BENEFIT-COST ANALYSIS FRAMEWORK FOR EVALUATING INTER-CITY TRANSIT INVESTMENT

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16. Abstract

This report describes the development and application of a benefit/cost analysis (BCA) model to support the evaluation of investment decisions for intercity bus services. The model recognizes two principle types of intercity bus benefits: benefits that accrue to users of the transportation system and benefits that accrue to local areas from the presence of intercity bus services. The model was implemented into a MS Excel spreadsheet application, referred to as the IBBCA model. The IBBCA model takes as input various information relating to the proposed bus service, as well as the travel volume and LOS information corresponding to two scenarios: with the bus service and without the bus service. The model produces as output the total costs, total benefits, net benefits, and benefit-cost ratio associated with the intercity bus service being considered. Four out of the thirteen intercity bus routes proposed in Wisconsin's long range plan, Connections 2030, were analyzed using the IBBCA model. The analysis results indicate that most routes have relatively high benefit-cost ratios and are therefore worthwhile investments for Wisconsin. Madison-Wausau route gives the highest return of all in three future scenarios. The Madison-Green Bay route has the second highest return, followed by the Eau Claire-Green Bay and Wausau-Hurley routes. The results also show that user benefits are the dominating effects of intercity bus investments. Safety and environmental impacts – although are smaller in magnitudes – also provide significant societal benefits.

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Project Summary

The making of intercity bus investment decisions requires rigorous evaluation of the attainable benefits against the costs. The goal of this project is to assist transportation planners in Wisconsin and other states in the country in quantifying the impacts of existing and proposed intercity bus services. This project develops a benefit-cost analysis (BCA) model to more comprehensively evaluate investment decisions for intercity bus services. The proposed model not only recognizes the benefits and costs that accrue to users of the transportation system; it also accounts for the diverse range of economic, social, and environmental impacts of intercity bus service to a community. The capability of this BCA model was demonstrated through the application of the model to selected intercity bus routes proposed for Wisconsin.

Background

Transit agencies and policymakers have long struggled to provide effective public transit. A particular transit challenge that the Wisconsin Department of Transportation (WisDOT) is facing is the provision of intercity bus services to ensure the regional mobility of all people in Wisconsin. Over the last few years, private carriers such as Greyhound have cutback their service aggressively in Wisconsin in attempt to sustain their businesses profitability. This cutback left many residents and communities of Wisconsin with few or no intercity transportation options, leading to substantial personal, economic, and sociological impacts. The abandonment of intercity bus routes also results in critical gaps in the interconnectivity of the statewide multimodal network. To address these immediate issues, WisDOT is considering expanding and subsidizing intercity bus service along key corridors as part of its Connections 2030 long range transportation plan. In a related effort, WisDOT is also reviewing the feeder bus system to better integrate with the existing, and future, intercity passenger rail service.

Although federal funding for developing and supporting intercity bus transportation is available, it is still limited and requires significant matching funds from the local level. This means that states need to be able to get the most out of potential service additions or changes. Also needed is solid evidence of societal benefits from the proposed service improvement to win local financial support. Many past evaluations of intercity transit investments focus on ridership benefits and operating costs, leaving other important economic, environmental, and societal impacts unaccounted for. The omission of these less tangible impacts often leads to the undervaluation of intercity bus investments, which are then placed on an unequal footing when competing for public monies with highway-oriented projects.

Jointly funded by the Midwest Regional University Transportation Center (MRUTC) and the Wisconsin of Department of Transportation (WisDOT), this project addresses the shortcoming of past evaluation studies of intercity transit investments by developing a BCA tool capable of translating all positive and negative impacts associated with an intercity bus investment into monetary terms and assessing them on a common temporal footing.

Process

The project began in March, 2007, and was completed in August, 2008. The research entails conducting the following eight tasks:

1. Synthesize existing literature on the evaluation of intercity transit systems.

2. Review existing BCA tools for transit investment evaluation.

3. Identify a list of, and the corresponding measures for, benefit and cost impacts most relevant to the evaluation of intercity bus investments based on the findings from tasks 1 and 2.

4. Identify the data items required for calculating the measures identified in task 3 and acquire these data items for selected intercity bus corridors in Wisconsin.

5. Develop an Excel-based spreadsheet model that incorporates the measures identified in task 3.

6. Apply the proposed model to the test corridors and assess applicability.

7. Prepare a final report and a guidebook for benefit cost analysis using the proposed model.

8. Conduct a workshop for WisDOT staff on the use of the proposed model.

Findings and Conclusions

Our review of existing literature and BCA tools revealed that, compared to the large body of theoretical and practical work on the benefit and cost assessment of highway investments, existing studies of intercity transit benefits and costs are much fewer. Few studies have attempted to assess the full range of benefits of intercity bus service, though more inclusive transit impact taxonomies have been developed with intercity HSR and rural/urban transit improvements in mind. These transit impact taxonomies are not directly applicable to the intercity bus context for at least two reasons. First, some of these impact categories are more relevant to the intercity bus context than the others. Second, the methods for valuating intercity bus impacts are likely to differ from those used in the rail or local transit context.

This project builds on established definitions and measures of transit benefits/costs while examining the relevance and applicability of these definitions and measures to the context of intercity bus service. The result is a BCA framework specifically developed to capture a broad range of impact measures, including those accrue to users of the transportation system (referred to as *Individual Travel Impacts*) and those accrue to local areas from the presence of intercity bus services (referred to as *External Impacts*). Specifically, the individual travel impacts include user cost savings, option value of transit, and chauffeuring cost reduction. The external impacts include environmental, safety, and economic impacts of intercity bus service to society.

The proposed benefit-cost analysis framework was implemented in Microsoft Excel, referred to as the Intercity Bus Benefit/Cost Analysis (IBBCA) model. The model was applied to analyze four out of the thirteen intercity bus routes proposed by WisDOT. These four test routes are:

- Madison-Green Bay, via Fond du Lac and the Fox Cities
- Madison-Wausau, via Stevens Point
- Eau Claire-Green Bay, via Wausau
- Wausau-Hurley, via Merrill, Rhinelander, and Minocqua

Each of these three test routes was evaluated in the context of three 2030 scenarios, each representing an alternative for what the statewide transit network could look like in the year 2030. The scenarios are defined as follows:

- Scenario A – *Status Quo plus a single proposed route*. This scenario assumes that, in year 2030, the status quo (year 2008) intercity transit network would be maintained and each test route has been separately added to this network.
- Scenario B – *Status Quo plus all proposed routes*. This scenario assumes that call thirteen candidate bus routes will have been implemented and added to the current-year intercity bus service.
- Scenario C – *Status Quo plus high-speed rail and all proposed routes*. This scenario assumes the addition of the High-Speed Rail (HSR) network (along with the accompanying feeder bus service) to Scenario B.
- Scenario D – *Status Quo plus High Speed Rail, Essential Bus and Proposed Routes*. This scenario assumes the presence of not only the status quo bus service, the HSR and its feeder buses, and the thirteen proposed routes; but also the future essential bus (FEB) service.

The scenario analysis results revealed that the Madison-Wausau route has the highest BCR – and therefore the highest economic return – among the four test routes consistently across future scenarios B, C and D. In scenario A, it is the Madison-Green Bay route that has the highest BCR. In scenarios B and D, the Madison-Green Bay route has the second highest BCR, followed by the Eau Claire-Wausau-Green Bay and Wausau-Hurley routes; while, in scenario C, Eau Claire-Wausau-Green Bay route has the second highest BCR. Therefore, Madison – Wausau and Madison – Green Bay are the best two routes. Madison – Green Bay performs better when it is added to the status quo intercity transit network (scenario A), while Madison – Wausau performs better in the scenarios with more other transit service (scenario B, C and D). Even though the Wausau-Hurley route has the lowest return of all test routes, its BCR is still relatively high for the three scenarios (except scenario A). The consistently high BCR values suggest that the gain from implementing any of these test routes significantly out weighs their cost, with a large contributing factor being the user benefits from implementing intercity bus service.

The BCR of each bus route was found to vary significantly across scenarios. This is because the marginal impact of adding any given bus service depends on its relative location, complimentary effect and competitiveness to existing bus lines, the presence/absence and the relative performance of other modes in the system, as well as existing travel conditions along the corridor, and various environmental, and economic conditions.

Recommendations for Further Action

- Our analysis of test routes demonstrated the importance of recognizing the substitutive and complimentary effects among the intercity bus routes. Since an intercity bus route is operated in a statewide transportation network, its performance is likely to depend on the other part of the transit network or even other modes. Thus, it is important to analyze any given intercity bus route from a statewide perspective. Analyses that focus only on the corridor where the bus route is to be implemented would lead to erroneous conclusions.

- The accurate analysis of intercity bus benefits and costs requires reliable travel demand forecasts. This in turn calls for a well calibrated travel demand forecasting model that is capable of producing accurate forecasts at a finer level of geography than typically required for statewide long range forecasting. To support BCA studies such as those demonstrated in this project, analysts should consider enhancing their travel demand model in the following ways:

    - Apply a tighter convergence criterion and allow for longer run time.

    - Integrate long distance travel model with daily travel model through appropriate feedback.

    - Code the transit network with as much and as accurate temporal (scheduling) and spatial (stop/route location) details as possible.

- Data availability is a limiting factor to the comprehensive analysis of intercity transit benefits, as evident in our application of the IBBCA model to Wisconsin. Often, information such as the number of avoided chauffeuring trips and the amount of induced commute and recreational/retail travel are not readily available from travel forecast models or the travel survey data used to develop these models. In order to properly account for the benefits arisen from chauffeuring reduction and/or the various economic impacts of intercity bus service, states are highly recommended to collect the necessary data through on-board surveys or stated preference surveys. Such surveys will also provide a valuable opportunity to expand the BCA framework presented here by assessing and including other probable types of induced travel (for example, access medical and educational facilities) and their corresponding societal impacts.

CHAPTER 1. INTRODUCTION

Under Title 49 U.S.C. 5311(f), intercity bus service is defined as regularly scheduled bus service for the general public which (1) operates with limited stops over fixed routes connecting two or more urban areas not in close proximity; (2) has the capacity to carry passenger baggage; and (3) makes meaningful connections with scheduled intercity bus service to points outside the service area. Clearly, intercity bus service plays a vital role in the provision of regional mobility. It is particularly important in rural and non-urbanized areas, where transportation connections are often needed to access the more diverse economic, education, health care, and other services in larger urban areas. Moreover, it often provides the only means of travel for those who cannot, or choose not, to drive or fly for long-distance travel.

The intercity bus industry arose in the early 1900s, with the ridership totaled over seven billion passenger miles in 1929. The concerns about the extent and stability of the long-distance bus industry led to the Motor Carrier Act (MCA) of 1935, which placed interstate bus service under the authority of the Interstate Commerce Commission (ICC) and provided federal regulation on route authority, service types, and financial responsibility. Such government involvement demonstrates that both federal and state policies have long recognized a need to support rural bus services (KFH Group, 2002). Intercity bus ridership peaked just above 27 billion passenger miles and the industry attained highest-ever market share during World War II (Walsh, 2003). In the postwar period, intercity bus ridership began to plunge as the Interstate Highway System opened up and air travel became an increasingly attractive option for long-distance travel. The hope of saving the intercity bus industry's decline led to the passage of the federal Bus Regulatory Reform Act (BRRA) in 1982, giving bus operators greater flexibility in setting fares, routes, and service frequency. However, the enactment of the BRRA was followed by a further declining service due to operators abandoning money-losing routes. For example, in Wisconsin alone, 35 communities lost existing service within three months of deregulation. Over 18% of communities throughout the nation lost service in the first year.

Recognizing the need to provide ongoing funding assistance for rural intercity routes, federal policymakers created as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) the Section 18(i) program to support intercity bus service. In 1994, legislation codified the Federal transit program, changing the citation for the rural transit program from 49 U.S.C. app. 18, to 49 U.S.C. 5311. Funding under Section 5311(f) covers capital, operating, and administrative costs for state and local agencies, transportation operators, and other entities operating transit services. The Federal share for intercity projects is limited to 50 % of the net cost for operations and 80 % of the net cost for capital projects and project administration. Strong local financing is therefore necessary to help support intercity bus service provision. Other possible sources of funding include the Transportation Program (STP) for supporting vehicles and facilities and the state Rural Transit Assistance Program (RTAP) for providing training, technical assistance, research, and related support services for rural public transportation.

Increased state and Federal funding for public transit has contributed to an expansion of mobility options. Yet, it could not stop the continued decline in intercity bus service provision. Between 1980 and 2002, the drop in scheduled service is estimated at 50.6 % (Schwieterman *et al.*, 2007). In the recent years, however, there were also signs of modest service increase in some cities. For example, due to the emergence and expansion of low-cost operators, the level of service on the East and West Coasts and in the Central States was growing significantly for the first time in more than 40 years (Schwieterman *et al.*, 2007). Factors such as high fuel prices, rising traffic congestion, and more aggressive marketing strategies have also led to regained respectability for intercity bus among the traveling public. The energy-efficiency advantage of intercity bus transportation as compared to other modes of long distance travel also increases its appeal (Congressional Digest, 2001). In response to the rising consumer demand for intercity bus service and concerns over as energy and environmental issues, many States are working to better support their intercity bus program.

Although federal funding for developing and supporting intercity bus transportation is available, it is still limited and requires significant matching funds from the local level. This means that States need to be able to get the most out of potential service additions or changes. Also needed is evidence of societal benefits from the proposed service improvement to win local financial support. The making of intercity bus investment decisions – just as the decision-making for other types of transportation investments – thus requires rigorous evaluation of the attainable benefits against the costs. Benefit-cost analysis (BCA) is a widely accepted method for this task. In a nut shell, BCA entails translating all positive and negative impacts associated with an investment or policy into monetary terms and assessing them on a common temporal footing. When applied to justify public expenditure on a transportation improvement project, the analysis needs to account for the diverse range of economic, social, and environmental impacts to the greatest extent possible. While naming the impacts and summing up their monetary values are relatively straightforward tasks, estimating the monetary values of impacts and identifying data for doing so are not. Quantifying in terms of monetary values is particularly challenging for the less tangible impacts. For this and perhaps other reasons, many past evaluations of intercity transit investments focus on ridership benefits and operating costs, leaving other important economic, environmental, and societal impacts unaccounted for. The omission of these less tangible impacts often leads to the undervaluation of intercity bus investments, which are then placed on an unequal footing when competing for public monies with highway-oriented projects.

The goal of this research project was to assist transportation planners in estimating the impacts of intercity bus service improvement and prioritizing investments based on their potential pay-off. Specifically, this project worked to:

- Identify the benefit and cost considerations most relevant to the evaluation of intercity bus services and the methods by which these considerations can be measured and quantified.

- Develop a spreadsheet model that serves as a comprehensive BCA framework specifically for evaluating proposed intercity bus investments.

- Use Wisconsin as a case study and apply the proposed BCA model to evaluate selected intercity bus routes.

It should be noted that, while the BCA model created through this work was applied and evaluated using Wisconsin data, it is a generic decision-support tool applicable to the evaluation of intercity transit investments in other geographic contexts.

The purpose of this report is to detail the research performed, and the model building, testing, and analysis effort completed as part of this project. The remainder of the report is organized as follows. CHAPTER 2 provides an overview of the benefit cost analysis method as it applies to transplantation decision making. CHAPTER 3 presents the literature review conducted on past intercity bus studies, transit impact definitions, and transit benefit-cost analyses. CHAPTER 4 discusses the analysis framework that was developed in this project to measure the impacts associated with intercity bus service. CHAPTER 5 describes the implementation of the Excel-based benefit-cost analysis tool. CHAPTER 6 outlines the process of applying and verifying the proposed benefit-cost analysis tool using data from Wisconsin. The results of the model application are discussed in CHAPTER 7. Finally, CHAPTER 8 offers conclusions on the analysis results and the implications of the research.

CHAPTER 2. OVERVIEW OF BENEFIT AND COST ANALYSIS CONCEPTS

Benefit-cost analysis (BCA) is a widely accepted method for making and defending transportation investment decisions. The method is used to determine the future impacts of an investment or policy and compare them to the costs. The positive and negative impacts are all translated into monetary terms and assessed on a common temporal footing. The end result often takes the form of a Benefit-Cost Ratio (BCR), which is derived from the total net benefits divided by its total cost. The BCR is used for determining whether the mitigation project being considered is a sound investment, as compared to the status quo. The BCR can also be used to compare and rank alternative courses of action.

The transportation arena has seen widespread use of BCA. To set the stage for the remainder of this report, this chapter provides a brief overview and discussion of the general framework for conducting a BCA of transportation investments. Section 2.1 outlines the typical steps for analyzing the full benefits and costs of a transportation investment. Section 2.2 discusses the common pitfalls and issues encountered in a BCA. Section 2.3 describes popular software packages that decision makers use to evaluate transportation investments.

