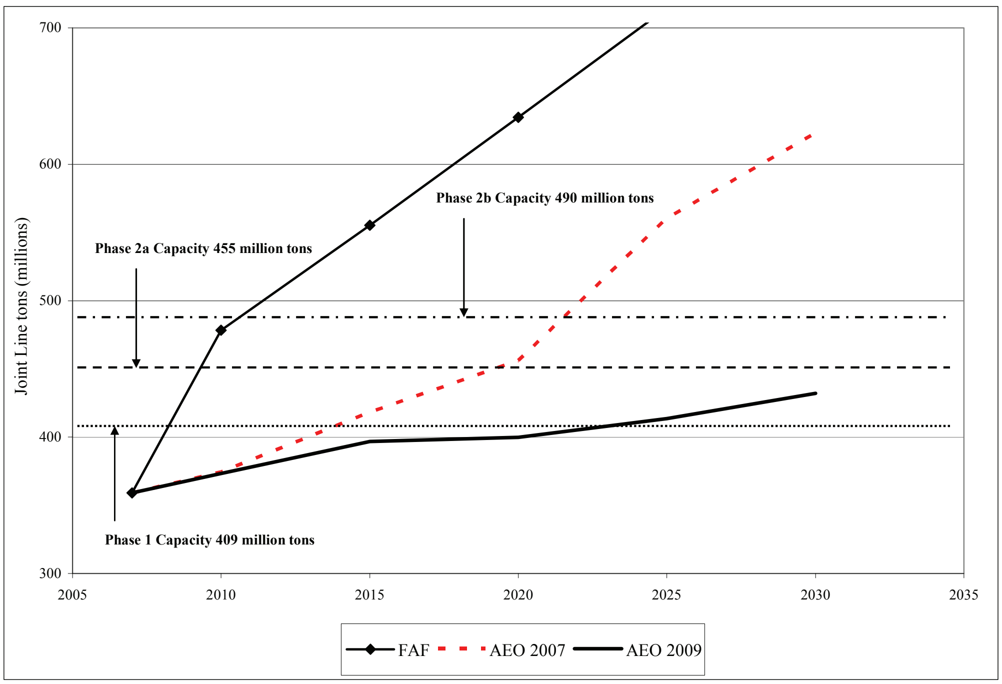
[23] Since rail capacity investment requirements would follow a step function, we expect that small variations in traffic may be absorbed by existing capacity, assuming the network is largely unconstrained to start. With large variations in traffic and many rail network links requiring additional investment, we would expect investment requirements to increase (at least) linearly with rail traffic aggregates.

[24] The change in contribution equals the change in revenue less the change in marginal cost.

[25] Christensen Associates, *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition,* report to the Surface Transportation Board, November 2008, p. 11-22. These estimates are based on the estimated marginal cost of one cent and the econometric Lerner Markup Index of 0.42 for coal shipments reported in Table 11-6 of our report, implying revenue per ton-mile of 1.724 cents in constant 2000 dollars.

be accommodated with relatively little cost, but eventually more significant investments such as construction of additional main track are needed to serve large traffic increments. Thus the need for certain major capacity-expanding investments will depend on traffic levels reaching and/or exceeding various thresholds. Figure 5-8 provides an example based on the PRB Joint Line. As we noted above, BNSF Railway and Union Pacific had planned a series of capacity expansions on this line. A first phase, which was under construction in 2007-2008, was intended to provide capacity of 409 million tons per year. A subsequent phase, for which engineering work was scheduled in 2008, would increase capacity to 455 million tons. A third phase would provide 490-500 million tons of capacity.

FIGURE 5-8
PRB JOINT LINE TRAFFIC SCENARIOS AND CAPACITY THRESHOLDS



We observe that in all three coal growth scenarios, future traffic projections exceed the 409 million ton capacity from the 2007-2008 expansion work. However, the timing varies greatly among these scenarios. The growth rates in the FAF would fill the capacity from the third phase of expansion as early as 2010. In the AEO 2007 scenario, which features coal production growth much lower than the FAF but higher than the current AEO scenario, capacity beyond current expansion plans is required, but not until the 2020s. The growth rates in the AEO 2009 forecast imply that current capacity would not be exceeded until the early 2020s, and the Phase 2a capacity would be sufficient through at least

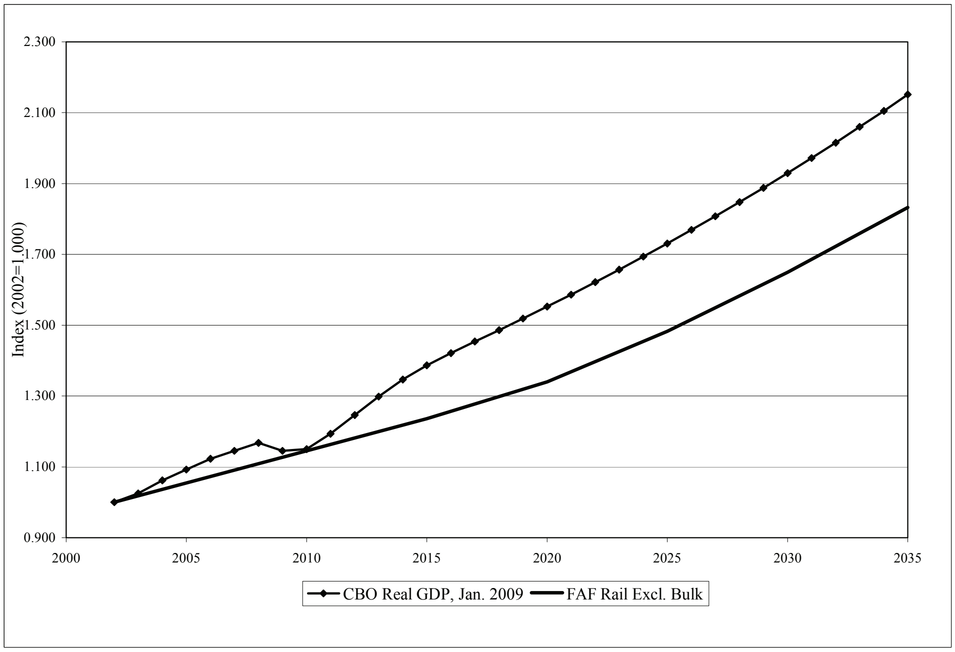
2030. In the low-coal-growth AEO 2009 scenario, the projected traffic growth also would be expected to have relatively minor effects on other line segments with dense traffic, such as the UP Overland Route east of North Platte, Nebraska.[26] With much of the projected traffic not anticipated to materialize until late in the forecast period, there does not appear to be an urgent need for investments to support PRB coal shipments that are not already in the railroads' plans.

5F INTERMODAL TRAFFIC AND TRUCK-RAIL MODAL SHIFTS

Although intermodal shipments are not readily identifiable in the FAF database,[27] it is possible to partition rail traffic between commodities commonly shipped in bulk and those likelier to be shipped in standard shipping containers or truck trailers. The FAF tonnage for the latter group of commodities[28] is of a similar magnitude to the estimated tonnage for trailer-on-flat-car and container-on-flat-car (TOFC/COFC) shipments in the Carload Waybill Sample. Rail tonnage for this group of commodities is projected to grow at approximately the same rate as rail tonnage as a whole. As shown in Figure 5-9 below, "non-bulk" rail shipments are projected in the FAF to grow less rapidly than the CBO's forecast of real GDP, though the FAF forecast predates the current recession and presumably is based on a forecast implicitly assuming higher real GDP growth. The FAF forecast actually may understate the growth in this component of rail shipments if tonnage roughly tracks trend economic growth after recovery from the current recession. The effect of growth at real GDP rates[29] on tonnage for this component of rail would be relatively modest—recalibrating the FAF forecast to the 220 percent cumulative real GDP growth implies some 60 million tons of additional rail freight. However, the effect on carloads (and hence train counts) would be relatively large, since the median TOFC/COFC shipment in the 2007 Carload Waybill Sample is only 10 tons, versus more than 100 tons per carload for coal and grain shipments.