2.1 Analysis Framework

Although the process of evaluating a transportation investment varies depending on the setting and purpose of the evaluation, the process typically follows the following sequence of steps (Transport Canada, 1994; Weisbrod and Weisbrod, 1997; ECONorthwest, 2002):

1. *Define the base case and identify the option(s).*

   Typically, the BCA process starts by defining the common point of reference (*i.e.* the base case) against which to assess the incremental benefits and costs of the alternatives. This is followed by identifying a wide range of options to ensure that promising solutions are not overlooked. The specification of the base and options can be thought of as identifying alternative values for key decision variables for the problem.

2. *Identify the scope of analysis.*

   This entails determining the types of investment impacts that are relevant to the evaluation, the user and non-user groups that should be considered, and the temporal and geographic scale at which the potential impacts are to be evaluated.

3. *Identify investment impacts within the defined scope.*

   As part of this process, investment impacts are often grouped into categories based on the ease of being translated into monetary terms and in a way that reduces interdependency.

4. *Measure selected impacts and convert them into standard units (dollars).*

   To the extent possible, impacts identified in step 3 are measured and monetized. Those that cannot be easily quantified would be documented.

5. *Determine the net present value for each alternative.*

   Discount rates are applied to obtain the present values of all impacts. These are then combined to provide a net benefit value, or a benefit-cost ratio, for each alternative.

6. *Conduct sensitivity and/or risk analyses.*

   A sensitivity analysis determines how changes in key assumption or variable values affect the outcomes of the analysis. A risk analysis determines the expected net benefits by factoring in the ranges and probabilities of cost and benefit values.

7. *Make investment decision based on all the information.*

   The final decision making would incorporate any significant but unquantifiable impacts, the net present values, and the sensitivity/risk analysis findings.

2.2 Issues and Limitations

A number of issues often arise in the BCA process and warrant special attention in the design of a BCA tool. These issues include the comprehensiveness of impact measures, double-counting, measurement accuracy, and discounting to present value. Each of these issues is discussed further below.

2.2.1 Comprehensiveness

Identifying the full range of benefits and costs is an important but challenging step in any BCA of transportation investments. This is because not all impacts of a transportation policy or mitigation project are tangible and obvious. This is particularly true for transit investments, whose social impacts are often difficult to quantify and easily overlooked during the analysis process. As a result, the value of transit investments is often understated when compared against, for example, highway projects (Cambridge Systematics, Inc., 1996).

2.2.2 Double counting

Due to the underlying causal relationships between various investment impacts, double-counting of benefits often arises in a BCA. This means one dollar value of impact on society is counted in more than one measures of benefit or cost. To avoid double-counting, one needs to define the benefits and costs as mutually exclusive from each other as possible.

2.2.3 Accuracy

The accuracy of the outcome of a BCA depends on the accuracy of the measurement/valuation of benefits and costs. Yet, the impacts of transportation investments often cannot be predicted with certainty. Also, timely and detailed data are not always available for analysis. For these and other reasons, the estimates of benefit and cost values could be incomplete and imprecise, leading to possibly highly inaccurate results. Therefore, the outcomes of cost-benefit analyses should be treated with caution. Whenever possible, sensitivity and risk analyses should be conducted to account for the possibility and effects of error.

2.2.4 Present values

Transportation investments typically produce streams of benefits and costs over time. For example, a major capital cost can be incurred early in the life of a project while the benefits may extend over many years. Therefore, in a BCA, a discounting rate is used to account for the difference between the perceived value of a dollar today compared to years from now. However, selecting an appropriate discounting rate is not a straightforward task. For federal projects, the rate may be set by the federal government (TCRP, 2003). For BCA of similar investment alternatives (e.g. alternative routes for the same transit service), the choice of discounting rate is less of an issue because it is unlikely to affect the rank ordering of the alternatives. For other types of evaluation, the discount rate should be treated as a variable during sensitivity and risk analyses.

2.3 Existing BCA Tool for Evaluating Transportation Investments

To date, a number of BCA tools have been developed and widely used in practice for evaluating transportation improvements. These include the Cal-B/C, Highway Economic Requirements System (HERS), MicroBENCOST, StratBENCOST, Sketch-Planning Analysis Spreadsheet Model (SPASM), and Surface Transportation Efficiency Analysis Model (STEAM). Guo and Zheng (2007) provide a review of these tools and a critique of their respective applicability to evaluating transit and, in particular, intercity bus investments. It was found that, out of the six BCA tools listed above, only Cal-B/C (Booz-Allen & Hamilton Inc., 1999a and 1999b), STEAM (Cambridge Systematics, 2000; DeCorla-Souza and Hunt, 1999), and SPASM (Cambridge Systematics, 1998) support the analysis of transit improvements. Yet, these tools have primarily been developed and applied to the urban context when transit improvements are considered. No documentation was found that describes the application of these tools to specifically analyze intercity bus projects, suggesting the need for a custom-build BCA tool for the intercity bus context.

CHAPTER 3. LITERATURE REVIEW

A large body of literature has been reviewed as part of this research project. This chapter presents a summary of past studies most relevant to our research. Specifically, three topics are covered: statewide intercity bus studies, transit benefit and cost accounting, and empirical analyses of transit benefits and costs. These topics are discussed in turn below.

3.1 State Intercity Bus Studies

The provision of a good intercity bus service is of interest to many states across the country. This section presents a brief review of recent intercity bus studies from several states, including Alabama, Minnesota, Illinois, Pennsylvania, and Washington. The review is intended to develop a profile of intercity bus service provision, rider characteristics, and potential improvements in the respective states. It also serves to demonstrate the need for improved intercity bus service in many states and the potential demand for the work presented in this report.

3.1.1 Alabama

Lindly and Hill (2002) provided a recent survey of the intercity bus industry in the state of Alabama. At the time of their survey, 81 locations across the state were serviced regularly by intercity bus. 53% of the passengers were below the age of 35 and the majority of passengers had an income well below the nationwide median income. Greyhound Lines was the largest of the three intercity bus companies operating in Alabama, covering 12,470,000 passenger miles and averaging $1,200,483 in monthly passenger revenue. While the most profitable route segment in the state generated revenue per mile of $4.47, only 28 of the 158 route segments were profitable at all.

Lindly and Hill's study also identified 29 cities of populations greater than 10,000 and 35 cities with populations between 5,000 and 10,000 that lack intercity bus service. The distances between these cities and their nearest intercity bus service ranged from 3 miles to 43 miles. Finally, the study noted the need to improve the integration of intercity bus service with rural transit service, which was found to be an important means for accessing medical facilities.

3.1.2 Minnesota

SRF Consulting *et al.* (1997) surveyed the status of intercity bus service in the state of Minnesota, as well as its needs for improvement. At the time of the survey, 2,500 route miles of service existed in Minnesota, with Greyhound Bus Lines and Jefferson Lines being the largest. Intercity bus service in Minnesota operated with the Minneapolis-St. Paul metropolitan area as its hub, and reached a significant proportion of the population of greater Minnesota. According to the study, 90% of Minnesota's population outside of the Minneapolis-St. Paul area resided within 20 miles of a city served by intercity bus. However, portions of the southwest, southern, and northern parts of the state were identified as needing improved intercity bus service coverage. In terms of rider characteristic, 44% of intercity bus riders were found to be from households earning less than $15,000 annually. The most represented ages were those between 18 and 34 and those over 55 years of age.

3.1.3 Illinois

Pagano *et al.* (2001) evaluated the intercity bus netowrk in Illinois, as well as strategies for funding intercity bus service in states across the U.S. Six intercity bus operators operated in Illinois at the time of this report, with Greyhound Bus Lines having the most expansive service. The intercity bus service in Illinois used the Chicago metropolitan area as a route hub, and made connections across the state and to the major destinations along the western border (including St. Louis, Missouri) and in southern Wisconsin. The study indicated that, although all metropolitan statistical areas in Illinois had intercity service by either bus or rail, additional service needs to be added to supplement some intercity routes. Needs analysis was conducted through travel demand forecasting, potential market identification, intercity bus supply analysis, and an analysis of deficiencies by comparing demand and supply. Most notably, the southern and western parts of the state were in need of additional intercity bus service; service throughout the state was reported as irregular and inconvenient. The report offered recommendations for improving and expanding service, integrating intercity bus service with rural connections, and using funds to sponsor routes and improve bus terminal facilities.

3.1.4 Washington State

KFH Group (2007) surveyed existing intercity bus service and made policy recommendations for satisfying intercity bus needs in the state of Washington. Seven bus operators provided service in Washington State, with Greyhound Lines having the most stops of all the operators. The study identified commuters, airport service, and regular-route intercity bus service as the three distinct passenger markets for intercity bus in the state. Ridership profile analysis were performed as part of the study and yielded demographic results similar to national rider characteristics. Primary groups of riders included those age 18 to 24, those over 60 years old, low-income individuals, and those without access to an automobile.

KFH Group's study also developed a method to determine the extent to which the current intercity bus network served the needs of those that would most benefit from intercity bus service, called "potentially transit-dependent persons." Route maps and schedules were evaluated to determine coverage in the state. Results from this research indicated that the areas with the highest density of potentially transit-dependent persons were mostly congruent with those areas with the highest population densities and already with adequate intercity bus service. Those identified with the highest need for transit services were persons age 18-24, persons age 60 and above, persons living below the poverty line, persons with a disability, and persons from households without a private automobile available. Evaluation was performed to determine the areas served by the intercity bus network and the density of those most in need of transit services. Those areas with the highest density of persons most in need of transit should be the areas that intercity bus network expansion should focus on. Areas of relatively high levels of these dependent persons were identified in the rural parts of central Washington, locations that were not served by intercity bus within twenty-five (25) miles.

The study further identified factors that encourage of intercity bus travel, including colleges and universities, airports, hospitals, military bases, correctional facilities, and linkages with rail transportation. These sources of intercity bus passengers are common in many states, including Wisconsin. The Washington state intercity bus study identified problems with using federal 5311(f) funding for intercity bus, including poor skills in writing grants for funding, misperception that intercity transit does not see the ridership that other transit sees, and trouble finding local support, sponsorship, and matching funds. Four policy options for improving the management and function of intercity bus in the state were recommended and the preferred alternative entails the Washington Department of Transportation becoming the grantee of federal funding, with the ability to directly contract with intercity bus providers.

3.2 Transit Benefit and Cost Accounting

Identifying the various benefits associated with a given transit investment is the first challenge faced in transit BCA. As found by HLB Decision Economics Inc. (2002), comprehensive accounting of transit benefits and costs in practice is extremely rare. Only a few studies have attempted to offer a theoretically more comprehensive picture of transit impacts and a systematic framework for dealing with the interrelationships between different benefits and costs. The typical benefits measured in intercity transit BCA usually include user benefits, economic benefits, and environmental benefits (Scheinberg, 2001; Hansen and Beimborn, 1987; de Rus and Inglada, 1997). The purpose of this section is to provide a compressive enumeration of the various benefits and costs that have been suggested in past studies.

3.2.1 Transit costs

Comparing to identifying transit benefits, identifying the costs associated with a transit investment is relatively straightforward. The typical cost elements considered include the direct capital costs and operating costs of the investment. They are typically paid by non-transportation users, including transit agencies, private provider of transit services, and other public agencies. In the context of intercity bus services, capital costs are primarily for right-of-way, facilities and vehicles. Operating costs are recurring costs that usually include salaries, wages and benefits, materials and supplies, utilities, and other expenses related to ongoing operation and maintenance.

3.2.2 User benefits

Although user benefits are generally recognized as the largest component of transit benefits, the definition of user benefits varies in previous studies. For example, Hansen and Beimborn (1987) defined user benefits as the difference in user cost between the bus mode and alternative modes. Brand *et al*. (2001) interpreted user benefits as the value that individuals receive from a transportation service improvement minus the fare they pay. More commonly, user benefits are defined based on the consumer surplus theory as the difference between the price of the service and consumer's willingness to pay.

Past studies also differ in their definition of "user" when quantifying user benefits. Some studies consider only the user of the proposed transit mode. Under this definition, user benefits could accrue in three ways: for existing users (who use the transit mode before and after the transit improvement), for diverted users (who are diverted to the transit mode from other modes such as auto and air), and for induced users (who now travel or travel more because of the transit improvement). While the benefits for existing and diverted users are often accounted for, the benefits to induced travelers are mostly neglected. This is attributable to two reasons: (a) the amount of induced travel is often small; and (b) conventional data sources and travel demand models typically do not support the assessment of induced travel (Volpe National Transportation Systems Center, 1993).

An alternative approach is to consider also the users of other modes in the system who benefit indirectly from the improvement in the transit investment. This is because of the travel time savings experienced for these other modes as a result of mode shift to the transit mode in question. The benefits for the remaining users on the other modes are referred to as “non-user benefits” in some studies (Hansen and Beimborn, 1987; Brand *et al.*, 2001). It should be noted that travel time savings is affected by two factors: time savings for a trip and the total number of trips effected. Even if the transit improvement results in only a small reduction in travel time for a single trip, the total travel time savings may still be significant because the travel volume is large. Moreover, since intercity travelers often share the roadways with local auto users who constitute a large portion of the traffic, most of the potential travel time savings due to intercity bus improvement would be experienced by the local auto users rather than by the transit travelers (Volpe National Transportation Systems Center, 1993).

In addition to the passenger modes that compete with the transit service of interest, freight modes – and particularly truck users – may also experience time saving benefits. Depending on the characteristics of the commodities being transported, these time savings may be considerably more valuable than those experienced by automobile travelers (Volpe National Transportation Systems Center, 1993).

3.2.3 Land use/economic development benefits

Transit service has long been associated with increased urbanization and agglomeration. More clustered, accessible land use patterns would increase productivity and efficiency of public services since the more compact land use development would result in reduced need and operating costs for sewer, water, and other public utilities (ECONorthwest, 2002; Beimborn *et al.*, 1993; Litman, 2006). Transit investment may also have a positive impact on community economic development. In particular, the increased mobility and accessibility provided by transit may lead to increased residential and commercial property values (HLB Decision Economics Inc., 2002; ECONorthwest, 2002; Litman, 2006). They could also help alleviate the job-housing mismatch predicament and enhance employment accessibility (Litman, 2006; ECONorthwest, 2002). Moreover, transit expenditure creates new jobs and business activities. It also promotes interaction among people, thereby facilitating interpersonal contacts, business contacts, and productivity (Beimborn *et al.*, 1993).

In the intercity transit context, economic development benefits apply more so than land use benefits. While a number of past studies acknowledged the positive effect of intercity transit on regional economic development (e.g. de Rus and Inglada, 1997;

Congressional Digest, 2001), few studies included it in the actual calculation of benefits. A recent study of the commuter rail between Boston and New York stated that the economic benefit of a Bostonian being employed by a New York employer is not limited to the new commuter trip only. Instead, it may be extended to include the productivity gain and increased competitiveness of the New York employer and, by extension, of the New York urban economy. This type of employer benefits is not generally recognized by the conventional intercity transportation BCA.

3.2.4 Environmental benefits

Motor vehicle use results in numerous indirect and direct environmental externalities such as air, water, and noise pollution. These negative externalities often result in financial costs to the society as a whole. For instance, air pollution emissions from motor vehicle use can have detrimental affects on human health, and cause reduced visibility, crop loss, and material and forest damage through ozone, acid rain, and other components. In addition, motor vehicles account for a significant proportion of carbon dioxide emissions in Wisconsin and the United States that contribute to global climate change and the affects of a warming climate. Emissions from motor vehicles are also a significant contributor to water pollution in the form of urban runoff from oil and other pollutants.

The environmental benefits of transit investment are mostly due to reduced auto usage. The benefits usually include reduced air pollution, noise pollution, and water pollution (ECONorthwest, 2002; Beimborn *et al.*, 1993; Litman, 2006). In addition, land preservation due to transit investment would leave more preserved space for agriculture and natural areas, and reduce intrusion into sensitive settings (Beimborn *et al.*, 1993; Litman, 2006). The net reduction in energy consumption is also another possible environmental benefit.

Delucchi (2000) offers a conceptual framework for calculating the savings in costs of environmental externalities associated with transportation improvements by extracting the values for the effects of noise, air, and water pollution from previous work and applying these values to some identified change in motor-vehicle use. Both ECONorthwest (2002) and Litman (2006) draw from the work of Delucchi and offer methodologies for quantifying the environmental impacts of transportation improvement projects. These methodologies are both based on applying a summary of Delucchi's previous work (1996a,b; 1997; 1998a,b; 2002), drawing important unit cost values out and applying them to reductions in automobile use through transportation improvements. Unit cost values are on a per VMT basis.

Environmental benefits are often recognized in the intercity transit context. Yet, the environmental benefits associated with intercity rail investments have been found to be marginal as the modal shift to rail is typically small (de Rus and Inglada, 1997; Brand *et al.*, 2001). Moreover, from an energy consumption perspective, intercity rail is inferior to intercity bus service as past rail studies have found that Amtrak is much less energy-efficient than intercity bus transportation and about equal in energy efficiency as automobiles for trips longer than 75 miles (Scheinberg, 2001; Congressional Digest, 2001). Therefore, intercity bus is the most energy efficient intercity transportation mode (Congressional Digest, 2001).

3.2.5 Safety benefits

As auto users shift to transit, the number of auto crashes is likely to reduce. This safety benefit is recognized in the general transit literature (TCRP Report 20, 1996; HLB Decision Economics Inc., 2002; ECONorthwest, 2002; Litman, 2006). However, few past BCA of intercity transit have accounted for crash cost reduction, except for Brand *et al.* (2001) and de Rus and Inglada (1997). Brand *et al.* (2001) measured the value of fewer crashes (and deaths) due to reduced VMT. De Rus and Inglada (1997) applied known elasticities of crashes with respect to traffic volume and the monetary values of different type of crashes.

3.2.6 Other benefits

There are other benefits that could be derived from improved intercity transit service. For example, intercity transit is a more reliable mode than air transportation when weather-related factors are concerned. Transit service enhances social equity by providing service to people who cannot afford auto or air travel (Congressional Digest, 2001).

The availability of transit as an alternative mode should the need arises also provides what is often referred to as 'option value'. These characteristics of intercity transit represents potentially significant source of additional benefits from investment to improve service quality (Volpe National Transportation Systems Center, 1993; Hansen and Beimborn, 1987).

Improvement of intercity transit service may also attract more people to use transit who originally use chauffeuring, thus reducing the cost of chauffeuring. Chauffeuring refers to additional automobile travel specifically to carry a passenger (e.g. chauffeuring children to school and sports activities, family members to jobs, and elderly relatives on errands). Such trips are very inefficient especially when they require drivers to make an empty return trip (Litman, 2006). It could be even more inefficient in the context of intercity travel, as intercity trips usually imply a longer travel distance then urban trips.

3.3 Transit Benefit-Cost Analysis Studies

3.3.1 Intercity bus

The study by Hansen and Beimborn (1987) was the first study that focused specifically on the benefits of intercity bus service. In that study, 'user benefits' of intercity bus service were defined to include travel cost savings, improved convenience, and reduced travel time, and freight use. These were estimated based on the concept of consumer-surplus and by comparing the disutility of travel by a given intercity bus route to that by an alternative mode or route. The study showed a user benefits index of $1.86 per trip for the Green Bay – Milwaukee route and $3.73 per trip for the Ashland – Abbotsford route in Wisconsin. Broader societal benefits such as option value, merit value, and perception of community accessibility were defined as 'nonuser benefits'. These benefits did not enter their analysis. The authors explained that these nonuser benefits would be hard to measure and likely negligible for small communities. Since Hansen and Beimborn (1987), there were few publications on the BCA of intercity bus service.

3.3.2 High speed rail

Among recent BCA studies of intercity transit, high speed rail (HSR) investments have become a popular topic. Allport and Brown (1993) pointed out that conventional BCA of HSR typically examines the following impacts: net travel time savings to travelers, operating cots savings to operators of the transport system, rolling stock costs, and infrastructure capital costs. Their proposed BCA framework identifies five additional economic impacts on business travelers: (a) in-travel work capability, (b) access time saving, (c) new opportunities for day return trips, (d) higher service frequencies, and (e) greater service reliability. In a subsequent BCA of HSR in Spain, de Rus and Inglada (1997) accounted for what Allport and Brown (1993) referred to as the conventional impact categories. In addition, de Rus and Inglada (1997) also included in their analysis the reduction in vehicular crashes and the vehicle operating cost savings for travelers who switched to HSR. More recently, in an analysis of a proposed high-speed rail (HSR) system in California, Brand *et al.* (2001) considered three categories of benefits: (a) passenger revenue, (b) user benefits in terms of net change in consumer surplus, and (c) highway and air nonuser benefits in terms of travel delay, crashes, and pollution reductions. The total benefits equate to about $44.15 billion in 1999 dollars, which is more than twice the total project costs (roughly $21.46 billion).

3.3.3 Rural transit

Another group of studies focus on the economic impact of rural transit services. For example, Burkhardt (1998) examined the differences in economic growth between rural counties with and without public transit systems. Specifically, the average net earning growth differential between the two types of counties is 11%. Southworth *et al.* (2005) developed a detailed transit benefit assessment tree, which distinguishes ‘transit use’ benefits from ‘transit supply’ benefits. ‘Transit use’ benefits include mobility-based accessibility, environmental, and safety and security benefits accrue to users of the transportation system; while ‘transit supply’ benefits refer to the contribution to local and regional economies from the infusion of transit investment. Due to data limitations, the authors used sensitivity analysis extensively to identify the range of benefit values for alternative scenarios.

3.3.4 Urban transit

In the context of urban transit, there is a voluminous literature on developing taxonomies of transit benefits/costs and measuring these benefits/costs. Key studies from this literature are briefly discussed below. The reader is referred to Guo and Zheng (2007) for a detailed review of these studies.

The report by Beimborn *et al.* (1993) represents one of the earliest attempts at outlining a comprehensive BCA framework for urban transit service. Later, Report 20 by Transportation Research Board’s Transit Cooperative Research Program presented a six-way categorization of transit impacts and outlined analysis techniques by which these impacts can be assessed (Cambridge Systematics Inc., 1996). HLB Decision Economics Inc. proposed a framework that recognizes three main categories of transit benefits: congestion management and related environmental benefits, low-income mobility benefits, and community economic development benefits (2008). A more recent TCRP Report 78 (ECONorthwest, 2002) put forward a framework in which transit benefits and costs are first divided into two main categories: basic and other. The basic benefits and costs are those traditionally identified with transportation improvements and include primary travel impacts, secondary impacts, and direct costs. The 'other benefits and costs' are those derived from the primary impact of building, operating, and maintaining more transit facilities and service. Litmans (2006) proposed a framework very similar to TCRP Report 78. He considered transit expenditure, user benefits, Mobility benefits, Efficiency benefits, Land use benefits, and Economic development impacts.

In a survey and evaluation of thirty past transit investment appraisals, HLB Decision Economics Inc. (2002) found that many studies used ridership growth as the sole indicator of benefits. Moreover, about 60% of the studies estimated only travel time savings and vehicle operating savings as transit benefits. As a result, highway investment projects nearly always appear more effective, even where induced demand guarantees that the effects of highway investments are short-lived. This is in part because many of the mainstream BCA tools do not support the comprehensive assessment of transit impacts (except for Cal-B/C, STEAM, and SPASM).

3.3.5 Summary

In sum, there have been very few studies focused on assessing the full range of benefits of intercity bus service. Early studies of intercity transit BCA tend to focus on the financial viability, such as annual ridership and annual profit or deficit. It is only recently that more inclusive transit impact taxonomies have been developed with intercity HSR and rural/urban transit improvements in mind. Different researchers have identified differing, yet overlapping ranges of impacts and developed taxonomies that represent their own points of view. It is unclear whether these more inclusive BCA frameworks could be directly applied to analyzing intercity bus service investments. This is because, in the intercity bus context, some impacts may be more relevant than the others and the valuation methods of these impacts are likely to differ from those used in the rail or local transit context.

CHAPTER 4. PROPOSED BCA FRAMEWORK

The current study builds on established definitions and measures of transit benefits/costs while examining the relevance and applicability of these definitions and measures to the context of intercity bus service. The result is a BCA framework specifically developed to capture a broad range of impact measures.

4.1 Framework Overview

The BCA framework developed in this research effort is intended for assessing the impacts of a single bus corridor at a time. The framework recognizes two principle types of intercity bus benefits: benefits that accrue to users of the transportation system (referred to as *Individual Travel Impacts*) and benefits that accrue to local areas from the presence of intercity bus services (referred to as *External Impacts*). These two types of benefits are further divided into subcategories as illustrated in the “benefit tree” in Figure 4-1. Our proposed analysis framework considers the cost associated with the intercity bus service as comprising capital and operating costs. A brief definition of each benefit and cost components considered in our analysis is provided in Appendix A. It should be noted that, since the ultimate goal of our benefits-cost analysis is to measure the net impact of intercity bus investment decisions, the monetary components which are transfers (e.g. transit fares that are simply passed on from transit users to transit operators) and the components which are not expected to be impacted by the proposed investment (e.g. parking costs for commercial trucks that are not likely to change due to transit service expansion) were excluded from the study framework.

The remainder sections of this chapter describe the methods developed for calculating the monetary value of each intercity bus benefit/cost component identified above. Note that all calculation refers to 2008 dollar values. Quantities that reference other years are first converted to 2008 value using the appropriate consumer price index (CPI) values before used in the actual calculation.

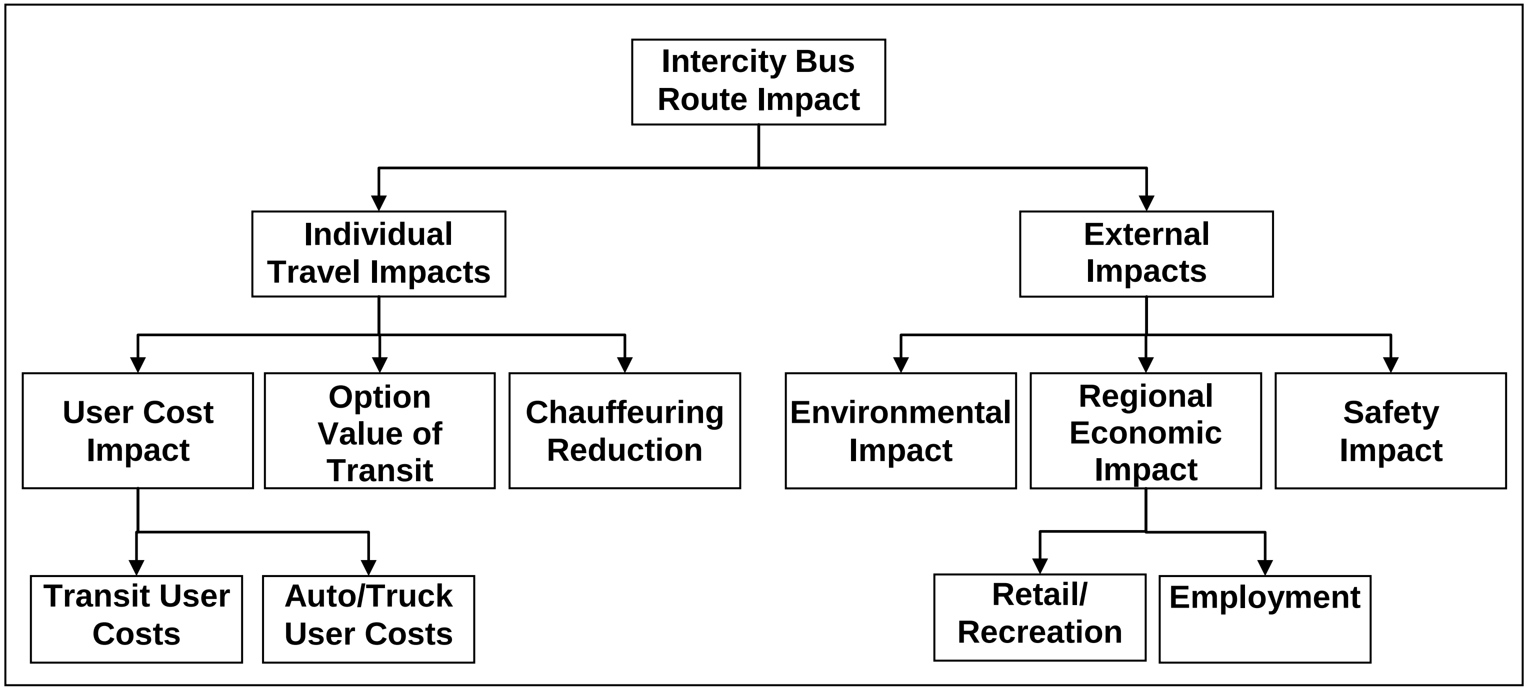

Figure 4-1. Intercity bus benefit categories

4.2 Individual Travel Impacts

Individual travel impacts are the direct impacts of the proposed transit investment on travelers, including both transit (e.g. bus and rail) and non-transit (e.g. auto, truck, bicycle, pedestrian) users. For example, travel speed of the transportation network might change due to the project; thus, the travelers might enjoy a faster travel speed or suffer from a slower speed, and the out-of-pocket costs might also change correspondingly. The rail ridership may also be raised due to better bus feeder service. In the context of intercity travel, since bicycle and pedestrian modes are typically not used, auto and truck users are the only non-transit users considered in our analysis. And bus and rail are the two transit modes considered. In our analysis framework, individual travel impacts are further divided into three components: user costs, option value of transit, and chauffeuring reduction. Our proposed methods for measuring these three benefit components are presented in sections 4.2.1, 4.2.2, and 4.2.3, respectively.

4.2.1 User costs

As mentioned in section 3.2.2, user benefits (changes in the perceived user costs) are probably the most significant individual travel impacts. If a transit improvement does not change the cost of travel perceived by users, it cannot affect user travel behavior. In addition, if a transit improvement is to generate user benefits, it must reduce perceived user costs. Therefore, reduction in user costs should be the primary source of societal benefits from transit. User costs include "out-of-pocket" costs and the value of time spent traveling. And this impact on user costs is not only restricted to transit mode, but also applies to the other modes in the interconnected transportation network.

A typical way to measure the impact of a transportation improvement on user costs is through the notion of consumer surplus. According to the consumer surplus theory, travelers are usually willing to pay more than the actual cost for their travel. The difference between the traveler's willingness to pay and their perceived cost of travel is known as the consumer surplus. This concept is typically illustrated using a demand curve as shown in Figure 4-2, where UC_1 and UC_2 denote the user cost before and after the transportation improvement, respectively. This change in user cost is expected to result in changes in the system-wide traffic volume, from V_1 and V_2. The shaded area is thus the change in consumer surplus, which can be used to represent the impact of the transportation improvement on user costs.

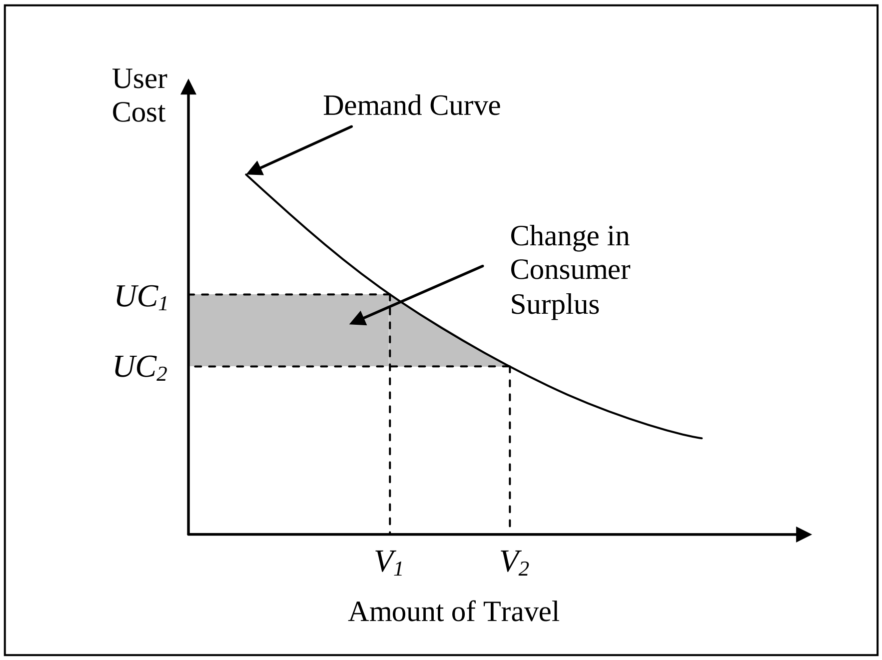

Figure 4-2. User benefit associated with a given mode *m* as given by consumer surplus theory

The above discussion, however, represents an over-simplification of how an intercity bus investment would impact the demand-price relationship underlying a multimodal transportation network. When multiple modes are concerned, the calculation of changes in consumer surplus needs to properly account for the differing user costs across modes and the likely modal shifts across modes. In the present study, we accomplish this using the following equation:

$$\Delta TUC = \sum_{m \in \{bus, rail, auto, truck\}} \left(TUC_{m,1} - TUC_{m,2} \right),$$

where ΔTUC is the total change in user benefits attributed to the intercity bus improvement being considered; m is the mode index; $TUC_{m,1}$ and $TUC_{m,2}$ are the total user costs associated with mode m before and after the bus improvement. The calculation of *TUC* for transit and non-transit modes is discussed separately below.