[26] The UP's expected share of the additional 73 million tons of Joint Line traffic would imply less than eight trains per day based on current car loading and train length. While we understand the North Platte-Gibbon segment operates at a high fraction of its fluid capacity as determined by the railroad, this would not in itself cause a capacity constraint.
[27] In particular, the tonnage for shipments using the FAF model's "Truck & Rail" mode is much lower than that for trailer and container shipments in the Carload Waybill Sample.
[28] FAF commodity groups excluding coal and the commodities listed in Footnote 2 above.
[29] Certain components of intermodal shipments, such as imported manufactured goods arriving at West Coast container ports, had been growing faster than real GDP prior to the current economic downturn.

FIGURE 5-9
GROWTH COMPARISON BETWEEN REAL GDP AND RAIL SHIPMENTS OF SELECTED ("NON-BULK") COMMODITIES



Unlike coal, where rail is the dominant transportation mode and thus rail shipment growth will tend to be constrained by coal production growth, the main uncertainties for intermodal shipments relate to economic factors including surface transportation policies that may encourage mode shifting from highways to rail. For the collection of commodities in Figure 5-7, interstate truck tonnage in the FAF grows faster than rail tonnage (232 percent versus 183 percent during the 2002-2035 time period).[30] This implies a reduction in rail's effective modal share after 2010, as shown in Figure 5-10.[31]

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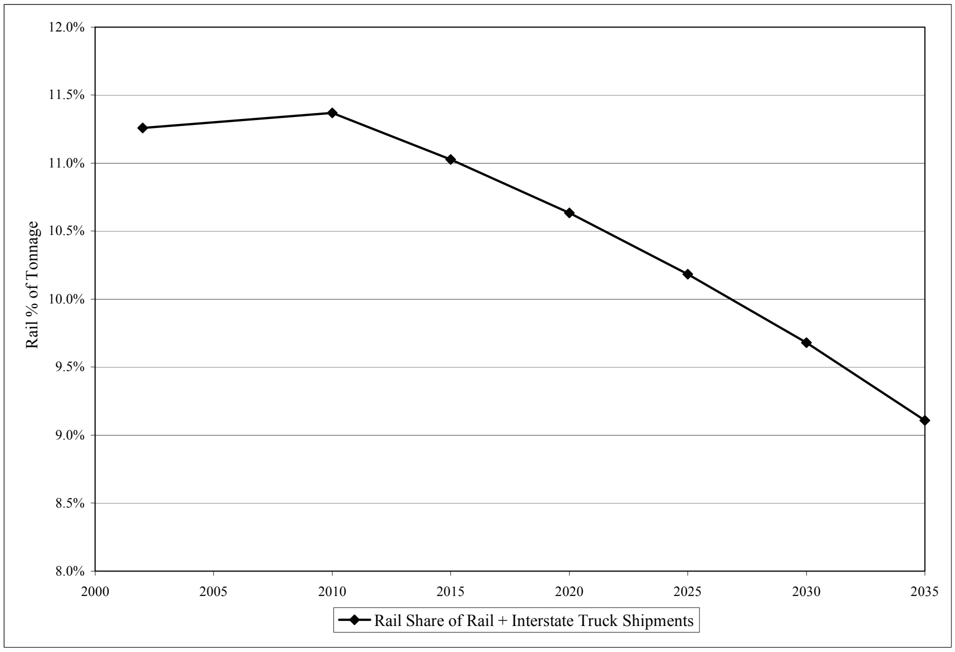
[30]The FAF model's forecasted growth for interstate truck tonnage also represents somewhat faster growth than the January 2009 CBO forecast for real GDP growth (220 percent) for the same period.

[31] Other sources indicate slightly higher truck-rail intermodal shares for longer hauls. See, e.g., "Lower Fuel Prices, International Trade Impact Intermodal's Market Share in Fourth Quarter," *Progressive Railroading*, February 17, 2009, at http://www.progressiverailroading.com/news/article.asp?id=19697.

FIGURE 5-10
RAIL SHARE OF TONNAGE[32] FOR SELECTED ("NON-BULK") COMMODITIES, FREIGHT ANALYSIS FRAMEWORK



In the near term, we would expect weak economic conditions and low fuel prices to exert considerable downward pressure on intermodal traffic volumes. Over the long-term, though, rail's relatively low modal share provides considerable room for truck-to-rail mode shifting to materially increase rail carloads regardless of whether truck tonnage actually increases as rapidly as indicated in the FAF forecasts. As described in Chapter 4, the effects of shocks that raise truck costs more than rail costs (and hence would tend to increase relative prices for trucking) is ambiguous as demand reduction from the own-price elasticity of demand may outweigh mode-shifting due to cross-price demand elasticities. Road pricing initiatives may yield stronger mode-shifting effects, since raising highway user fees or implementing highway congestion charges would tend to raise costs for truck freight without increasing rail costs.

CONCLUSION

In this chapter, we reviewed alternative forecasts for major commodity components of rail freight in the Freight Analysis Framework, which provides the rail traffic forecasts behind the CS investment study. Particularly for coal, the largest component of rail freight by tonnage, rail shipments are likely to be constrained by coal production growth, since

[32] Domestic rail shipments plus domestic interstate truck shipments.

rail is already the dominant transportation mode. Recent environmental concerns that may raise the cost of coal-fired electricity generation create considerable downside risk for coal shipments relative to the FAF forecast. The potential reductions in rail traffic volumes relative to the FAF forecasts would be expected to materially reduce incremental investment needs, but also railroad net revenues relative to the CS study's baseline. It is extremely difficult to narrow the range of forecast uncertainty given the diversity of potential policy responses—ranging from the status quo to radical carbon emissions reductions—and technological uncertainty associated with technologies such as carbon capture and sequestration.

The corresponding risk for intermodal shipments over the long-term appears to be on the upside of the FAF forecast, though intermodal traffic has shown substantial declines due to current economic weakness and may be expected to remain below long-term trends for some time given forecasts of a protracted economic downturn. Rail's share of long-haul shipments of commodities that are amenable to shipment in trailers and standard containers is relatively low, so shifts of moderate fractions of truck freight to the rails would have particularly large effects on rail carloads. A number of key rail corridors have seen considerable capacity-expanding investments, largely in response to increased international trade in manufactured goods, which may also be useful for the provision of truck-competitive services under surface transportation policies that reduce the implicit subsidies to highway transportation from unpriced negative externalities.

Using the rail investment costs developed by Burton as a rule of thumb, the magnitude of the incremental investment requirement from the CS study appears to be roughly correct given the use of the FAF commodity flow forecasts. Current forecasts for the major bulk commodities shipped by rail suggest that much of that traffic may not materialize, though any projection as far out as the FAF is subject to great uncertainty. However, the future path of rail traffic is sensitive not only to commodity forecasts but also surface transportation policy, as the FAF forecasts show that there is considerable potential demand for long-distance transportation that may be economically served by rail, particularly if the negative externalities associated with highway transportation are priced. The OneRail coalition and the AAR are currently sponsoring an update to the CS Study that seeks to quantify the "realistic potential for diversion to/from freight rail" and the "capital and capacity implications" of "emerging environmental and energy scenarios."[33] It would be valuable for a CS study update to explicitly consider a wide range of scenarios representing both current commodity outlooks, and surface transportation and environmental policy options.

[33] Matthew K. Rose, "One Industry, One Vision," *Railway Age*, February 2009, p. 46.

Chapter 5 Appendix
Selected Commodity Origin and Railroad Network Maps

Figure 5-11
Intermodal Shipments, California and Southwest

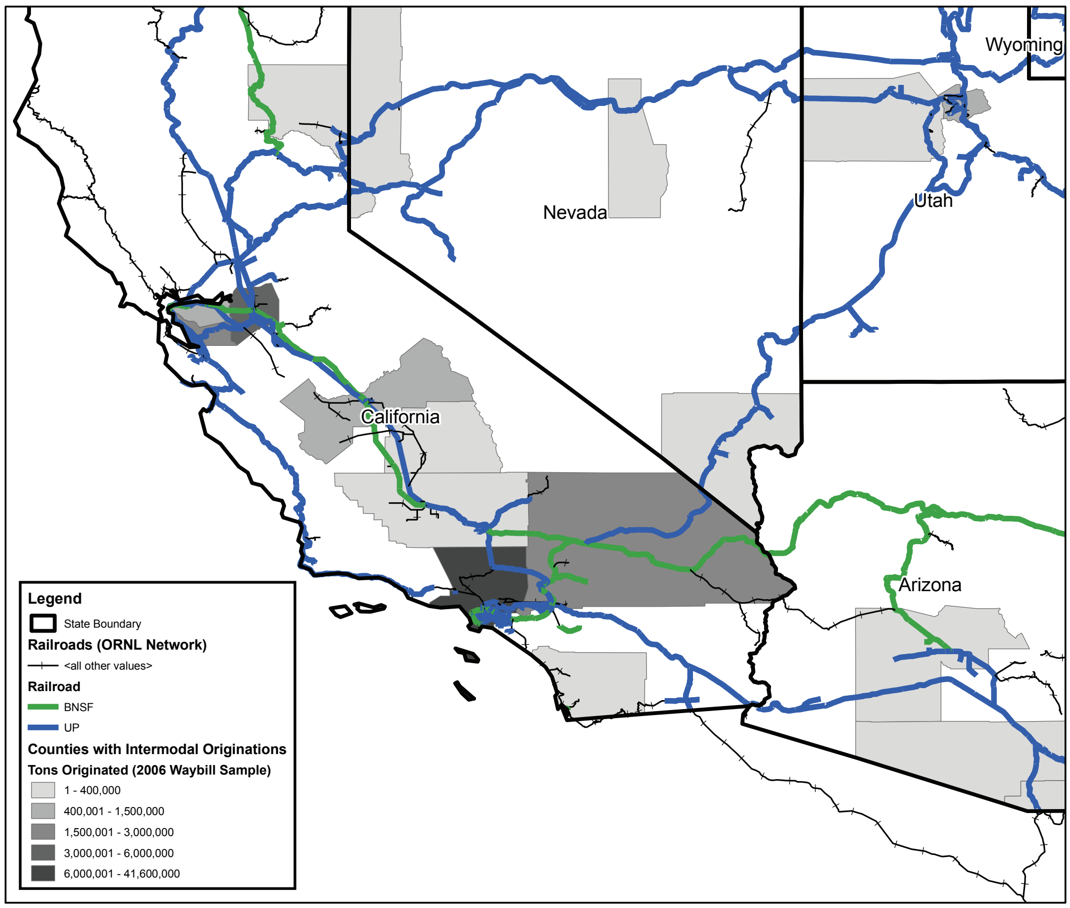


FIGURE 5-12
INTERMODAL SHIPMENTS, NEW YORK METRO AREA

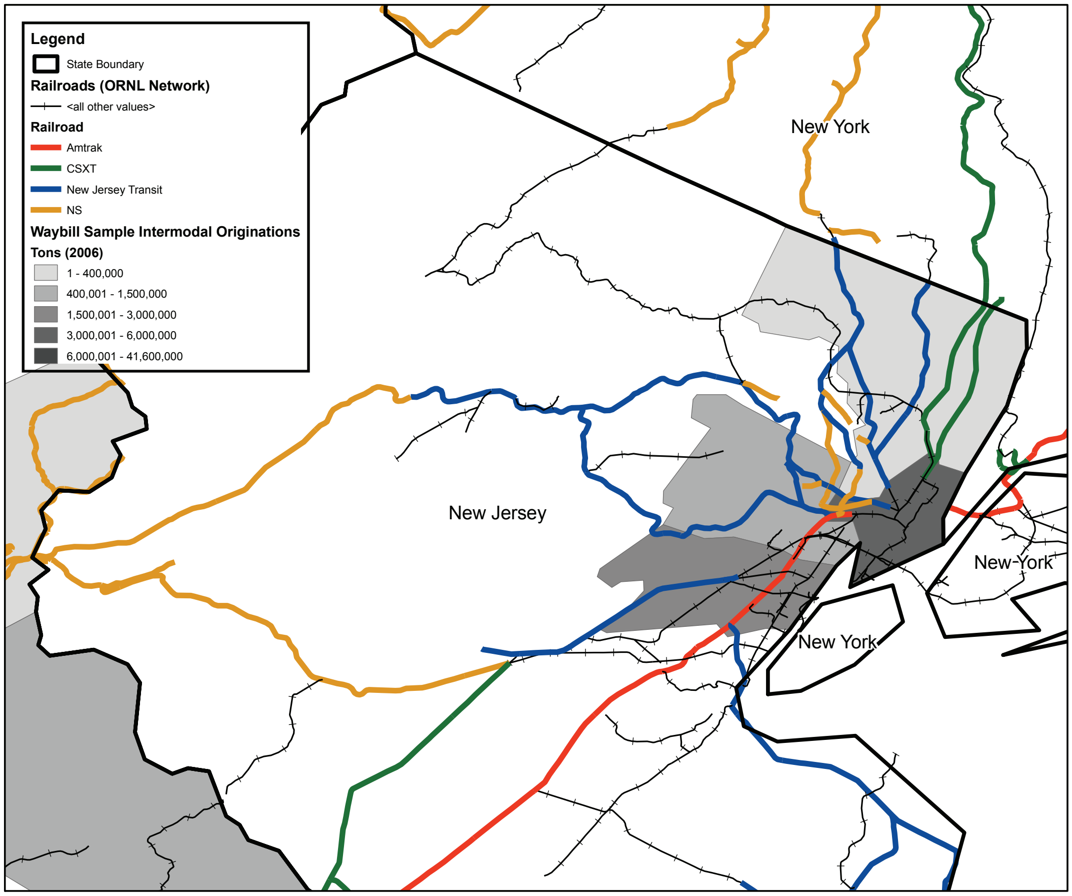


FIGURE 5-13
INTERMODAL SHIPMENTS, SOUTHEAST

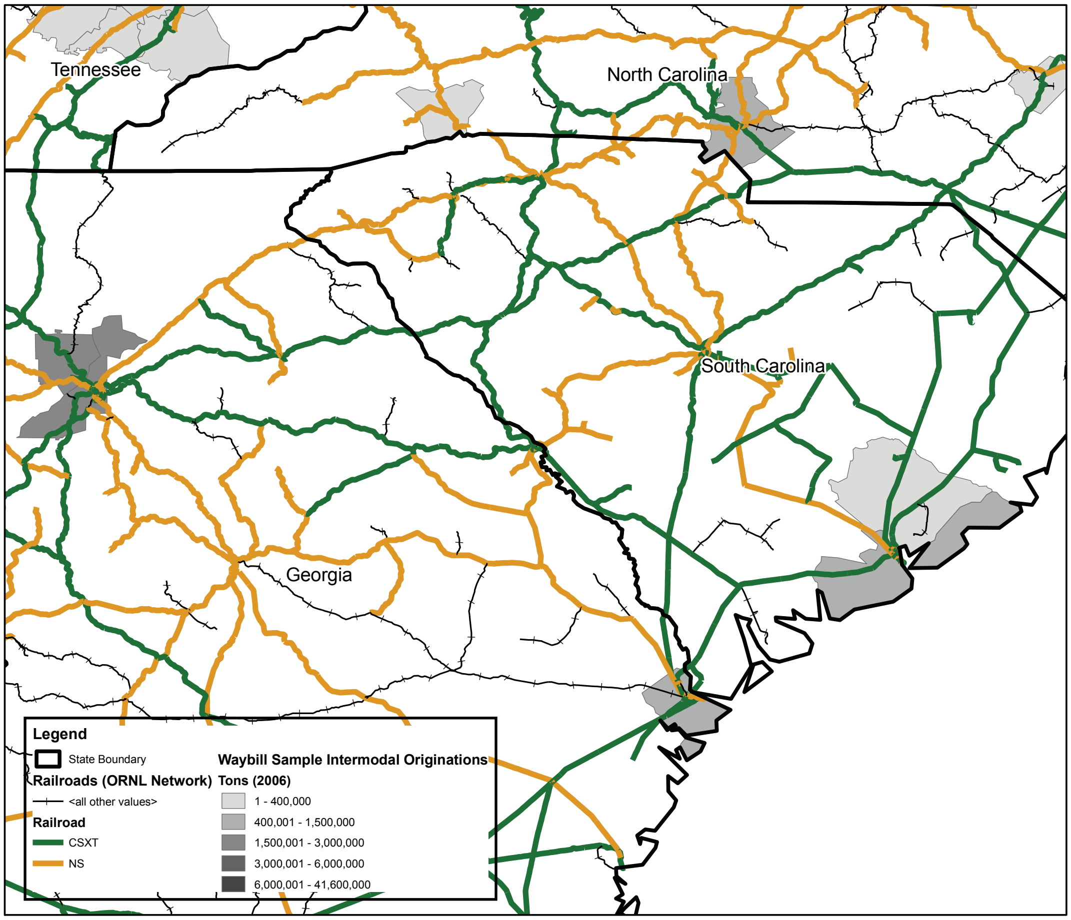


FIGURE 5-14
WHEAT SHIPMENTS, NORTHERN GREAT PLAINS

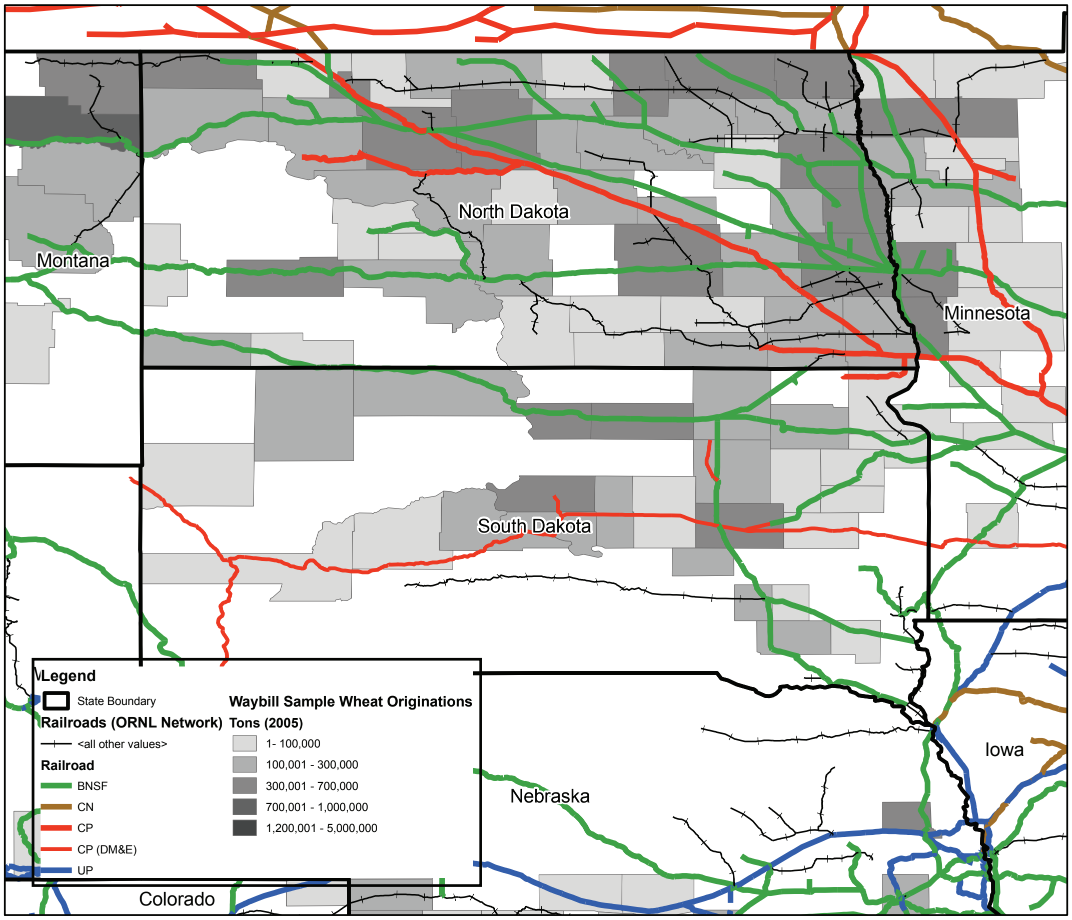


FIGURE 5-15
WHEAT SHIPMENTS, SOUTHERN GREAT PLAINS

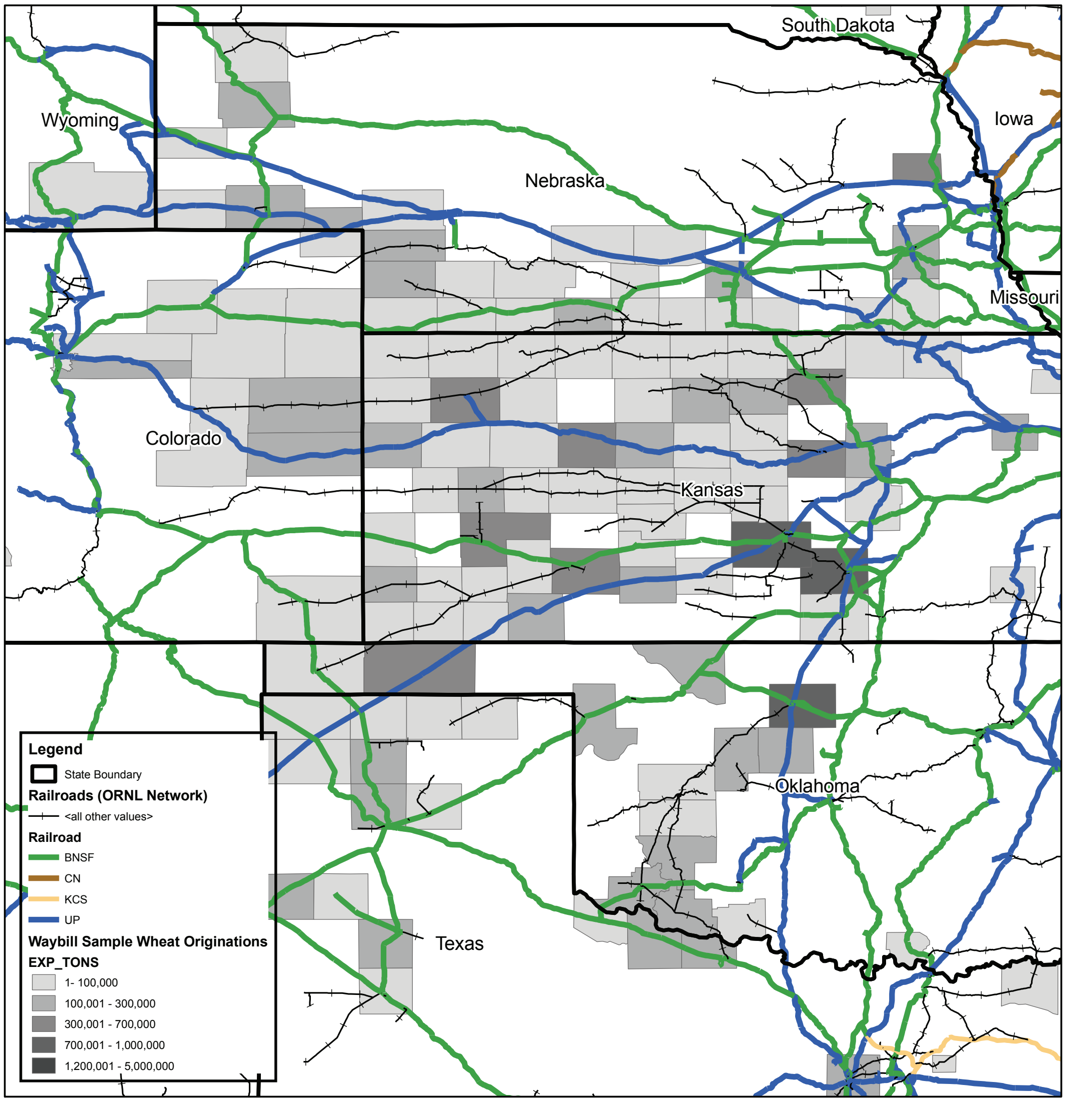


FIGURE 5-16
WHEAT SHIPMENTS, NORTHWEST

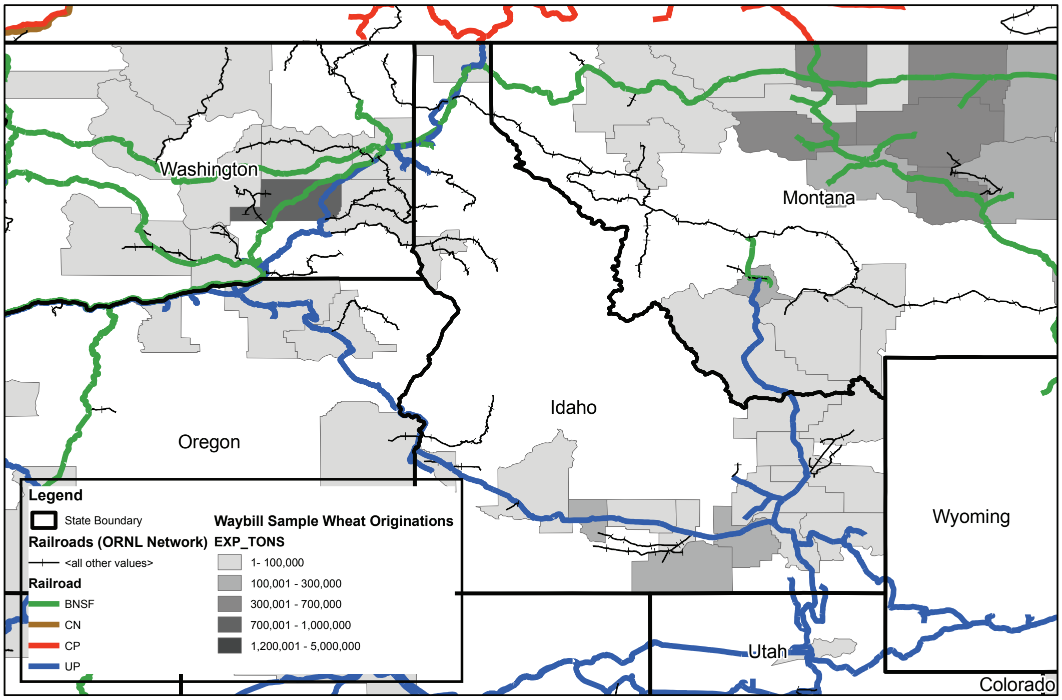


FIGURE 5-17
CORN SHIPMENTS, UPPER MIDWEST

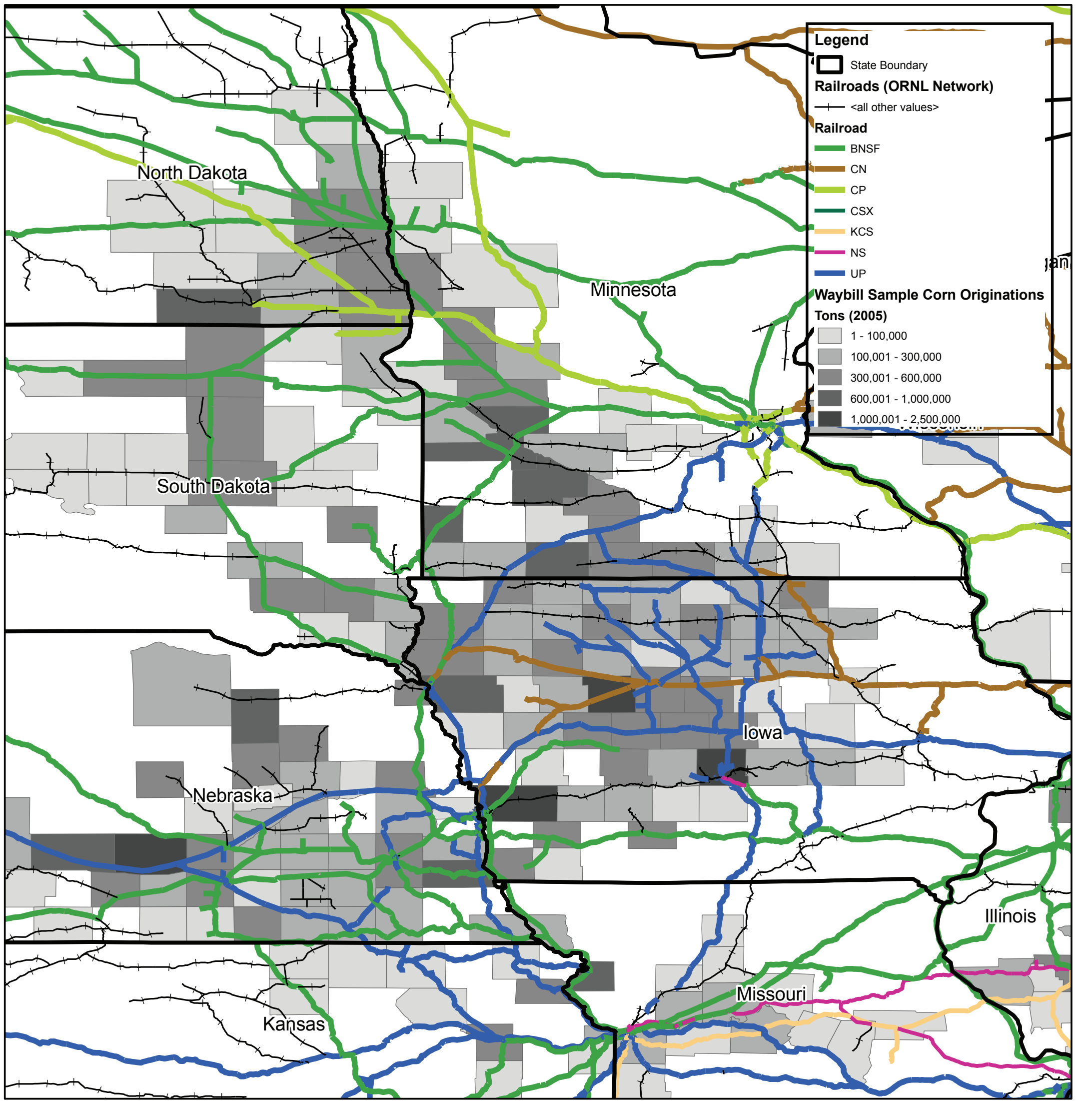


FIGURE 5-18
CORN SHIPMENTS, LOWER MIDWEST

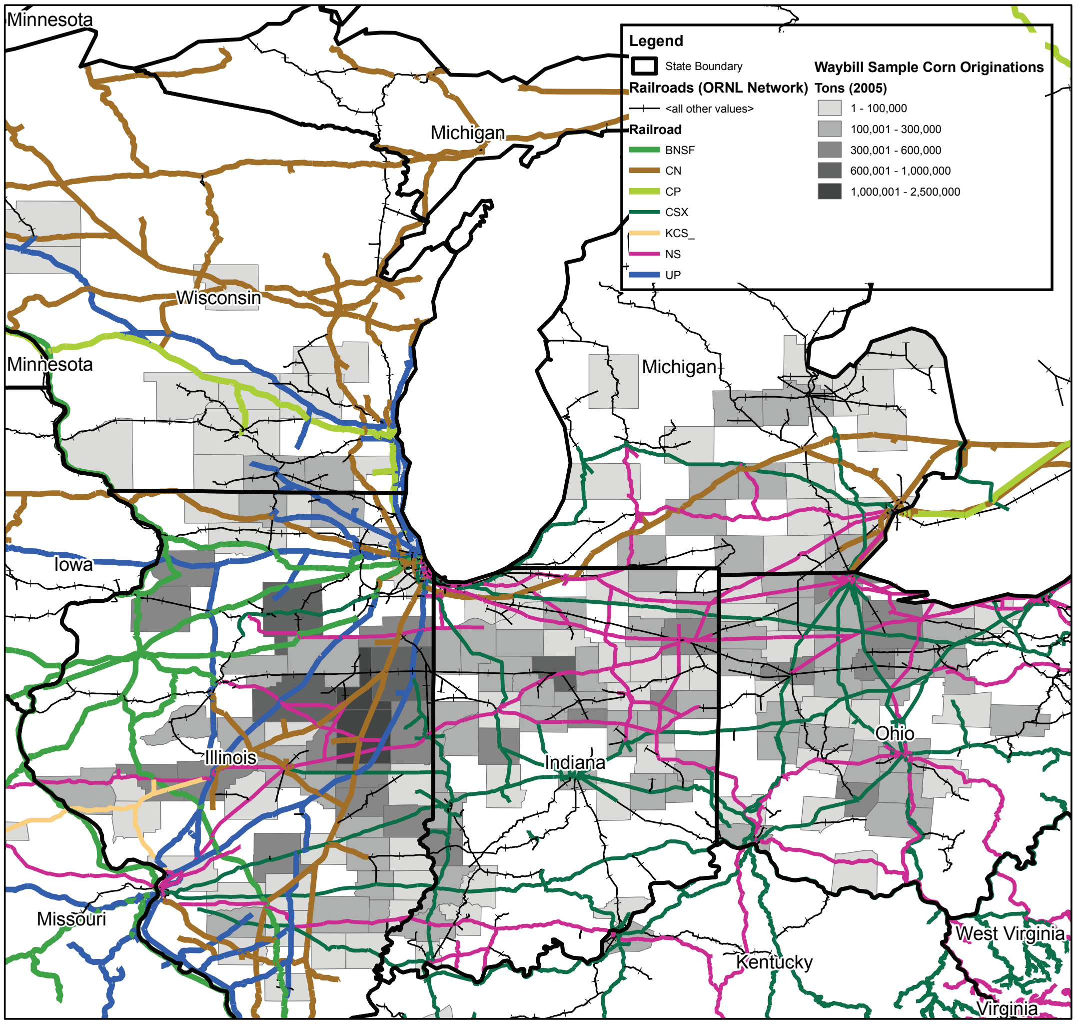
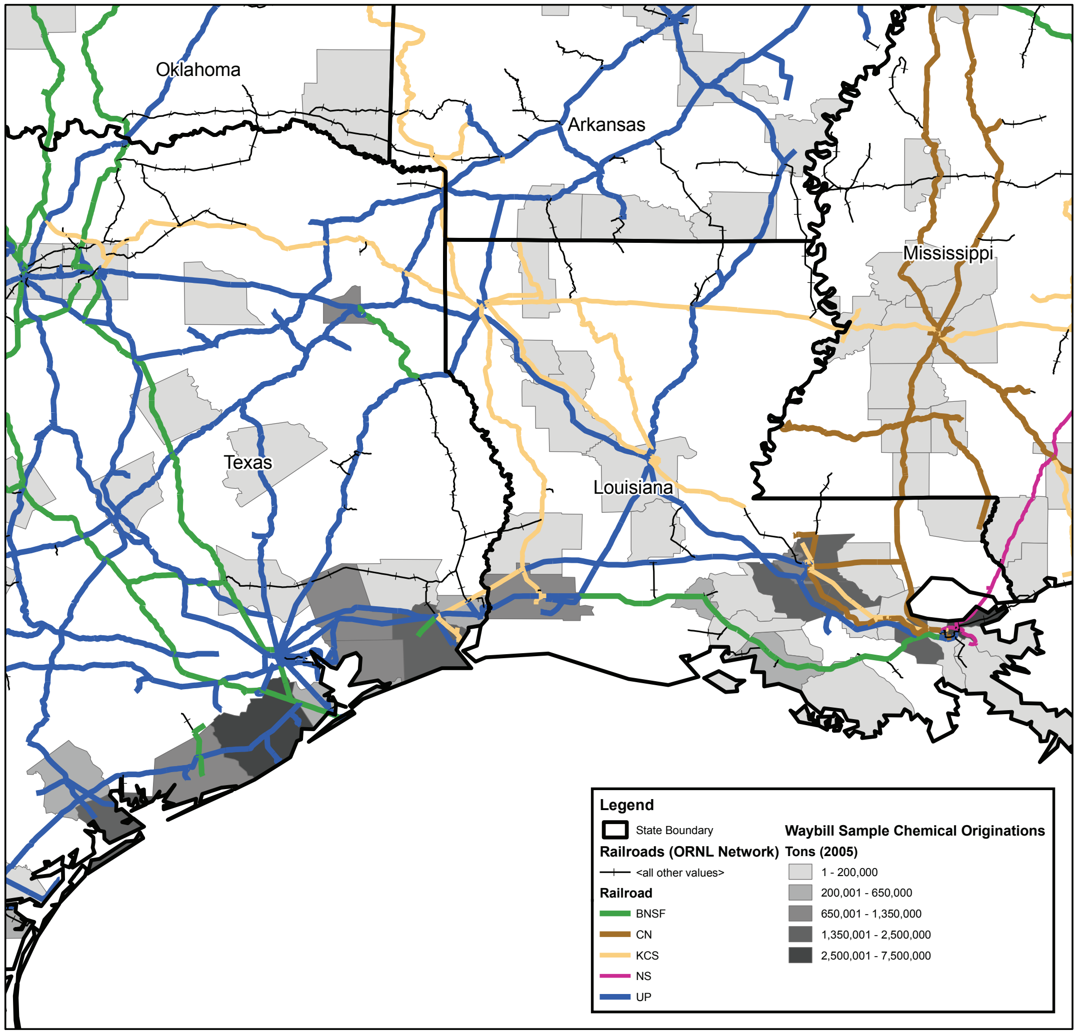


FIGURE 5-19
CHEMICAL SHIPMENTS, LOUISIANA AND TEXAS GULF COAST



Chapter 6 Contents

CHAPTER 6
PUBLIC INFRASTRUCTURE INVESTMENT POLICIES

INTRODUCTION

In this chapter, we discuss the pubic funding of railroad investments and the appropriate economic framework in which the benefits and costs of railroad infrastructure projects should be evaluated. The economic justification for public involvement (e.g., public funding of some type) in private sector investment is that the private market does not provide