TUC for Bus/Rail Users

For the transit modes – including both bus and rail – the user costs comprise travel time costs and transit fares. But since transit fares are transfers (i.e., from transit users to transit agencies) and do not contribute to the net impact of the proposed project, we exclude it from transit user costs analysis[1]. Thus, only travel time costs are included in the calculation:

[1] This is not to say that transit fares do not impact the benefit/cost assessment. Rather, the impact of transit fares is captured through changes in transit ridership.

$$TUC_m = \sum_p VIVTT_{m,p} \cdot IVTT_{m,p} + VOVTT_{m,p} \cdot OVTT_{m,p}$$

where p is the index for trip purpose; $IVTT_{m,p}$ and $OVTT_{m,p}$ are the total in-vehicle travel time and out-of-vehicle travel time experienced by the users of mode m for trip purpose p; and $VIVTT_{m,p}$ and $VOVTT_{m,p}$ are the values of in-vehicle and out-of-vehicle travel times, respectively. Here we assume that travel time and value of time estimates are available for three trip purposes: pleasure (*pl*), personal business (*pb*) and business (*bs*). If changes in travel time due to intercity bus investment are expected to be localized, then the above calculation should be applied to only the corridor being impacted. Otherwise, $IVTT_{m,p}$ and $OVTT_{m,p}$ need to capture the system-wide travel time.

Typically, the value of travel time can be interfered from a mode choice model estimated using travel survey data. In our subsequent analysis of bus routes in Wisconsin, we adopted the set of values of time as implied by the Statewide Demand Model. These values are summarized in Table 4-1. Another typical way to measure value of time for transit mode is using wage rate. Table 4-2 lists the value of time by trip purpose as a percentage of wage rate. These percentages are converted to dollar values based on the national average wage information as shown in Table 4-3.

Table 4-1. Value of intercity transit travel time (in 2008 Dollar Value)

	Bus	Rail
Value of In-Vehicle Time ($/hour)		
Pleasure	15.76	15.76
Personal Business	11.45	11.45
Business	34.80	34.80
Value of Out-of-Vehicle Time ($/hour)		
Pleasure	40.63	40.63
Personal Business	29.50	29.50
Business	89.71	89.71

Source: Wisconsin Statewide Demand Model.

Table 4-2. Value of intercity transit travel time using wage rates percentage

Time Component	Value of Time (per person-hour as a % of wage rate)
In-Vehicle Personal (Intercity)	70%
In-Vehicle Business (Intercity)	100%
Excess (Walk access, waiting, and transfer time)	100%

Source: U.S. Department of Transportation. "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis", Office of the Secretary of Transportation, U.S. Department of Transportation, 2003. Available at: http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf

Table 4-3. Value of intercity transit travel time using dollar value

Time Component	Value of Time (2000 U.S. $ per person-hour)
In-Vehicle Personal (Intercity)	$14.80
In-Vehicle Business (Intercity)	$21.20
Excess (Walk access, waiting, and transfer time) Personal	$21.10
Excess (Walk access, waiting, and transfer time) Business	$21.20

Source: U.S. Department of Transportation. "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis", Office of the Secretary of Transportation, U.S. Department of Transportation, 2003. Available at: http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf

TUC for Auto Users

Improvement in intercity bus service is likely to lead some existing users of passenger cars to switch to bus. This reduction in auto users (and resulting improvement in auto LOS) would impact the remaining car users and truck users. The end result is that, while travel condition may improve for some links on the network, the condition on others may worsen due to the increased transit vehicles. All of these changes may affect the statewide level car/truck user costs. When evaluating the total user costs for the car mode, we consider travel time costs and vehicle operating costs.

$$TUC_{car} = \sum_{p} VIVTT_{car,p} \cdot IVTT_{car,p} + \left(FC_{car} + NFC_{car}\right) \cdot VMT_{car}$$

In the above equation, p, $IVTT$, and $VIVTT$ are defined as before. Again, we assume that travel time and value of time estimates are available for three trip purposes: pleasure (*pl*), personal business (*pb*) and business (*bs*). The first term on the right-hand-side captures the travel time costs in a similar way to that for the transit modes, except that out-of-vehicle travel time is now excluded. The second term accounts for the vehicle operating costs, which is a function of fuel cost and non-fuel cost. The per VMT fuel cost, FC_{car}, is in turn given by:

$$FC_{car} = FCR \cdot PcFl$$

where *FCR* is fuel consumption rate (in gallon per VMT traveled) and *PcFl* is the fuel unit price (averaged at $4 per gallon in 2008 dollar). Table 4-4 summarizes the *FCR* values used in the present study. The non-fuel auto operating cost per VMT, NFC_{car}, is estimated to be $0.203 (Cambridge Systematics, 2000).

Table 4-4. Fuel Consumption Rates (Gallons/Mile)

Speed (mph)	Fuel Consumption (gallon/VMT)
5	0.182
10	0.123
15	0.089
20	0.068
25	0.054
30	0.044
35	0.037
40	0.034
45	0.033
50	0.033
55	0.034
60	0.037
65	0.043
70	0.052

Source: Booz-Allen & Hamilton Inc. California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C)—Technical Supplement to User's Guide. California Department of Transportation.

A well-calibrated intercity travel demand model would again be the best source of estimates for the in-vehicle travel times, as well as the corresponding value of time, for both auto and truck modes. In the case study of Wisconsin, we apply a set of values of time as shown in Table 4-5. Similarly, the values of time evaluated using wage information for non-transit mode are shown in Table 4-6 and Table 4-7.

Table 4-5. Value of intercity auto travel time (2008 Dollar Value)

	Auto[1]	Truck[2]
Value of In-Vehicle Time ($/hour)		
Pleasure	15.76	
Personal Business	11.45	
Business	34.80	22.26

Source: 1. Wisconsin Statewide Demand Model.
2. U.S. Department of Transportation. "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis", Office of the Secretary of Transportation, U.S. Department of Transportation, 2003. Available at: http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf

Table 4-6. Value of intercity auto/truck travel time using wage rates percentage

Time Component	Value of Time (per person-hour as a % or wage rate)
AUTO	
In-Vehicle Personal (Intercity)	70%
In-Vehicle Business (Intercity)	100%
TRUCK	
In-Vehicle Business (Intercity)	100%

Source: U.S. Department of Transportation. "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis", Office of the Secretary of Transportation, U.S. Department of Transportation, 2003. Available at: http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf

Table 4-7. Value of intercity auto/truck travel time using dollar value

Time Component	Value of Time (2000 U.S. $ per person-hour)
AUTO	
In-Vehicle Personal (Intercity)	$14.80
In-Vehicle Business (Intercity)	$21.20
TRUCK	
In-Vehicle Business (Intercity)	$18.10

Source: U.S. Department of Transportation. "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis", Office of the Secretary of Transportation, U.S. Department of Transportation, 2003. Available at: http://ostpxweb.dot.gov/policy/Data/VOTrevision1_2-11-03.pdf

TUC for Trucks.

Because the amount of truck trip-makings is unlikely to be changed due to bus service improvement, the vehicle operating costs for trucks are unlikely to change. Therefore, the total user costs for the truck mode accounts for the travel time costs and not the operating costs. Unique to the truck mode is the additional inventory costs involved. This is because travel time delay imposes opportunity costs associated with storing commodities before they are used, especially for vehicles carrying high-value cargo. Taken together, the total user costs for the truck mode is computed by

$$TUC_{truck} = VIVTT_{truck} \cdot IVTT_{truck} + CIC_{truck} \cdot IVTT_{truck}$$

where CIC is the value of inventory cost per vehicle-hour. The values of time for trucks are listed in Table 4-6 and Table 4-7 (note that the value of commercial truck travel time is not available from the WI statewide model and is, instead, drawn from federally recommended value and converted into 2008 dollar value). The inventory cost values for cargoes of various values at multiple interest rates are shown in Table 4-8.

Table 4-8. Cargo inventory costs (dollars per vehicle-hour)

Cargo Value per Vehicle ($)	Annual Interest Rate			
	5%	10%	20%	40%
10,000	0.1	0.1	0.2	0.2
50,000	0.3	0.6	0.9	1.1
100,000	0.6	1.1	1.7	2.3
500,000	2.9	5.7	8.6	11.4
1,000,000	5.7	11.4	17.1	22.8
10,000,000	57.1	114.2	171.2	228.3

4.2.2 Option value of transit

The option of having transit available will be valuable to those in the population that might conceivably use the transit system at some point during the year, especially in the events such as bad weather, the automobile being unavailable or broken down, increases in fuel prices or other factors that raise the cost of operating an automobile, and loss of the ability to operate a vehicle (ECONorthwest, 2002; Litman, 2006; Southworth *et al.*, 2005; Hansen and Beimborn, 1987). In economics terms, the value that is associated with avoiding such contingent events is called option value. Compared to urban travelers, the option value of transit would be more significant for intercity travelers, since intercity travels have higher requirement of driving task and are also more vulnerable to weather conditions.

Economists have developed mathematical procedures for quantifying option value. Some of the mathematical formulae that are used to evaluate financial options can be used to establish transit's option value. The application to transit options involves linking the parameters of the conventional financial options formula to the analogous dimensions of transit service availability. In this project, we adopt the formula given in ECONorthwest (2002) and calculate option value as:

$$OPT = UOPT \cdot NAT \cdot FRQ$$

where OPT is the transit option value; $UOPT$ is the option value of transit per option; NAT is the number of auto users who might conceivably use transit at some point; FRQ is the average frequency for auto users to switch to transit during the year. The unit option value of transit is given by the Black-Scholes call option pricing formula as:

$$UOPT = S \cdot N(d_1) - X \cdot e^{-\gamma T} \cdot N(d_1)$$

where S is the usual or expected "price" of an automobile trip and X is the "exercise price" of a transit trip. $N(\ )$ denotes the normal distribution. r is the risk-free return. T is the time to the expiration of the transit option and is calculated as the inverse of transit usage frequency. d_1 and d_2 are defined by:

$$\begin{cases} d_1 = \dfrac{\ln(S/X) + (r + \sigma^2/2)T}{\sigma\sqrt{T}} \\ d_2 = d_1 - \sigma\sqrt{T} \end{cases}$$

where σ is the standard deviation of S. The price of automobile trip S and price of transit trip X can be calculated through the equations below:

$$S = VOC_{auto} \cdot L + \sum_p VIVTT_{auto,p} \cdot UIVTT_{auto} \cdot PP_{auto,p}$$

$$X = \sum_p \left(VIVTT_{bus,p} \cdot UIVTT_{bus} \cdot PP_{bus,p} + VOVTT_{bus,p} \cdot UOVTT_{bus} \cdot PP_{bus,p} \right)$$

where $UIVTT_{auto}$ is the in-vehicle travel time for one average auto trip along the corridor; $UIVTT_{bus}$ and $UOVTT_{bus}$ are, respectively, the in-vehicle travel time and out-of-vehicle travel time for one average bus trip along the corridor; $PP_{auto,p}$ and $PP_{bus,p}$ are the proportion of trips for purpose p along the corridor for auto and bus respectively.

4.2.3 Chauffeuring reduction benefits

As suggested by Litman (2006), the benefit from chauffeuring reduction can be estimated based on the number of chauffeured automobile trips shifted to transit multiplied by vehicle cost and driver travel time savings. Since the auto vehicle cost is already accounted for in the auto user benefits section, here we only consider the chauffeurs' travel time savings, as given by:

$$CHAUF = PTC \cdot TstRd \cdot DTC_{auto}$$

where $CHAUF$ is the avoided cost of chauffeuring for the chauffeurs; PTC is the percentage of transit trips which would otherwise be chauffeured automobile trips if there is no transit service provided; $TstRd$ is the transit ridership during the year; DTC_{at} is the chauffeurs' travel time savings, which can be calculated by the following equation.

$$DTC_{auto} = UIVTT_{auto} \cdot VIVTT_{auto,personal\quad business} \cdot 2$$

4.3 External Impacts

As explained earlier in section 4.1, the impacts of intercity bus service on local areas are referred to as *External Impacts*. Three categories of such impacts are considered in our proposed analysis framework: environmental, economic and safety. The calculation of the monetary values of these impact categories are described below.

4.3.1 Environmental impacts

Ideally, the monetary value of environmental impact changes due to a transportation project (in this case intercity bus) should be determined by:

1. Identifying the travel (vehicular) patterns before and after project implementation;
2. Estimating the corresponding levels of energy use, air pollution emissions, water pollution, and noise pollution;
3. Translating the before and after energy use, air pollution emissions, water pollution, and noise pollution into monetary values by applying appropriate unit cost estimates; and
4. Computing the net change in monetary values.

While Step 1 of this ideal approach can be accomplished by using the travel forecast models that are typically available at a state DOT, step 2 calls for a suite of environmental forecast models that are not usually accessible or available. Moreover, step 3 relies on accurate unit cost estimates of different kinds of environmental impacts. These values will vary depending on the specific characteristics of the scenario in which those impacts are made. For instance, the effects of noise and air pollution will vary depending on the density and proximity of residential areas and human activity to transportation systems. Locally specific unit cost information is required in order to ensure maximum accuracy, but this information is difficult to obtain as well. Simplification of this ideal approach, by making appropriate assumptions, is therefore needed.

A more simplified approach would be to skip step 2 above of estimating the pre and post-program levels of environmental impacts and, instead, relate changes in travel patterns directly to unit cost estimates of environmental impacts. In this approach, changes in travel patterns are measured in vehicle miles traveled (VMT) and the various environmental impacts are valued based on an aggregate unit cost estimate for different vehicle types. Specifically, we measure the change in total environmental costs, ΔTEC, by:

$$\Delta TEC = \sum_{vt} ECR_{vt} \cdot \Delta VMT_{vt} ,$$

where *vt* denotes vehicle type (we consider car, SUV and bus). ΔVMT_{vt} is the total change in vehicle miles traveled by vehicle type *vt*. ECR_{vt} is the environmental cost rate in $ per mile. The values of *ECR* are drawn from Litman (2006), which was in turn derived from Delucchi's earlier work. These values are quoted in Table 4-9. They represent generalized environmental cost relating to air, water, and noise pollution. Note that Litman provided separate unit pollution costs for urban and suburban settings.

Table 4-9: Environmental unit costs in cents per vehicle mile traveled

	Urban	Suburban	Average
Current Diesel Bus	$0.30	$0.15	$0.225
New Diesel Bus (meets 2004 standards)	$0.15	$0.05	$0.10
Hybrid Electric Bus	$0.05	$0.03	$0.04
Average Car	$0.05	$0.03	$0.04
SUV, Light Truck, Van	$0.10	$0.06	$0.08
Average Automobile	$0.075	$0.045	$0.06

Source: Litman (2006)

A couple of limitations need to be recognized when applying this methodology. First, as the unit cost estimates presented above are national averages from a previous study, location estimates should be used where possible to improve accuracy of analysis. Second, the cost estimates account for only the effects of air, noise, and water pollution. Significant environmental impacts of other nature that may result from the specific transit investment under evaluation should be factored into these cost estimates as needed.

4.3.2 Safety impacts

We quantify safety impacts in terms of changes in system-wide, externalized vehicular crash cost. As outlined in TCRP Repot 78 (ECONorthwest, 2002), two issues need to be considered when analyzing safety impacts: (1) whether the examined transit project will change the quantity or severity of crashes and (2) what value to place on those changes. In the context of intercity bus improvement, it is likely that the quantity, rather than the severity, of vehicular crashes will change as the total amount of vehicular travel reduces due to modal shift. Below, we discuss two methods for calculating the safety benefits derived from reduced crashes.

General VMT based Measurement

A typical method for measuring safety benefits involves estimating changes in VMT (preferably further disaggregated by vehicle type) and applying the following equation to calculate the change in the total crash costs:

$$\Delta TAC = \sum_m UAC_m \cdot \Delta VMT_m$$

where ΔTAC is the change in total crash cost across all modes *m*; ΔVMT_m is the change in vehicle miles traveled by mode *m*; UAC_m is the unit crash cost per vehicle mile for mode *m* and are given by Table 4-10.

Table 4-10. Estimates of unit crash cost by vehicular modes

Mode	Cost Per Vehicle-Mile
Bus	\$0.32
Light truck	\$0.19
Medium/heavy truck	\$0.13
Combination truck	\$0.23
Car (average)	\$0.12
Car, Drunk driver	\$5.50
Car, Sober driver	\$0.06
Motorcycle	\$1.50

Source: Presentation of Federal Highway Administration Colloquium on Social Costs of Transportation, December 12, 1994, Washington, D.C.; Miller *et al.*, "Railroad Injury: Causes, Costs, and Comparisons with Other Transport Modes," *Journal of Safety Research*, Vol. 25, No. 4, 1994, pp. 183-195, as cited in Litman, 1999.

Source: Table 4-10 of TCRP Report 78 (ECONorthwest, 2002)

Although this method for measuring crash costs is quite straight forward, it should be noted that the unit crash cost estimates are based on national average. When applied to areas where the distribution of crash types are significantly different from that found at the national level, local estimates of crash costs should be used.