enough of a "good" whose social benefits exceed its private benefits—i.e., there are positive externalities (external benefits) produced by the investment. There are various approaches to public investment in railroad capacity (e.g., public-private partnerships and tax credits) and, where possible, the social benefits and costs should be quantified to determine the appropriate level of public involvement. In the current recessionary climate, there has been greater emphasis on programs that provide economic stimulus through the creation of jobs and aggregate economic activity. In a more robust economy, some of these programs may not pass a cost-benefit test.[1]

We first discuss the role of public involvement in railroad infrastructure investment. Next we discuss the appropriate framework for assessing costs and benefits of public investment projects. This is followed by a discussion of the potential for public investment when external benefits can not be fully quantified. Finally, we examine various public funding options.

6A RATIONALES FOR THE PUBLIC FUNDING OF RAILROAD INVESTMENT

It is a well-understood economic principle that private, profit-maximizing firms will under-invest from a social perspective when *public* benefits (i.e., positive externalities) exist, creating a demand for public participation of some form. While railroads will typically under-invest in projects that have public benefits (because additional private investment could be unprofitable), they also recognize that they may benefit from public investment. When this occurs, a basis for some type of public-private partnership is formed:

[1] However, even when the economy is performing better, highway projects are not always required to pass rigorous cost-benefit tests.

> After two decades of experience with deregulation, there is recognition that a deregulated, profitable, private-sector rail industry either will not or cannot play the role that the public wants it to play. At the same time, the rail industry is beginning to realize that it cannot expand in size or profitability without help from governments in adjusting the network and in providing equitable treatment of all modes.[2]

The catalyst for such partnerships is the commitment of capital:

> The primary foundation for partnership between the railroads and the public sector is created by intersecting needs, and the catalyst for their partnership is capital: each party gains advantage from the other's contribution, and together they are able to sustain growth.[3]

Of course, public investment must be justified by public benefits:

> The catalyst for partnership is public capital justified by public benefits. By the public shouldering part of the capital burden, the high capital expense to railroads is reduced, and returns on the carrier portion of investment are rendered more competitive for internal and other private funds. Carriers then are enabled or induced to pursue business that is attractive but below hurdle rates, business development is made possible that rail carriers could not justify on their own, and they can address more projects with public benefits. The policy rationale for doing this is that public benefits normally do not invite private capital, but are a proper use of government revenue and deserving rail projects may realize certain of these benefits better than other uses of government money. Public advantages—including road relief—in this way can be brought within reach.[4]

[2] Transportation Research Board, *Rail Freight Solutions to Roadway Congestion – Final Report and Guidebook*, National Cooperative Highway Research Program, NCHRP Report 586, 2007, p. 24.
[3] Transportation Research Board, *Rail Freight Solutions to Roadway Congestion – Final Report and Guidebook*, National Cooperative Highway Research Program, NCHRP Report 586, 2007, p. G-10.
[4] Transportation Research Board, *Rail Freight Solutions to Roadway Congestion – Final Report and Guidebook*, National Cooperative Highway Research Program, NCHRP Report 586, 2007, p. G-9.

One of the primary justifications for public involvement in railroad investment is that there is an economically inefficient level of congestion in the highway transportation network (a negative externality) that can be alleviated by encouraging a shift to more rail transportation. Therefore, the public benefit of increased rail transportation is actually a diminished level of a negative externality:

> Partnerships in rail are appropriate, realistic, and increasingly valuable for the two parties. Rail will not stop road congestion, but it can blunt it. Rail is not always a remedy for freight capacity, but in fitting conditions it is competitive and effective. … When public funds moderate the capital intensity of railroading, new services become possible at a lower cost. When the new services are competitive with highway transport—as many can be—their cost position creates a persuasive advantage and rail wins traffic. In short, good service at a lower cost wins freight business, public funds used with discrimination can help that to happen on rail, public benefits can result, and railroads can grow.[5]

A direct way to relieve highway congestion would be to expand the highway network, but AASHTO argues that railroad infrastructure investment may be a more cost-effective way of relieving highway congestion. Increasing the capacity of the railroad network should lead to a movement of some highway traffic onto the railroad network, which in turn would relieve highway congestion. The role for public involvement in infrastructure projects that change modal transportation shares arises because the users of highway transportation do not face the social costs of their road usage. Policies such as congestion pricing could be imposed on the highway infrastructure, causing users to "internalize" congestion costs, resulting in more economically efficient utilization of the highway network.

Similarly, taxes or other regulatory policies can lead trucks to pay their full costs of wear-and-tear on highway infrastructure, diesel emissions, and so on. Such policies could actually reduce the need for public highway investment to the extent highway freight shippers would make their modal choices on the "correct" or full costs. Under these circumstances, trucking freight rates faced by shippers would likely increase, thus resulting in a reduction in the demand for truck freight services (especially when competitively priced rail or water freight

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[5] Transportation Research Board, *Rail Freight Solutions to Roadway Congestion – Final Report and Guidebook*, National Cooperative Highway Research Program, NCHRP Report 586, 2007, p. G-10.

services are available). However, at present these policies have not been adopted, except in very limited circumstances, and it is likely that the externalities associated with highway usage will be present for the foreseeable future. To the extent that highway transportation is explicitly or implicitly subsidized, then forms of countervailing subsidies for rail and other transportation modes may represent an alternative (though perhaps not ideal) approach for advancing infrastructure improvements with public benefits (or reductions in negative externalities).

Other arguments for public sector involvement in railroad infrastructure improvements are that shifting freight shipments from truck to railroad transportation would lower detrimental emissions, reduce highway maintenance and security costs, increase fuel efficiency, and promote economic development:

> [F]reight rail promises a series of public benefits beyond its effect on overloaded highways. Maintenance and security costs, for example, are borne by the public for highway freight and are privately provided on rail. The environmental advantage and fuel efficiency of the railroad motive system accrue to the public welfare, and their value may be more acutely felt as the 21st Century progresses. Economic development and competitiveness are a common justification for public rail investments, especially in seaport and hub markets where traffic is dense and service extensive. Benefits of this sort imply that congestion relief does not have to be sufficient grounds for a rail project in order to be an attainable result, because projects justified by other objectives can reduce road volumes as well.[6]

Economic development, including an expansion of international trade through port facilities, is considered a strong political (but not necessarily economic) justification and magnet for attracting public funds for railroad investment:

> All of the cases considered here create solutions to roadway congestion, but in almost no case was this the primary motivation for the project. The most common impetus was economic development or the related matters of port or regional competitiveness. Viewed from the perspective of how projects attract political

[6] Transportation Research Board, *Rail Freight Solutions to Roadway Congestion – Final Report and Guidebook*, National Cooperative Highway Research Program, NCHRP Report 586, 2007, p. G-8.

> support and financial backing, these illustrations suggest that the economic card is a strong one to play and can win relief for roadways where a program based on congestion happens not to suffice. Even so, reduction in road congestion formed an important part of project justification in every instance, and crowded roads are linked to the question of competitiveness.[7]

Along these lines, in the current recessionary climate, there has been greater emphasis on programs that provide economic stimulus through the creation of jobs and aggregate economic activity. One must be careful, however, when citing economic development as a public benefit flowing from railroad investment. First, as the passage above recognizes, a reduction in highway congestion is often the underlying factor driving the arguments for increased economic development and global competitiveness. Second, while the promise of economic development may enhance the attractiveness and likelihood that railroad projects will be publicly financed (especially at sub-national levels), whether an initiative under the "economic development" rubric provides a true economy-wide public benefit depends on whether it adds to total economic activity or merely relocates economic activity from one location to another, thus redistributing but not creating new economic opportunities.

Transportation network investments are less likely to be zero or negative-sum economic development games as the benefits of the improvements are not confined to the localities where they are made. A local government may fund a transportation project with the primary intention of benefiting local businesses and industries, but benefits will also accrue to other recipients with traffic moving to (or through) the improved infrastructure. For example, in Chapter 2 we discussed the CREATE project that was designed to alleviate railroad and highway congestion in the Chicago area. However, given the importance of Chicago to the national rail system, congestion reductions in the Chicago area will likely also reduce railroad congestion and backups in far-removed regions, such as west coast ports. Note that the potential for network externalities, as we described above, could lead localities to under-invest in network improvements to the extent that their decision processes fail to account for the spillover benefits in distant locations served by the network. The existence of geographically dispersed network externalities favors policies that coordinate public expenditures at higher levels of government. As an example, we noted in Chapter 2 that CREATE is of such national importance that a team from the U.S. DOT was created to oversee the project at a national level. The balancing act

[7] Transportation Research Board, *Rail Freight Solutions to Roadway Congestion – Final Report and Guidebook*, National Cooperative Highway Research Program, NCHRP Report 586, 2007, p. 27.

here, however, is to make appropriate economic decisions that consider the "big picture" without creating multilayered government bureaucracies that resemble and behave as central planning organizations.

6B COST-BENEFIT ANALYSIS OF RAILROAD INFRASTRUCTURE IMPROVEMENTS

As noted, justifications for public participation in railroad infrastructure improvements generally focus on the public benefits arising from reduced traffic congestion, economic development, reduced environmental emissions, increased safety, and other externalities. Cost-benefit analysis is a policy evaluation tool that has been used in a variety of public investment projects to determine whether the social benefits of a public investment project outweigh its social costs, and to rank projects according to their cost effectiveness. The tools necessary to identify externalities and quantify the benefits that would result from railroad infrastructure improvement include demand models that account for shipper responsiveness to changes in prices, quality of service, and economic activity, and supply models that can be used to model the impacts of particular infrastructure investments on capacity.

If one were to look at railroad infrastructure investment from a railroad's perspective, a cost-benefit analysis would suggest that the shippers' willingness to pay for improved service[8] would provide monetary incentives to railroads for making infrastructure improvements. As long as the shippers' willingness to pay exceeded the project cost, the investment would be undertaken. If the shippers' willingness to pay was less than the project cost, then the investment would not be made, as the private benefits to the railroad would be less than the cost of the investment. However, a different decision may result in the case where the project is viewed from a social perspective, where externalities are considered in the cost-benefit test and the investment decision is based on a comparison of social (private plus public) benefits and costs.

On a highway network where congestion fees are not charged, a cost-benefit analysis would evaluate whether the cost of infrastructure improvements would be lower than the value associated with the reduced congestion (and potentially increased safety). Where the project costs are lower, then the project passes the cost-benefit test. As mentioned above, AASHTO suggests that due to the substantial costs of highway infrastructure projects in some areas, it may be more cost-effective to reduce highway congestion through improvements in railroad infrastructure that divert some freight traffic to rail, rather than through improvements in highway infrastructure that directly increase the capacity of the highway network. In considering the relative merits of the highway

[8] Shippers have expressed interest in improving both the reliability of service as well as the speed of service. For example, see Christensen Report, p. 5-12.

versus railroad project, one must analyze both the relative costs of the two projects and the degree to which traffic would transfer from highways to rail. For the rail project to achieve a higher rating than the highway project in a cost-benefit test, its social benefits would need to exceed its social costs by a higher margin than is true for the highway project, and the shift of highway traffic to rail would have to be at or above a minimum threshold required to relieve the highway congestion.