Crash type based measurement

As an extension to the VMT-based approach, we propose to differentiate crash costs by crash type (i.e. severity of injury) and VMT by roadway class. This entails using different values of unit crash cost for each type of crashes. It also requires knowledge about crash rates (usually in terms of number of crashes per VMT) by crash type and roadway class. This alternative way for calculating changes in crash costs is given by:

$$\Delta TAC = \sum_{at} UAC_{at} \cdot \left(\sum_{rt} AR_{at,rt} \cdot \Delta VMT_{rt} \right),$$

where *at* is the index for crash type; *rt* is the index for roadway class; UAC_{at} is the unit cost of crash type *at*; $AR_{at,rt}$ is the average crash rate of type *at* per VMT on roadway type *rt*; and ΔVMT_{rt} is the change in total VMT across all vehicular modes in roadway type *rt*.

A source of unit crash costs is the National Safety Council (NSC), which provides estimates of the average crash costs by injury type. In this study, we adopt the 2006 figures published by the NSC, as listed in Table 4-11. These comprehensive cost estimates have been recommended by the NSC for cost-benefit analyses wherever feasible. These crash cost estimates account for:

- Wage and productivity losses – loss of wages and benefits, cost of replacing household services, travel delay costs associated with vehicular crashes;
- Medical expenses – doctor fees, hospital and drug charges, future medical costs, emergency response costs;
- Administrative expenses – police and legal costs, administrative costs of public and private insurance;
- Motor-vehicle damage – costs associated with damage to motor-vehicles as a result of crashes; and
- Employers uninsured costs – costs incurred by employers that are uninsured, including production slowdowns, training of new workers, cost of overtime to make up for lost work, and others;

Table 4-11. Crash Costs by Injury Types, 2006

Crash Injury Type	Comprehensive Cost in 2006 $	Comprehensive Cost Converted into 2008 $
Fatality	$ 4,000,000	$ 4,346,944.44
Incapacitating Injury	$ 201,100	$ 218,542.63
Non-Incapacitating Injury	$ 50,400	$ 54,771.50
Possible Injury	$ 24,400	$ 26,516.36
No Injury	$ 2,200	$ 2,390.82

Source: National Safety Council, http://www.nsc.org/resources/issues/estcost.aspx

Estimates of crash rates by injury type and roadway class should be obtained from local sources. In our subsequent application of the proposed BCA framework, we obtained the crash rates from the 2006 WisTransPortal database. A 4-way roadway classification is used: rural interstate, rural non-interstate, urban interstate, and urban non-interstate. For each roadway class, these crash rates were generated by dividing the frequencies of crashes of different injury category recorded for the roadway class by the total VMT on that roadway class. The resulting per VMT crash rates are shown in Table 4-12.

Table 4-12. Crash Rates by Injury Type and Roadway Class, 2006

Crash Rate (per Million VMT)	Rural Interstate	Rural Non-Interstate	Urban Interstate	Urban Non-Interstate
Fatality	0.0044	0.0210	0.0021	0.0056
Incapacitating Injury	0.0264	0.0998	0.0136	0.0530
Non-Incapacitating Injury	0.0691	0.2386	0.0522	0.2183
Possible Injury	0.0706	0.2710	0.1630	0.4668
No Injury	0.5693	1.6292	0.5721	1.4823

4.3.3 Economic impacts

Economic benefits are an important part of any transportation program. Increasing mobility through intercity bus programs means more individuals will be able to access earning and spending opportunities. These benefits are particularly evident in the rural context. Intercity bus transportation links rural residents to urban centers where they can access jobs, retail spending opportunities, health care, and other amenities. As evident in the many sate intercity us studies (section 3.1), this type of transit is particularly important and beneficial for poor, elderly, and disadvantaged residents who oftentimes lack an alternative means of transportation. The 1995 American Travel Survey Profile also showed that 30.2% of intercity bus users lived in households where no vehicular transportation existed. Individuals who are without personal vehicle or other modal alternatives for such access are likely to have foregone their trips. Providing intercity transit clearly facilitates economic linkages.

Although past literature has pointed to the importance of intercity and rural transportation on economic development, few have developed a methodology for measuring the economic benefits arisen from an intercity transit investment. As part of our proposed BCA framework, we develop a relatively general method to account for two types of mobility-related economic benefits: improved accessibility to retail/recreation opportunities and to employment opportunities[2]. Below, we describe the proposed methods for measuring the economic benefits associated with retail/recreation spending (ΔTS) and with increased job access (ΔTI). The sum of these two quantities gives the added total economic impacts ΔTE due to an intercity bus investment:

$$\Delta TE = \Delta TS + \Delta TI$$

Access to Retail and Recreation

Retail and recreation activities represent an important part of the spending economy and intercity bus helps provide this access. The trend in regional retail centers also provides added motivation for expanding intercity bus programs, especially those that link rural residents with urban areas (Burkhardt *et al.*, 1998). It is necessary to understand the potential economic benefits of intercity bus service increasing access to retail and recreation spending opportunities to emphasize the overall economic importance of intercity bus service.

In this project, we calculate the added economic benefit due to improved access to retail and recreational opportunities by:

$$\Delta TS = \frac{\Delta NPT_{bus} \cdot \%RR}{2} \cdot US$$

where ΔTS denotes the change in total spending among intercity bus users; ΔNPT_{bus} is the number of additional annual person trips using the intercity bus service; $\%RR$ indicates the percentage of induced person trips that are made for recreation and/or retail purposes; US is the unit spending associated with an average person round-trip for retail and recreation. The division by 2 accounts for the return trips.

[2] In addition to economic benefits relating to increased spending and earning, we also recognize the value of intercity bus investment in providing improved access to medical care. However, our analysis framework does not account for this benefit category due to the scarcity of supporting data and information in the public health and transportation literature.

Obviously, the value of US is geographically dependent. We attempted to estimate the value of US for Wisconsin using the data from the 2006 tourism spending survey by the Wisconsin Department of Tourism. In particular, we examined the data associated with three types of tourism travel: resort, rural, and urban. On average, the daily spending associated with the three types of tourism travel are \$113.18 for resort, \$111.02 for rural, and \$117.06 for urban. The average amount spent per day across these three realms is \$113.75. Also, according to a report prepared by Davidson-Peterson Associates for the Wisconsin Department of Tourism, the average length of stay for tourism travel in Wisconsin in 2006 was 2.04 days for trips to hotels/motels and resorts; 3.84 for trips to cabins, cottages, and condos; and 2.38 for trips to campgrounds. These numbers yield an average length of stay of 2.75 days. Multiplying the average spending per trip by the average length of stay yields an estimate of \$313.20 for US.

The above estimate was the best we could obtain based on the data available. The accuracy of our estimation was limited by the inconsistencies in the spending data received for the different lodging types/trip purposes with the data received on length of stay. The length of stay data did not take into account those that may have been staying with friends or relatives, while the per-trip spending data did. Additionally, no national data was available regarding the proportion of induced intercity bus trips for recreation and retail purposes.

Access to Jobs

Accessing jobs is a central benefit of all types of transit programs, and intercity bus is no exception. As noted in TCRP Report 78 (ECONorthwest, 2002), the importance of transit across different scales serves to link the source of labor with the demand for that labor. Oftentimes, the labor force does not live within close proximity to the jobs that demand its labor, and this is true of the intercity case as well. Many intercity routes link areas with low labor demand pools to those with high labor demand pools, and it is the relatively short intercity bus routes that are particularly important for commuting, as bus users' benefits of being able to access work outweighs any costs associated with commuting by intercity bus. While many studies, such as Litman (2006), have demonstrated the importance and prevalence of local mass transit for commuting purposes, long distance commuting by intercity bus has also be shown to be significant. According to the 2001 National Household Travel Survey (NHTS), 12.7% of the nation's long distance trips (greater than or equal to 50 miles) made by bus were for commuting purposes.

In order to assess the economic benefits associated with increased access to jobs, we focus on the additional commuters that use the improved bus service to access better-paid jobs at their destinations. We assume that the improved intercity bus allow the new commuters to access higher paying jobs at the destination than the local jobs at their city of residence. Without the intercity bus service, these users will be forced to take lower paying and less desirable jobs locally. The additional total income, denoted by ΔTI, for these new commuters give us the economic benefits due to increased access to job opportunities. We compute ΔTI as:

$$\Delta TI = \Delta NCom_{bus} \cdot \Delta AI$$

where $\Delta NCom_{bus}$ is the number of new commuters using the intercity bus service and ΔAI is the net difference in average annual income between a distant and a local job. It should be noted that the value of ΔAI would be not only region dependent but also route specific, as it is largely a function of the type of economic activities taken place in the major stops along a given bus route.

The application of the above-proposed method is subject similar limitations and data constraints faced when measuring changes in retail/recreation spending.

4.4 Project Costs

The ideal and more accurate way to estimate transit project costs is to measure the various capital and operating cost components separately. However, detailed operational and cost information such as the number of new buses to be acquired, the life cycle length of these buses, and the number of employers needed are typically unavailable at the early stage of planning for intercity bus service. Thus, a practical and reliable way to estimate the project capital and operating costs is to apply appropriate unit costs ($/VMT) to bus VMT along the proposed corridor. We chose VMT- over person mile traveled (PMT)-based unit costs because the intercity bus service considered here is a fixed schedule service and so the project costs should be relative independent from the actual ridership.

Multiple data sources have been examined for the value of unit costs, as summarized in Appendix B. Since the study by Nookala and Khan (1988) is the only resource that provides a good unit capital costs estimation and its unit operating costs is also comparable to the other sources, its two unit cost values are selected for the current study. Since the original data is in 1982$/km, it has been converted into 2008$/mile and listed in Table 4-13Table 4-13. The unit capital cost of 0.17 (1982$/km) given by Nookala and Khan (1988) was calculated based on vehicle cost of $180,000~$200,000, interest rate of 14%~16%, and utilization of 160~240 (1000km/yr). The operating cost of 1.04 (1982$/km) comprises maintenance cost of 0.18 (1982$/km), fuel cost of 0.15 (1982$/km), driver cost of 0.55 (1982$/km), and overhead of 0.16 (1982$/km).

Table 4-13. Unit capital costs and operating costs used in the present study

	1982 $/km	1982 $/mile	2008 $/mile
Capital Cost (vehicles)	0.17	0.2736	0.5992
Operating Cost (maintenance, fuel, driver, overhead)	1.04	1.6737	3.6654
Total cost	1.21	1.9473	4.2646

Source: Transportation research record 1125.

CHAPTER 5. INTERCITY BUS BENEFIT/COST ANALYSIS (IBBCA) MODEL

The BCA framework that we proposed and described in the preceding chapter was implemented as a spreadsheet-based model in Microsoft Excel. This spreadsheet-based model, referred to as the IBBCA model, allows planners to analyze the comprehensive impacts of adding intercity bus service on a given route. IBBCA takes as input various information relating to the proposed bus service. It also requires various travel volume and level of service (LOS) information corresponding to two scenarios: with the bus service and without the bus service. The volume and LOS information could be estimates from the state level or corridor level – a choice that the analyst would have to make depending on the expected geographic extent of impact of the bus service being evaluated. Based on the inputs, IBBCA produces as output the total costs, total benefits, net benefits, and benefit-cost ratio associated with the intercity bus service being considered.

As shown in Figure 5-1, the model consists of a set of nine spreadsheets: the *Instructions* sheet, *Inputs* sheet, five intermediate sheets, *Results* sheet, and *Parameters* sheet. Once the user enters the required information either directly into the *Inputs* sheet or via a series of user-friendly dialog boxes, IBBCA uses the data to populate the intermediate sheets to estimate the individual travel impacts, environmental impacts, economic impacts, safety impacts, and project costs. These intermediate results are then summarized and the final model outputs are computed in the *Results* sheet.

The reader is referred to the *IBBCA User Guide* (Guo *et al.*, 2008) for detailed description of the IBBCA tool.

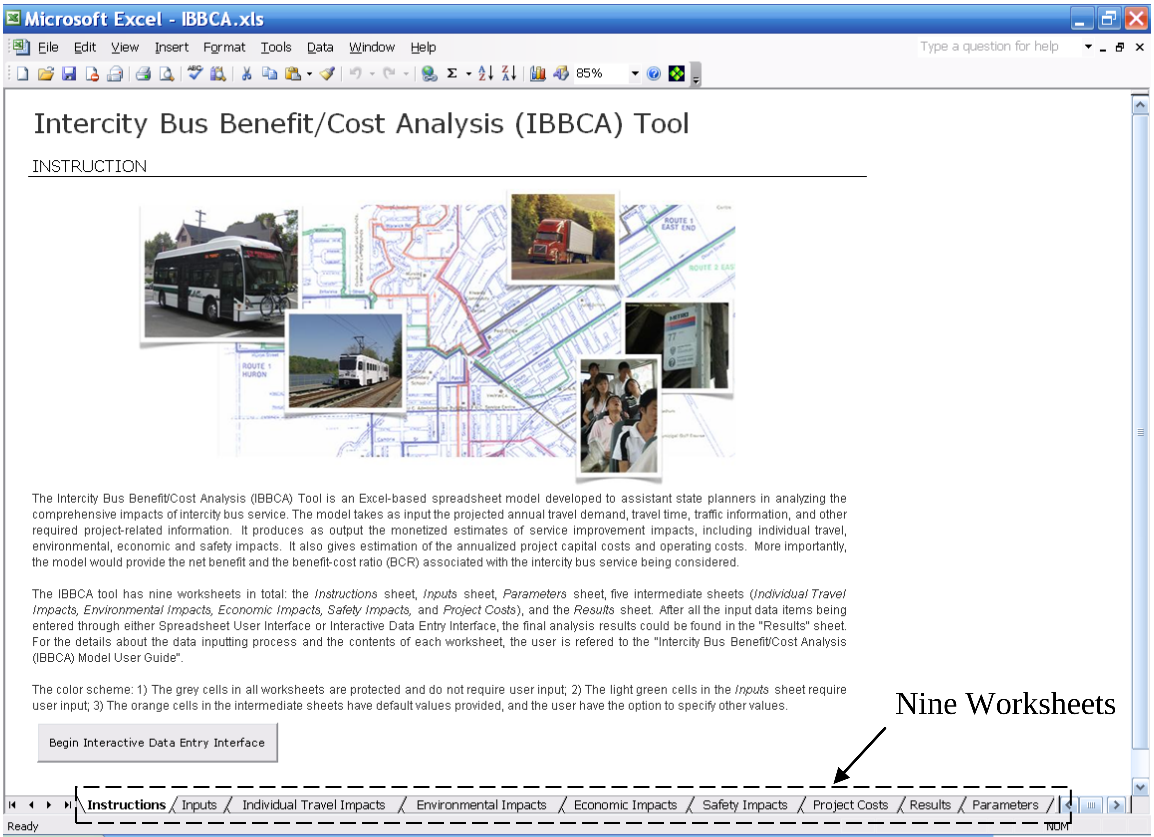

Figure 5-1. Instruction Page of the IBBCA Tool

CHAPTER 6. APPLICATION AND VERIFICATION OF THE IBBCA MODEL

This chapter describes the application of the IBBCA model to analyze selected intercity bus route additions in the state of Wisconsin. The purpose of this application effort is three-fold:

- To demonstrate the applicability of the IBBCA model on Wisconsin, and identify data sources for the model application.
- To verify the accuracy and rationality of the IBBCA model, and examine the sensitivity of the analysis methodology to input values.
- To provide the Wisconsin Department of Transportation (WisDOT) verified analysis results for the five chosen test routes.

Wisconsin is a state with an expanse of smaller urban and rural areas, making the provision of a stable intercity bus service important and appropriate. The intercity bus service cutback by the private operators has been particularly challenging for the state, and has resulted in critical gaps in the interconnectivity of the statewide modal network. In order to improve the statewide network connectivity and to address the various issues that have arisen from intercity bus service cutbacks, WisDOT is looking to restore, improve and expand existing bus routes as part of its long-range transportation plan.

As part of its latest long-range plan known as “Connections 2030”, WisDOT identified a list of thirteen intercity bus routes based on the blue print developed back in the 1995 “Translinks 21” plan. A three-phase implementation plan has also been proposed for these thirteen routes. Phase 1 routes are to be implemented in 2-4 years; Phase 2 routes in 5-10 years; and Phase 3 routes in 10 years and beyond. A table listing the characteristics of these routes – including the cities served, scheduled travel time, estimated fare structure, and frequency – and a map illustrating the alignment of the routes are provided in Appendix C. According to WisDOT, these routes were chosen based on the following considerations:

- Routes that connect metropolitan areas that currently do not have direct or convenient connections, leaving a gap in the intercity bus network
- Abandoned routes to be reinstated
- Routes that have ridership potential based on model
- Routes that connect key destinations (universities, medical facilities, etc.)
- Routes that were in previous budget submittals from the transit section.

Several of WisDOT’s thirteen proposed intercity bus routes were selected and analyzed using the IBBCA model developed in this project. The analysis process and the results for four particular bus routes are reported in this chapter. These four routes, hereafter referred to as “test routes”, are:

- Madison-Green Bay, via Fond du Lac and the Fox Cities
- Madison-Wausau, via Stevens Point
- Eau Claire-Green Bay, via Wausau
- Wausau-Hurley, via Merrill, Rhinelander, and Minocqua

6.1 Scenarios for Analysis

The benefits and costs of the four test routes were analyzed in the context of four 2030 scenarios, each representing a different level of public transportation service in Wisconsin. These scenarios are described in turn below.