As this discussion illustrates, because of the relationship of highway and rail freight transportation within a company's logistics operations that we discussed in Chapter 2, a well designed cost-benefit analysis of transportation projects would explicitly address this relationship. The Federal Highway Administration (FHA) has taken some initial steps in designing a cost-benefit tool that can be used to evaluate highway infrastructure projects.[9] This tool puts the demand for highway freight transportation in the context of the logistics operations of the firm. Using data on corridor traffic, the designers of this tool developed econometric models of highway freight transportation demand that related changes in the speed and reliability of transportation (which are related to congestion on the transportation network) to changes in the total amount of freight transported. This demand equation produced a "willingness to pay" function, which then could be used to compare the benefits arising from an improvement in highway infrastructure capacity to the costs of that capacity expansion.

The next step in the evolution of a cost-benefit tool for infrastructure planning would be to expand this framework into a multi-modal analysis of freight transportation demand. This multi-modal framework would fully incorporate the complementarities and the substitutability between highway and rail freight transportation, as well as incorporate safety and environmental benefits. Such an expanded tool could then be used to evaluate and compare the public benefits from highway infrastructure improvements and rail infrastructure improvements. Since a common model and set of assumptions would be applied across modes, a better "apples-to-apples" comparison of social benefits and costs by transportation mode (and, presumably, better decision-making) would result compared to using piecemeal approaches focusing on only a single mode. For example, the standardization of the discount rate used to evaluate all transportation projects would produce better analysis and resulting in better decisions than if some projects were evaluated with a market-determined discount rate and others were evaluated with a risk-free rate.

[9] HDR/HLB Decision Economics Inc, *Freight Benefit/Cost Study: Highway Freight Logistics Reorganization Benefits Estimation Tool Report and Documentation*, FHWA-HOP-08-017, prepared for the U.S. Federal Highway Administration, Office of Freight Management and Operations, February 2008.

6C INFRASTRUCTURE IMPROVEMENTS WHEN SOCIAL BENEFITS ARE NOT PRECISELY QUANTIFIED

Although the development of a comprehensive cost-benefit analysis as described in the previous section would be a desirable next step in improving the evaluation of transportation infrastructure projects, it is often not feasible to collect the information needed for such an analysis. This is particularly true where track has been taken out of service and other instances where detailed data on specific corridors, bridges, tunnels, and terminals are not available.[10]

In considering whether public funding should be used for rail projects when data on corridor traffic may not exist and public benefits are not econometrically quantifiable, some decision makers have eschewed a traditional or enhanced cost-benefit analysis and developed innovative approaches in implementing public/private partnerships. The Shellpot Bridge in Delaware is a prime example.[11] The Shellpot Bridge, a registered historic landmark dating to 1888, failed in 1994 and was taken out of service by then-owner Conrail. As part of the acquisition of Conrail by CSX Transportation and Norfolk Southern Corporation (NS) whereby NS received 58 percent of Conrail's track mileage including all trackage in Delaware, NS agreed to the State of Delaware's request to bring the Shellpot Bridge back into service. NS subsequently determined that the cost of fixing this bridge would be over $13 million, more than twice Conrail's estimate, and decided to indefinitely defer this project. However, the State of Delaware had long been concerned that the awkward rerouting of freight trains since the Shellpot Bridge was taken out of service was accompanied by the significant costs of "foregone rail traffic, increased truck traffic, longer transit times and poorer service."[12] Additionally, NS and the State of Delaware believed that the restoration of rail service over the Shellpot Bridge would reap the benefits of increased business growth to the Port of Wilmington, southern Delaware, and the Delmarva Peninsula.

Despite not being able to precisely quantify the public benefits from the Shellpot Bridge restoration project and no apparent detailed analysis of expected future traffic,[13] NS and State of Delaware officials

[10] For example, the Shellpot Bridge in Delaware (discussed below) had been taken out of service, so there were no current traffic data to develop a comprehensive cost-benefit analysis for an infrastructure investment project to repair this railroad bridge.

[11] The following summary of the Shellpot Bridge project is based on Randolph R. Resor, James R. Blaze, and David W. Campbell, "The Shellpot Bridge: A Public/Private Partnership That Worked," *Review of Network Economics*, 7(1), 2008, pp. 95-110.

[12] Randolph R. Resor, James R. Blaze, and David W. Campbell, "The Shellpot Bridge: A Public/Private Partnership That Worked," *Review of Network Economics*, 7(1), 2008, p. 102.

[13] Randolph R. Resor, James R. Blaze, and David W. Campbell, "The Shellpot Bridge: A Public/Private Partnership That Worked," *Review of Network Economics*, 7(1), 2008, p. 104.

agreed to a public/private partnership to repair the bridge. The traffic volumes over the Shellpot Bridge during the 15 months following its reopening and the railroad's payments to the State of Delaware based on these volumes indicate that if rail traffic continues at a similar level, Delaware will realize an annual return of 9.75 percent on its investment in this project.[14] While the Shellpot Bridge project represents an innovative public/private partnership approach for implementing a rail infrastructure investment project, it is possible that local/state/regional/federal government(s) could forge similar agreements with Class I railroads to upgrade bridges and tunnels that are chokepoints on the rail network as discussed in a 2007 GAO report.[15]

6D FUNDING CONSIDERATIONS

In terms of public funding options, across the board investment tax incentives are simple to implement, but they do not target those investments with the greatest impacts on identified externalities. Tax credits for investing in ways, structures, and qualified locomotive property can encourage general investment behavior that may or may not mesh with social priorities. However, such investment tax credits may be effective in the current recessionary environment to the extent they encourage additional investment or accelerate the timing of investments, producing an economic stimulus that creates jobs and income. On the other hand, targeted public/private partnerships can, in principle, focus on particular externalities, but these mechanisms can be complex and subject to political or bureaucratic manipulation. Where private and social incentives to engage in rail infrastructure investments are imperfectly aligned, efficient arrangements for funding the investments are likely to include a mix of private and public financing as public financing provides incentives for railroads to invest in socially-desirable projects that may not meet purely private investment criteria. The existence of public benefits creates a role for public funding of railroad infrastructure projects even in cases where railroads have sufficient earnings to fund projects on which private benefits accrue to railroads.

Regarding the targeting of railroad infrastructure investment, AASHTO has advocated focusing public participation in railroad

[14] Randolph R. Resor, James R. Blaze and David W. Campbell, "The Shellpot Bridge: A Public/Private Partnership That Worked," *Review of Network Economics*, 7(1), 2008, p. 95.

[15] Government Accountability Office, *Railroad Bridges and Tunnels, Federal Role in Providing Safety Oversight and Freight Infrastructure Investment Could Be Better Targeted*, Report to Congressional Requesters, GAO-07-770, August 2007. It should be noted that over the last decade there have been other innovative public/private partnerships developed to fund railroad infrastructure improvements that share some of the features of the Shellpot Bridge agreement.

investment on nationally significant corridor chokepoints, intermodal terminals and connectors, and urban rail interchanges, with the anticipated result of attracting and retaining freight rail traffic through improvements in service performance. AASTHO claims this "public-policy-driven" approach to public railroad investment is likely to relieve highway congestion, contribute to economic and social development, and provide environmental benefits. AASHTO notes that a number of states have taken steps in this direction, but argues that clear national policy goals must be enunciated and partnerships between railroads and various levels of government must be forged.[16]

Indeed as "public-private partnerships," such financing arrangements are employed in a number of current rail infrastructure projects—for example, the Chicago-area CREATE program and the Heartland Corridor double-stack clearance project. In some cases, the public-private partnership is an "up front" commitment of public money that is fully or partially paid back (e.g., bonds retired) through railroad user fees (usually on a per-car basis) of the facilities. Examples of this type of arrangement include the Shellpot bridge project in Delaware, the Sheffield Flyover in Kansas City, and the Alameda corridor in Los Angeles.

CONCLUSION

Unlike highway projects, where public infrastructure is involved, the public funding of railroad projects involves the commitment of public funds to the infrastructure of private entities. However, given the positive externalities or reductions in negative externalities associated with rail transportation (both freight and passenger), public commitments to railroad infrastructure investment can prove to be socially beneficial. The use of cost-benefit analysis that encompasses global costs and benefits is a key to targeting the most socially desirable projects. However, a tradeoff exists between decision making at the appropriate levels of government and the creation of inefficient government bureaucracies. Furthermore, while general investment tax credits may not always incent private decision makers to make socially optimal decisions, such tax credits will produce positive social benefits to the extent that society determines there generally are public benefits associated with rail transportation.

[16] American Association of State Highway and Transportation Officials, *Freight-Rail Bottom Line Report*, undated, p. 5.

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