6.1.1 Scenario A – Status Quo plus Single Proposed Routes

This scenario assumes that, in year 2030, the status quo (year 2008) intercity transit network would be maintained and each single test route would be implemented with the status quo.

The status quo intercity transit network consists of all the bus routes and Amtrak lines currently operating in the state of Wisconsin. The current bus routes run throughout the state, connecting cities within Wisconsin to each other and to the Upper Peninsula of Michigan, as well as the Minneapolis/St. Paul and Chicago metropolitan areas. As listed in Appendix D, operators of these current bus routes include Van Galder Bus, Badger Bus, Wisconsin Coach Lines, Lamers Bus, Megabus, Greyhound Bus, Indian Trails Bus Lines, and Jefferson Bus Lines. This intercity transit network is coded by the TUSA Lab researchers by updating the 2001 transit network used in the Wisconsin statewide demand model. Bus service frequencies and stop locations are changed to reflect the current schedules as accurately as possible. It should be noted that, due to variations in bus operations across different days of the week, the transit network was coded to represent the service level on an 'average' week day. The headways also represent average headway by dividing a 24-hour day by the number of services per day. The starting, ending, and intermediate stops of the bus services are coded at the traffic analysis zone (TAZ) level.

The highway network used for the 2030 scenario is the same as that used by WisDOT to forecast travel conditions for *Connections 2030*. This network includes the 2001 Wisconsin State Trunk Highway Network (STHN) and the projects already committed for this planning horizon.

6.1.2 Scenario B – Status Quo plus All Proposed Routes

This scenario assumes that, in year 2030, the status quo (year 2008) intercity transit network would be maintained and the test routes, together with the remaining proposed intercity bus routes, would also have been implemented.

6.1.3 Scenario C – Status Quo plus High Speed Rail and Proposed Routes

Scenario C assumes that, in year 2030, the status quo intercity transit network would remain, the high speed rail (HSR) would have been in operation, and all thirteen proposed intercity bus routes would also have been implemented. This scenario is therefore equivalent to the addition of HSR network to scenario B.

The HSR network considered here is the one envisioned as part of the Midwest Regional Rail Initiative (MWRRI), which seeks to link cities across the Midwestern United States with high-speed rail using Chicago as the central hub. The HSR network used for *Connections 2030* was adopted for the present study. This HSR network includes the rail service as well as a set of feeder bus routes. These feeder buses are meant to be timed with trains so that little wait time is required. A list of the feeder bus service and a map showing the routes are provided in Appendix E.

6.1.4 Scenario D – Status Quo plus High Speed Rail, Essential Bus and Proposed Routes

This is the most ideal vision of the state's transit network for 2030. The scenario assumes the presence of not only the status quo bus service, the HSR and its feeder buses, and the thirteen proposed routes; but also the future essential bus (FEB) service.

The FEB service is a network of regional buses envisioned to connect all cities, towns, and villages with a population of 10,000 or more. This network was first conceived in the *Translinks 21* plan, which outlined a multi-modal transportation plan for Wisconsin. The FEB network used for *Connections 2030* was adopted for the present study. See Appendix F for the definition and a map of the routes constituting the FEB network.

6.2 Analysis Procedure

The benefit/cost of each test route selected for analysis was evaluated under each of the four future scenarios, yielding a total of sixteen sets of analysis as listed in Table 6-1. Each set undergoes the analysis process depicted in Figure 6-1. For example, the analysis of the Madison – Green Bay route under scenario B involves first running the Wisconsin statewide demand model twice. The first model run uses the network that includes the status quo intercity transit network plus all thirteen proposed routes as described in Section 6.1.2. This network configuration is denoted as network B-0. The Madison – Green Bay route is then removed from the network to yield network B-1 and the demand model is run again. The difference in travel forecasts between these two networks (B-0 minus B-1) represents the change in the statewide travel demand attributed to the Madison – Green Bay route. Similar procedures are used to analyze the test routes under scenarios C and D. For scenario A, the procedure is a little different due to the different setup of the scenario. In this case, each proposed route is added separately so that the change in the statewide travel demand attributed to the route is represented by subtracting the travel forecast for the status quo network (A-0) from the travel forecast for the improved network (status quo plus the route of interest, e.g. A-1). The network configurations used to generate the various travel forecasts are defined in Appendix G.

As shown in Figure 6-1, the travel forecasts produced by the demand model provide key inputs to the subsequent benefit/cost analysis. Specifically, these include the variables listed in Table 6-2. Additional route-specific information needed for the analysis includes route length, unit capital/operating costs for the bus service, auto traffic distribution by vehicle type, and average truck cargo value along the corridor.

Table 6-1. The twelve sets of benefit/cost analysis conducted in the present study

Set	Test Route being Analyzed	Scenario Used for Analysis	Travel Forecasts	
			Test Route Included	Test Route Excluded
1	*Madison – Green Bay*	A	A-1	A-0
2	*Madison – Wausau*	A	A-2	A-0
3	*Eau Claire – Green Bay*	A	A-3	A-0
4	*Wausau – Hurley*	A	A-4	A-0
5	*Madison – Green Bay*	B	B-0	B-1
6	*Madison – Wausau*	B	B-0	B-2
7	*Eau Claire – Green Bay*	B	B-0	B-3
8	*Wausau – Hurley*	B	B-0	B-4
9	*Madison – Green Bay*	C	C-0	C-1
10	*Madison – Wausau*	C	C-0	C-2
11	*Eau Claire – Green Bay*	C	C-0	C-3
12	*Wausau – Hurley*	C	C-0	C-4
13	*Madison – Green Bay*	D	D-0	D-1
14	*Madison – Wausau*	D	D-0	D-2
15	*Eau Claire – Green Bay*	D	D-0	D-3
16	*Wausau – Hurley*	D	D-0	D-4

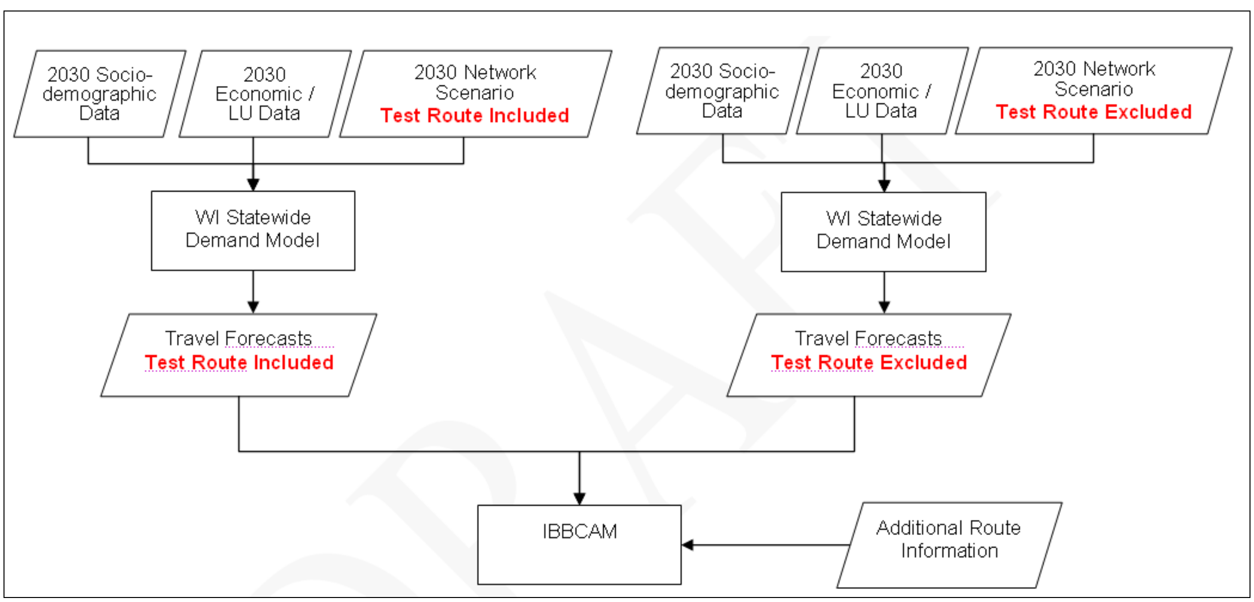

Figure 6-1. Process of analyzing each test route under a given future (year 2030) scenario

Table 6-2. Travel forecasts given by the statewide demand model runs that are used as key inputs to the IBBCA model

Demand Model Forecast Variables
Number of auto trips along the test route per year
Number of bus trips along the test route per year
Total bus passenger miles traveled along the test route (mi/year)
Proportion of pleasure trips by bus along the test route
Proportion of personal trips by bus along the test route
Proportion of business trips by bus along the test route
Proportion of pleasure trips by auto along the test route
Proportion of personal trips by auto along the test route
Proportion of business trips by auto along the test route
In-vehicle travel time for one average bus trip on the test route (hour)
Excess travel time for one average bus trip on the test route (hour)
In-vehicle travel time for one average auto trip on the test route (hour)
Total in-vehicle travel time for bus over the whole statewide transit network (hour)*
Total excess travel time for bus trips over the whole statewide transit network (hour)*
Total in-vehicle travel time for rail over the whole statewide transit network (hour)*
Total excess travel time for rail trips over the whole statewide transit network (hour)*
Total in-vehicle travel time for auto over the whole statewide highway network (hour)*
Total in-vehicle travel time for truck over the whole statewide highway network (hour)*
Total vehicle and person miles traveled by bus on the statewide transit network (mi/year)*
Total vehicle and person miles traveled by rail on the statewide transit network (mi/year)*
Total vehicle and person miles traveled by auto on the statewide highway network (mi/year)*
Total vehicle miles traveled by truck on the statewide highway network (mi/year)*
proportion of pleasure trips on the statewide transit network for bus*
proportion of personal trips on the statewide transit network for bus*
proportion of business trips on the statewide transit network for bus*
proportion of pleasure trips on the statewide transit network for rail*
proportion of personal trips on the statewide transit network for rail*
proportion of business trips on the statewide transit network for rail*
proportion of pleasure trips on the statewide highway network for auto*
proportion of personal trips on the statewide highway network for auto*
proportion of business trips on the statewide highway network for auto*

* Values of these variables are needed for both model runs (including and excluding the test route) so that their respective differences can be computed and used in the IBBCA model.

6.3 Generating Travel Forecasts

The Wisconsin statewide demand model used in the present study was developed by Cambridge Systematics, Inc. for WisDOT for updating the *Connections 2030* plan. The model, developed in Cube TP+/Voyager, consists of a freight model and a passenger model. This section aims to highlight the key characteristics of the passenger demand model that was configured and used to generate the travel forecasts for our route evaluation. This discussion serves to provide the background information for our subsequent discussion on the benefit/cost analysis results. For detailed documentation of the demand mode, the reader is referred to the report titled "*Wisconsin Statewide Model: Final Report*" prepared by Cambridge Systematics, Inc. (2008).

6.3.1 Statewide Model Overview

As shown in Figure 6-2, the passenger model is comprised of two major components: a daily travel (DT) model and a long-distance travel (LDT) model. The LDT model is the model component that is primarily responsible for capturing the impact of changes in intercity bus service. It considers three types of non-recurrent long-distance trip purposes (business, personal business, and pleasure) and three modes (auto, bus, and rail). The LDT model begins with the transit skimming process, which calculates the zone-to-zone transit level of service (LOS) measures (including bus and rail in-vehicle travel time, access time by auto, access time by walk, initial wait time, number of transfers, and fare) based on the analyst-specified transit network. The computed transit LOS measures, along with exogenous auto LOS information, are then fed into a conventional four-step modeling structure to predict long distance travel patterns. At the end of the mode split step, the LDT model generates the zone-to-zone number of person trips by mode in the form of trip original-destination (OD) tables. These long-distance trip OD tables, together with the daily trip OD tables (resulting from the trip distribution step of the DT model) and the truck trip OD table (separately predicted by the freight model), are subsequently loaded onto the highway network during the trip assignment step of the DT model. The output of this step includes the speed, volume, and other measures of travel condition on the highway links. Meanwhile, the transit assignment step of the LDT model independently loads the transit passengers onto the transit network to determine the ridership for each transit service route.

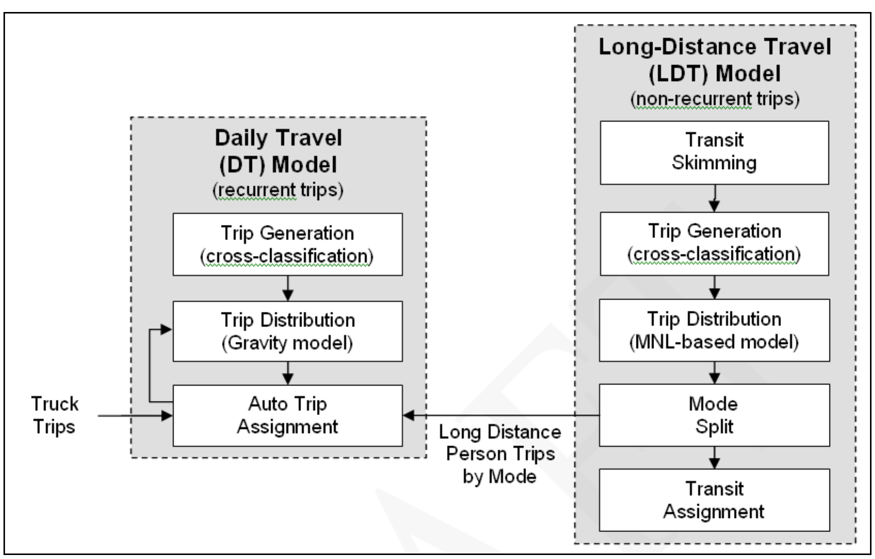

Figure 6-2. Overall structure of the passenger travel demand model component

6.3.2 Forecasting Results

A total of twenty sets (corresponding to network configurations A-0 ~ A-4, B-0 ~ B-4, C-0 ~ C-4, D-0 ~ D-4) of demand model outputs were generated to be used as inputs to the sixteen benefit/cost analyses designed for this study. For the purpose of verifying the reasonableness of the demand forecasting results, the system-wide, annual person miles traveled (PMT) by the three passenger modes and the vehicle miles traveled (VMT) by truck as predicted by the demand model are summarized in Appendix H. Overall, the forecasted mile traveled for most scenarios are intuitive. Across the four modes being considered in the statewide network, system-wide bus PMT tend to increase with the addition of a test route. Meanwhile, auto PMT decrease due to the modal shift to bus. The effect on rail is line-dependent. In cases where the test route being considered complements the existing/ proposed rail lines (e.g. the Eau Clair - Green Bay route), rail PMT are found to increase. In cases where the added bus route represents a competing service (e.g. the Madison - Green Bay route), rail PMT is found to decrease. Finally, the addition of a bus route to the network has little impact on truck PMT as expected.

It should be noted that in the travel demand model originally provided by WisDOT, model convergence was determined based on the gap criterion computed as the total vehicle cost difference between two successive iterations. This convergence criterion was found to result in the premature termination of the traffic assignment procedure in several scenario analyses. To overcome this problem, we replaced the gap function by the relative gap. It was also observed that the forecast results may be very sensitive to the threshold value chosen for the convergence criterion. For example, Appendix I shows the differing travel time forecasts between using 0.01 and 0.001 as the relative gap convergence threshold when analyzing the Madison-Wausau route. In fact, when the value of 0.01 was used, the model resulted in a slight decrease in in-vehicle travel time forecast for LDT autos, but significant increase for trucks. This somewhat counter-intuitive forecast results led to a negative user benefit and a negative total B/C ratio for the Madison-Wausau route. Compared with the forecast results obtained from setting the relative gap as 0.01, the results given by a relative gap value of 0.001 are more stable (this is evident in Appendix I where the map corresponding to relative gap equal to 0.001 shows more localized change in in-vehicle travel time near the route Madison-Wausau). Thus, the figures reported in Appendix H and used in our subsequent analysis were all generated using the 0.001 relative gap threshold value.

6.3.3 Limitations

In addition to the model convergence issue mentioned above, the following features of the statewide demand model may introduce additional uncertainty in the accuracy of travel forecasts used in the present study:

- Due to the absence of any feedback structure between the LDT and the DT models, the auto LOS used as input to the LDT model is different from the auto LOS estimated by the DT model. For the same reason, the bus LOS used in the LDT model is also not consistent with the auto LOS used for the same zone pair. The absence of inter-model feedback means that the mode split in the LDT model is not estimated based on the travel conditions at equilibrium. This could lead to either under- or over-estimation of transit ridership.

- Similar to how the 2001 transit network was coded for the *Connections 2030* study, the 2008 intercity bus network used in the present study represents a simplification of the actual bus operations. For instance, bus stops are assumed to locate at zone centroids as opposed to the actual terminals, thereby resulting in possible inaccurate estimates of access and travel times. Likewise, wait times and headways are coded to represent the average status of bus operations, which in reality vary by time of the day and day of the week. Similar simplification was also made to the 2030 transit network since the exact operational parameters are unknown at this point in time. While such simplification is often necessary to make the computation process manageable, the loss in temporal and spatial details may lead to forecast errors that deserve further evaluation.

CHAPTER 7. BENEFIT-COST ANALYSIS RESULTS

The analysis results given by our IBBCA model for the sixteen sets of analysis outlined in Table 6-1 are reported in Appendix J. The most important and informative output measure of all is the benefit-cost ratio (BCR). Table 7-1 highlights the BCR values for the four test routes under the four alternative future scenarios. The consistently high BCR values suggest that the gain from implementing any of these test routes significantly out weighs their cost. Below, we discuss and compare the sixteen sets of analysis results in more details by impact categories, test routes and alternative future scenarios.

Table 7-1. Benefit-cost ratios computed for the sixteen sets of intercity bus route analysis

Scenario	Madison – Green Bay	Madison – Wausau	Eau Claire – Green Bay	Wausau – Hurley
A	9.95	5.98	2.72	-0.4
B	4.74	6.23	4.07	1.76
C	4.76	6.64	5.74	2.81
D	4.97	5.66	4.56	1.72

7.1 Comparison across Impact Categories

The magnitudes of the various impact categories are first compared against each other and discussed below.

7.1.1 User cost impact

It can be seen from Appendix J that, for all sixteen sets of analysis, user cost impact is consistently the category with the highest benefit value, which is consistent with the general consensus (ECONorthwest, 2002) that user benefits should be the major source of benefits from transportation investments. User cost captures the value of travel time savings for all surface transportation mode users as the roadway frees up due to increased transit use. Our analysis results indicate that the total travel time costs reduce significantly across all modes, among which auto travel time cost reduction is the highest. Across the fifteen analysis sets, the reduction in auto travel time costs is two to four times the added bus travel time costs. Truck travel time costs should also theoretically reduce as the whole network level of service (LOS) is improved; however, since the change of truck travel time due to adding one bus line is very insignificant and the truck assignment result is not in ideal equilibrium either, the statewide demand model sometimes cannot reflect the reduction in truck travel time costs. The change of truck drivers' travel time costs exhibits unstable status: it will reduce in some cases, while increase in other cases. But no matter it is reduced or increased, the change of amount is in the scale of 0.01% since the total travel time costs for truck users is very large (in the magnitude of billion $/yr). The impact on rail is also relatively minor because the number of trips switched from rail to bus is much smaller than those switched from the auto mode. The user cost impact also includes changes in auto operating and parking costs due to intercity bus service changes. These costs are not negligible and account for about one half of the total auto travel cost reduction.

The problem with the Wausau – Hurley route under scenario A is that the user benefits are negative, which is much unexpected. This is because, when adding Wausau – Hurley into scenario A, the number of auto trips was reduced by such a small amount that the statewide demand model cannot reflect the network LOS improvement. Table 7-2 shows that the number of LDT auto trip reduction due to adding Wausau – Hurley into scenario A is only 30, which is much smaller than other cases in the table. Although the model convergence threshold has been set to a very small value (0.001), the traffic assignment procedure still could not converge to a stable point. Therefore, the negative BCR found for the Wausau – Hurley route under scenario A should not be interpreted as the true impact of the route, but rather as an indication that BCA at the route level places high demand on the accuracy of the travel forecasting model.

Table 7-2. Long distance travel (LDT) auto trip reduction due to adding the test routes under different scenarios (in trips/day)

Scenario	Madison-Green Bay	Madison-Wausau	Eau Claire-Green Bay	Wausau- Hurley
A	597	245	157	30
B	323	235	208	84
C	296	209	220	85
D	285	213	193	79

7.1.2 Safety impact

Safety impact represents the second highest impact category. This is because expanding and improving the intercity bus network reduces the use of personal automobiles, and the crashes and myriad costs associated with them. Interestingly, the Wausau-Hurley route experienced the least safety benefit out of the four test routes across all network scenarios. This makes sense since this route is the most rural and least busy of all test routes.

According to 2005 Wisconsin Department of Transportation figures, 801 people were killed in traffic crashes that year, with 53,462 people injured, and at least 5,129 people suffering incapacitating injuries. 39% of traffic crashes in 2005 occurred on the Wisconsin state highway and interstate highway network, which is the primary avenue of travel for intercity bus travel in the state. A majority of the deaths occurred in small cars and light trucks, and were a result of alcohol consumption and/or excessive speed, factors associated with personal automobile operators. Decreasing the VMT of personal automobiles by providing increased bus service leads to safer travel. Our BCR results are strong indication of this fact.

7.1.3 Environmental impact

The environmental impact accounts for the direct and ancillary costs associated with the air, noise and water pollution due to motor vehicle use. The environmental impacts found for all test routes were positive and significant. Environmental impacts are more moderate for routes with relatively lower traffic volumes, such as the Wausau-Hurley route.

7.2 Comparison across Test Routes

As shown in Table 7-1, the Madison-Wausau route has the highest BCR – and therefore the highest economic return – among the four test routes consistently across future scenarios B, C and D. In scenario A, it is the Madison-Green Bay route that has the highest BCR. In scenarios B and D, the Madison-Green Bay route has the second highest BCR, followed by the Eau Claire-

Wausau-Green Bay and Wausau-Hurley routes; while, in scenario C, Eau Claire-Wausau-Green Bay route has the second highest BCR.

Generally we can see that Madison – Wausau and Madison – Green Bay are the best two routes. Madison – Green Bay performs better when it is added to the status quo intercity transit network (scenario A), while Madison – Wausau performs better in the scenarios with more other transit service (scenario B, C and D).

Even though the Wausau-Hurley route has the lowest return of all test routes, its BCR is still relatively high for the three scenarios (except scenario A). The consistently high BCR values suggest that the gain from implementing any of these test routes significantly out weighs their cost, with a large contributing factor being the user benefits from implementing intercity bus service.

7.3 Comparison across Alternative Future Scenarios

The BCR of each bus route varies across scenarios. This is because the marginal impact of adding any given bus service depends on its relative location, complimentary effect and competitiveness to existing bus lines, the presence/absence and the relative performance of other modes in the system, as well as existing travel conditions along the corridor, and various environmental, and economic conditions. Since the four test routes behave quite differently under the four scenarios, they are discussed separately.

7.3.1 Madison – Green Bay

The Madison – Green Bay test route received the highest BCR in scenario A, followed by scenarios D, C and B. From Appendix J we can see that this trend is mainly due to the dominating effect of user benefits, which outweighs the other impacts (i.e. environmental impact and safety impact).

In scenario A, since Madison – Green Bay is an important corridor with much travel demand, adding the new bus service has prompted many auto users switching to transit mode (as shown in Table 7-2); the highway network performance thus has been improved a lot, resulting in very high user benefits. In scenarios B, C, and D, because of the presence of other bus lines which might compete with the Madison – Green Bay route, the added bus service cannot attract as many auto users to switch mode as in scenario A. Thus the network LOS improvement and user benefits are also smaller.

7.3.2 Madison – Wausau

The performance of the Madison – Wausau route under the four different scenarios does not change much, with the BCR ranging from 5.66 to 6.64. This variation is much smaller compared to other routes. This result indicates that the Madison – Wausau route will not be impacted much by the other transit services present in the different scenarios. It has a stable high BCR regardless of the existence of other bus lines.

7.3.3 Eau Claire – Green Bay

This route has the highest BCR under scenario C, followed by scenarios D, B, and A. It shows that Eau Claire – Green Bay performs better when it co-exists with other bus lines or rail lines, suggesting a complimentary effect among these transit services.

7.3.4 Wausau – Hurley

As explained in section 7.1.1, the Wausau – Hurley route in scenario A has a negative user benefits and thus negative BCR. It is also evident from Figure 7-3 that the Wausau – Hurley route has a much lower ridership forecast under scenario A compared to the other three scenarios. The reason for this difference across scenarios is because, under scenarios B, C and D, there are several bus lines which provide complementing service. Routes such as Madison – Wausau, Lacrosse – Wausau and Eau Claire – Green Bay are all connected to this line with some overlay, which expand the catchment area of the Wausau-Hurley route (e.g., for those who previously could not travel from Madison to Hurley by bus now are able to do so by transferring from the Madison – Wausau line to Wausau – Hurley line to complete the trip). Under scenario A, however, there few existing bus routes connected to the Wausau-Hurley route. Adding a single Wausau – Hurley route to the network cannot affect people's mode choice much. Thus, the benefits for operating such a route is less significant.

Table 7-3. Bus ridership for Wausau-Hurley under different scenarios

Scenario	Ridership of route Wausau-Hurley (persons/year)
A	18242.7
B	44179.6
C	43551.8
D	43851.1

7.4 Sensitivity Analysis

To test the robusticity of the model, we conducted a series of sensitivity analyses using the Madison – Wausau route, which was chosen for its relatively consistent and significant economic return under alternative future scenarios. The sensitivity of the BCA results was examined with respect to: (a) convergence condition selected for the demand forecast model and (b) input variables in the excel model.

7.4.1 Sensitivity to convergence condition

Since the convergence condition applies to only the traffic assignment for auto and truck, it does impact the bus and rail ridership. Rather, the choice of convergence condition is likely to affect the network LOS at convergence. Two convergence conditions were used: relative gap threshold value of 0.01 versus a value of 0.001. The resulting BCR computed for the route under alternative future scenarios are listed in Table 7-4 below.

Table 7-4. Relationship between the relative gap value and the BCR value for the Madison - Wausau route under alternative future scenarios

Scenario	BCR for the Madison - Wausau route	
	RelGap = 0.01	RelGap = 0.001
A	5.35	5.98
B	14.52	6.23
C	17.71	6.64
D	15.48	5.66

As shown in Table 7-4, decreasing the relative gap value has generally resulted in a smaller BCR value (except for scenario A). This is because the tighter convergence condition takes the estimation process closer to the 'true' equilibrium state. This is reflected in the smaller change in total auto in-vehicle travel time attributable to the route as estimated by the demand model, as shown in the right-most column of Table 7-5.

Table 7-5. Changes in total auto in-vehicle travel time by different converge condition

Scenario	System-wide Auto Person In-vehicle Travel Time (hour/year)					
	Without the Madison - Wausau route		With the Madison - Wausau route		Difference	
	GAP = 0.01	GAP = 0.001	GAP = 0.01	GAP = 0.001	GAP = 0.01	GAP = 0.001
A	301,390,513	298,304,642	301,042,858	297,968,114	347,656	336,528
B	299,745,762	296,373,629	299,105,728	296,033,583	640,034	340,046
C	289,642,205	286,282,962	288,809,475	285,941,545	832,730	341,417
D	289,169,284	286,053,692	288,443,002	285,735,451	726,282	318,241

In scenario A, when the relative gap is set to 0.01, the demand model projects an increase in the person travel time – and consequently a negative user benefit – for trucks after the Madison – Wausau route is added, which is counterintuitive (see Table 7-6). This is attributable to the larger error margin allowed for the traffic assignment procedure. This is also why in scenario A, the BCR is larger when the relative gap is set to 0.001.

Table 7-6. User benefits for auto and truck modes under scenario A by different GAP

Mode	User Benefits ($/year)	
	GAP = 0.01	GAP = 0.001
Auto	10,427,410	10,179,001
Truck	-601,243	129,998

In sum, we can see that the model output results are very unstable when a large relative gap value is used. Reducing the threshold to 0.001 can avoid this problem in most cases.

7.4.2 Sensitivity to BCA input variables

For the purpose of testing the sensitivity of analysis results to the input parameters, the Madison – Wausau route under scenario B is used. The input parameters being changed are: unit capital cost, unit bus operating cost, and vehicular composition in traffic stream. Each input variable is varied between 90% and 110% of its original value. The relationship between the input variable and the output BCR is shown in the figures below.

Figure 7-1 shows how BCR varies by bus unit capital cost. The trend is very intuitive: when everything else stays the same, increasing the unit capital cost would decrease the BCR. The same trend is found in Figure 7-2 for the effect of unit operating cost on BCA.

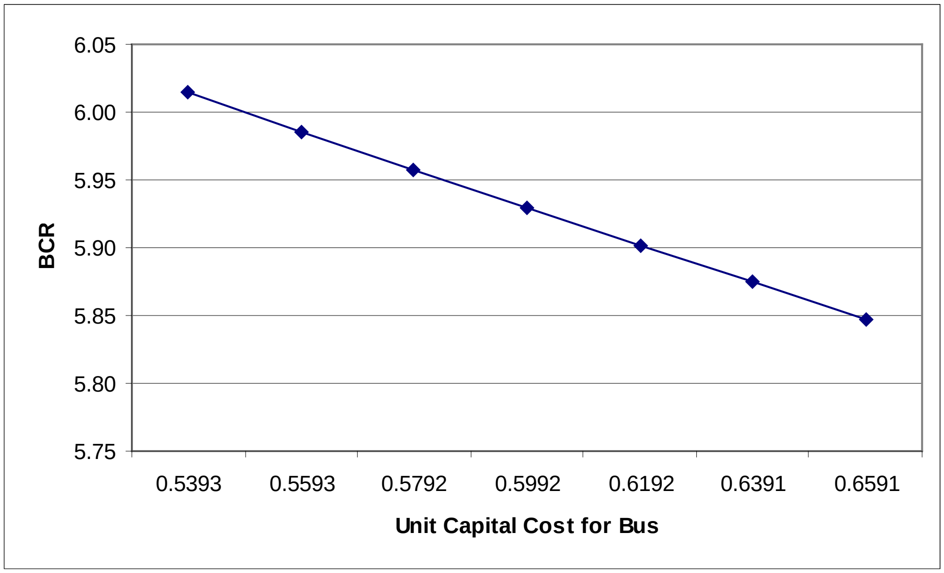

Figure 7-1. Relationship between BCR and Unit Capital Cost for Madison – Wausau in scenario B

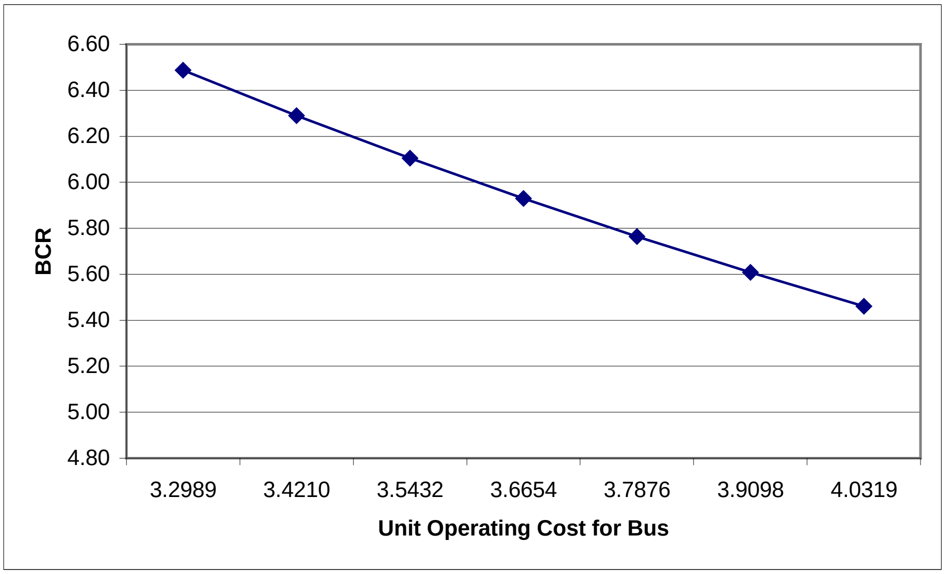

Figure 7-2. Relationship between BCR and Unit Operating Cost for Madison – Wausau in scenario B

The mix of vehicle types in the traffic is a quantity used in the calculation of environmental impacts. Two categories of vehicles are recognized in the BCA model: passenger car and other vehicles (e.g. SUV, van, and pickup). Since vehicles in the "other" category are associated with a higher pollution cost rate, the more passenger cars on the road the higher BCR is expected. This expectation is consistent with the sensitivity analysis results as shown in Figure 7-3.

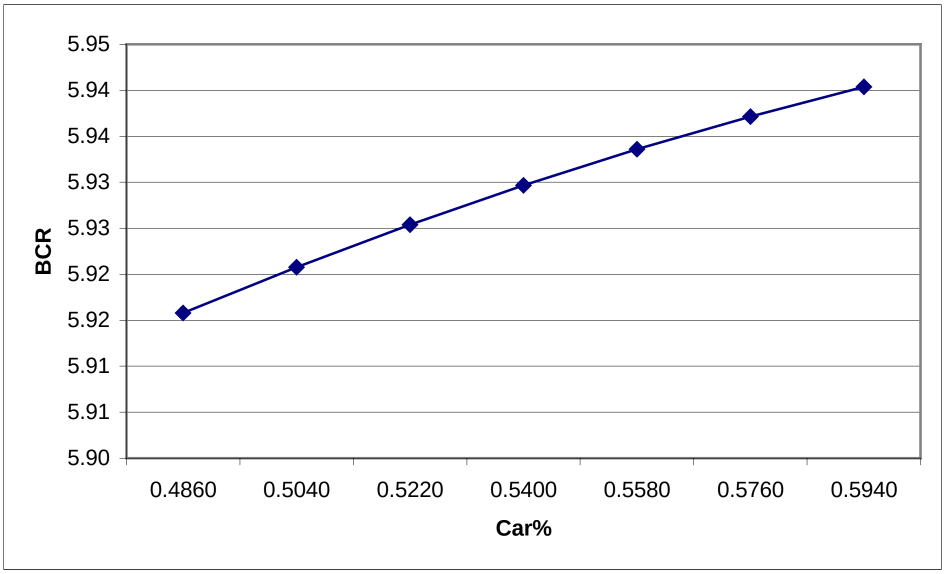

Figure 7-3. Relationship between BCR and percentage of passenger car for Madison – Wausau in scenario B

CHAPTER 8. CONCLUSIONS

The decline in intercity bus service has continued as major intercity bus companies face financial problems. Personal, economic, and sociological impacts of service abandonment are particularly severe in rural areas with no alternative public transportation and on those groups of people who frequently use intercity bus service: students, retirees, and low-income people. Intercity is important for linking these citizens up with surrounding communities and the rest of the state, giving them increased mobility and access to all kinds of personal and business-related trips.

The tools created and conclusions drawn through this research and analysis are important for transportation planners analyzing intercity bus potential. The work here helps to fill a need in public knowledge and planning functions, as intercity bus is a form of travel often overlooked and needing research investigation. Many states face the challenges of attaining wide recognition of the societal merits of intercity bus service and securing the financial support needed from both federal and local levels. These challenges call for a reliable benefit-cost analysis tool to evaluate and defend proposed investments. Such a benefit-cost analysis tool needs to comprehensively identify, and properly quantify, the benefits and costs associated with alternative intercity transit service scenarios. Although many benefit-cost analyses have been conducted in the urban transit, highway, and road contexts, there is a considerable lack of research in the intercity bus realm of benefit-cost analysis.

Building on previous transit BCA studies, the current study developed a BCA framework and implemented a MS Excel spreadsheet-based model – called the IBBCA model – for measuring the benefits and costs specifically for the intercity bus context. The IBBCA model takes as input various information relating to the proposed bus service, as well as the travel volume and LOS information corresponding to two scenarios: with the bus service and without the bus service. The model produces as output the total costs, total benefits, net benefits, and benefit-cost ratio associated with the intercity bus service being considered. The IBBCA model accounts for a wide range of transit benefits, including user-cost savings, environmental impact, economic impact, and safety impact. The total benefit is compared to the combined capital and operating costs associated with implementing a bus route. The analysis results, particularly in the form of benefit-cost ratios, can be used to help prioritize the routes.

Four out of the thirteen intercity bus routes proposed in Wisconsin's long range plan, *Connections 2030*, were analyzed using the IBBCA model under four future scenarios for year 2030: (1) status quo plus a single proposed route, (2) status quo plus all proposed routes, (3) status quo plus high-speed rail and proposed routes, and (4) status quo plus high-speed rail, essential bus, and proposed routes. The sixteen sets of benefit-cost analysis indicate that most routes have relatively high benefit-cost ratios and are therefore worthwhile investments for Wisconsin. Madison-Wausau route gives the highest return of all in three future scenarios. The Madison-Green Bay route has the second highest return, followed by the Eau Claire-Green Bay and Wausau-Hurley routes.

The analysis of test routes also showed that user benefits are the dominating effects of intercity bus investments. Safety and environmental impacts – although are smaller in magnitudes – also provide significant societal benefits. The more interesting findings are related to the substitutive and complimentary effects among the intercity bus routes. Since an intercity bus route is operated in a statewide transportation network, its performance is likely to depend on the other part of the transit network or even other modes. Thus, it is important to analyze any given intercity bus route from a statewide perspective. Analyses that focus only on the corridor where the bus route is to be implemented would lead to erroneous conclusions.

The research reported here shows that a properly designed intercity bus service could produce social benefits that significantly out-weigh its costs. The proposed intercity bus BCA model provides transportation planners a tool for assessing the impacts of implementing a specific bus route.

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APPENDIX A. INTERCITY BUS BENEFIT AND COST CATEGORIES

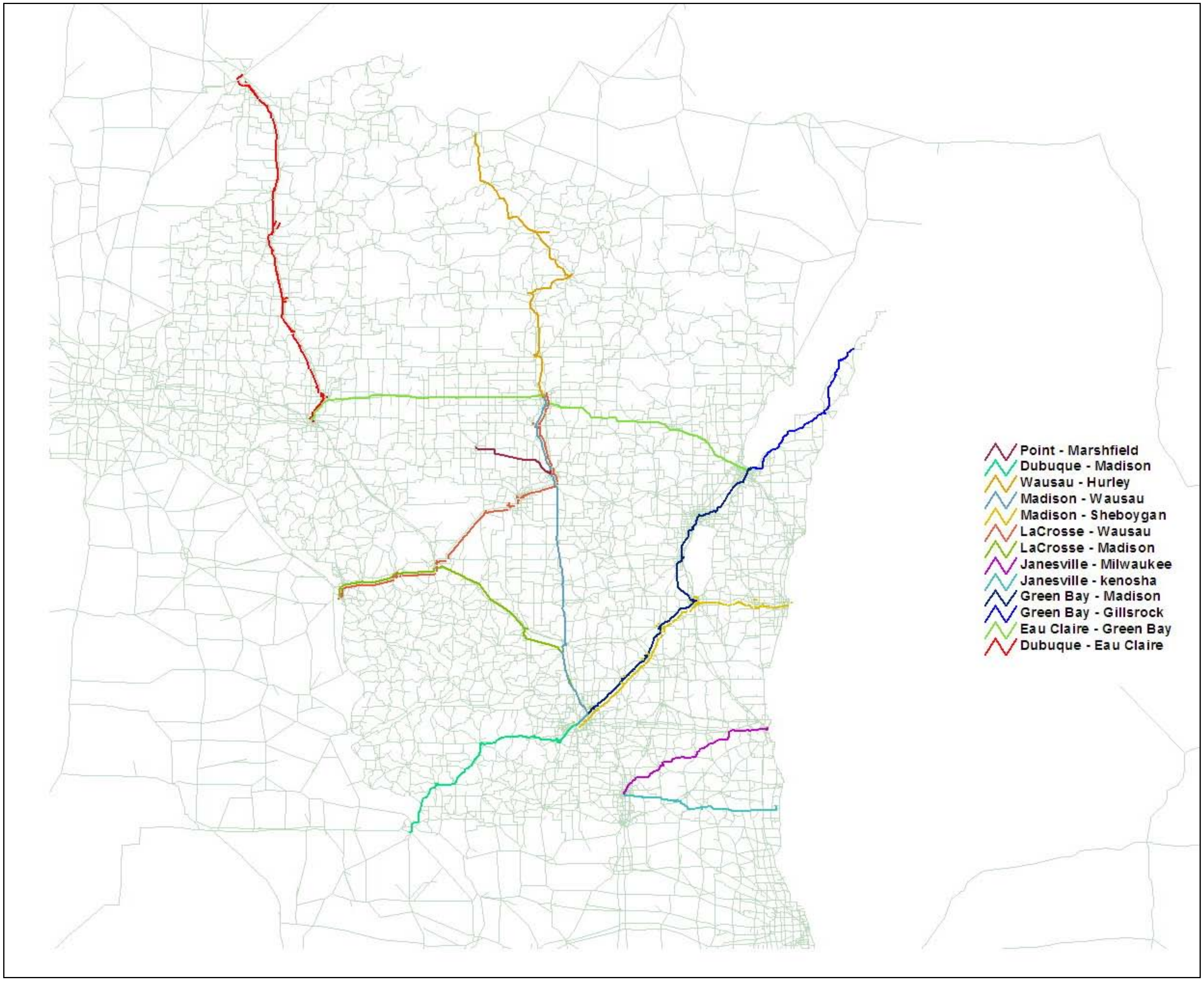
Intercity Bus Impacts	**Description**
Individual Travel Impacts	Impacts of the proposed transit service to travelers
User Cost Impact	Benefits and Costs of travel perceived by users; calculated through consumer surplus measurements
Transit (Bus/Rail) User Costs	Including bus/rail travel time costs
Auto/Truck User Costs	Including non-transit mode travel time costs, vehicle ownership and operating costs, and parking costs
Option Value of Bus Service	Availability of bus as an alternative mode, in case they are ever needed
Chauffeuring Reduction	Reduced chauffeuring responsibilities by drivers for non-drivers
External Impacts	Impacts of the proposed transit service that are external to travelers
Environmental Impact	Changes in impacts associated with air, water, and noise pollution
Regional Economic Impact	Economic impacts of increased access to health care, retail/recreation, travel, and job opportunities
Access to retail and/or recreation	Impact from increased access to retail and recreation spending opportunities
Access to job opportunities	Impact from increased access to job opportunities
Safety Impact	Changes in impacts from vehicular crashes
Intercity Bus Costs	**Description**
Transit Capital and Operating Costs	Direct costs of transit investments; typically paid by non-transportation users, including transit agencies, private provider of transit services, and other public agencies
Transit annualized capital costs	Primarily for right-of-way, facilities and vehicles; Annualized as to keep consistency with other annual benefits or costs
Transit annual operating costs	Recurring costs that usually include salaries, wages and benefits, materials and supplies, utilities, and other expenses related to ongoing operation and maintenance

APPENDIX B. ALTERNATIVE SOURCES OF INTERCITY BUS PROJECT COSTS

Sources	File Name	Data Items Available	Value (2008$)	Original Value	Context
MDOT Quarterly Reports for Greyhound and Indian Trails	MichDOT Quarterly Reports.xls	Operating cost per passenger	Multiple values for different routes and years	N/A	Intercity
		Operating cost per VMT	Multiple values for different routes and years	N/A	Intercity
Transportation Research Record 1125	"Cost-Efficiency of Intercity Bus Technology Innovations"	Capital cost per VMT	0.5992	0.17 (1982 $/km)	Intercity
		Operating cost per VMT	3.6654	1.04 (1982 $/km)	Intercity
Jefferson Lines	N/A	Capital cost per bus	458000	N/A	Intercity
		Operating cost per VMT	3.08	N/A	Intercity
ECONorthwest, 2002	Page II-49 ~ Page II-51	Capital cost per passenger	Three values for different city size	1.15, 1.61, 0.47 (1997 $)	Urban
		Capital cost per PMT	Three values for different city size	0.31, 0.27, 0.10 (1997 $)	Urban
		Operating cost per passenger	Three values for different city size	2.93, 4.26, 6.04 (1997 $)	Urban
		Operating cost per PMT	Three values for different city size	0.78, 0.87, 1.18 (1997 $)	Urban
		Operating cost per VMT	Three values for different city size	3.12, 4.46, 5.52 (1997 $)	Urban
http://www.sactaqc.org/Resources/primers/Primer_Transportation_Costs.htm	Full-Cost Analysis of Urban Passenger Transportation, University of Texas at Austin, 1996	Total cost per PMT	0.45 - 0.54	0.35 - 0.40 (1996 $)	Urban
http://www-pam.usc.edu/volume3/v3i1a4s1.html	Market-Based Transportation Alternatives For Los Angeles	Capital cost per passenger	0.3675	0.25 (1993 $)	Urban
		Capital cost per PMT	0.1029	0.07 (1993 $)	Urban
		Capital cost per passenger	2.8371	1.93 (1993 $)	Intercity
		Capital cost per PMT	0.0735	0.05 (1993 $)	Intercity
http://www.caltax.org/MEMBER/digest/oct97/OCT97-6.HTM	Alternatives To Rail: Rubber-Tire Transit	Operating cost per PMT	0.33615	0.249 (1996 $)	Urban
			0.22545	0.167 (1996 $)	Intercity
Greyhound	N/A	Operating cost per VMT	3.05	N/A	Intercity

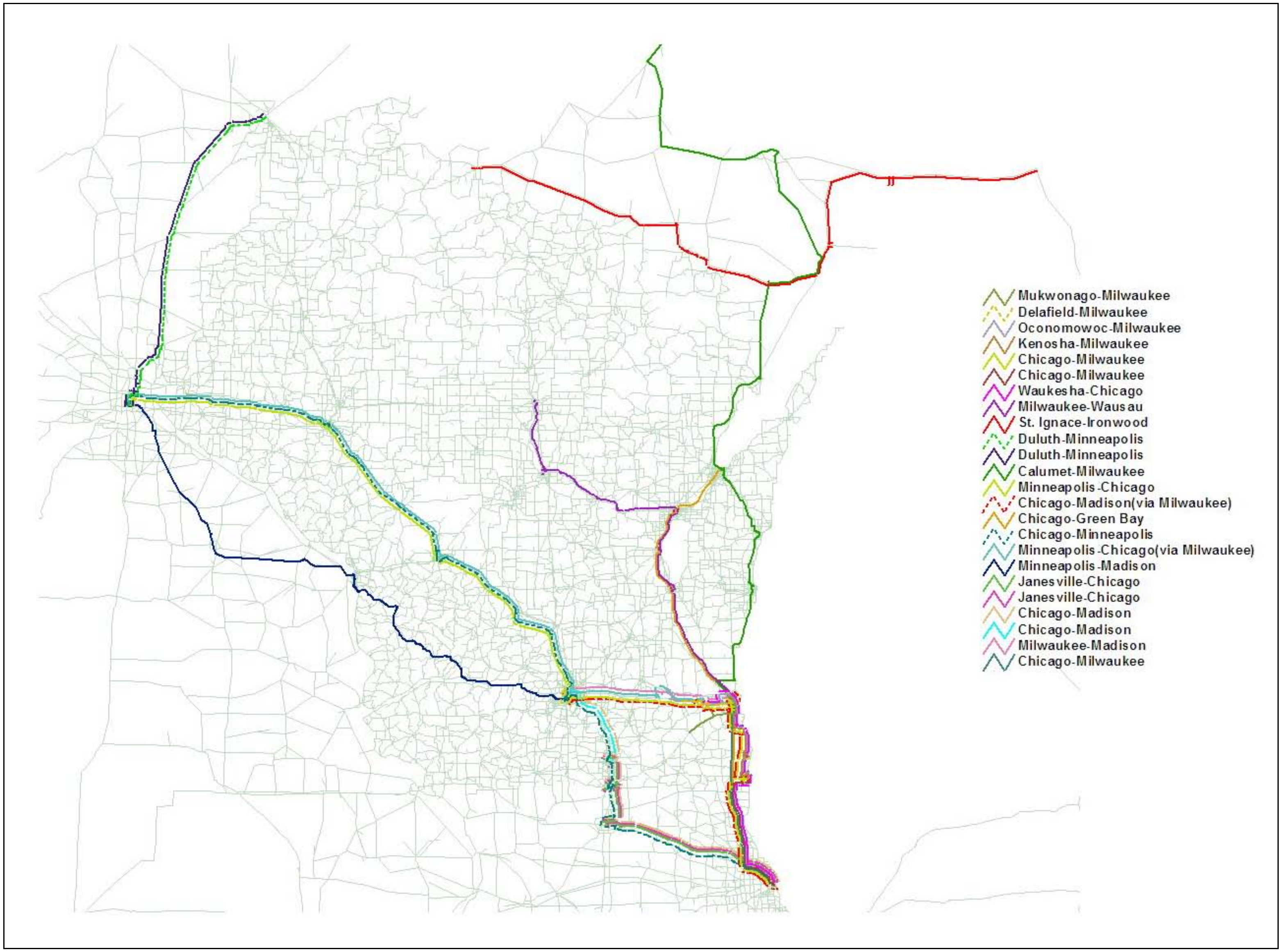
APPENDIX C. INTERCITY BUS ROUTES PROPOSED IN CONNECTIONS 2030

Routes	Unit fare ($ per mile)	No. of Stops	Headway (minutes)
Phase 1			
Route 1-1: Madison-Green Bay (via Fond du Lac, Oshkosh, Fox Cities)	0.198	11	480
Route 1-2: Madison-Wausau (via Stevens Point)	0.198	5	480
Route 1-3: Eau Claire-Wausau-Green Bay	0.198	4	480
Route 1-4: Eau Claire-Duluth/Superior	0.198	6	480
Phase 2			
Route 2-1: Madison-Dubuque (via Dodgeville, Platteville)	0.198	6	480
Route 2-2: Madison-Sheboygan (via Fond du Lac)	0.198	8	480
Route 2-3: Janesville-Kenosha (via Delevan and Lake Geneva)	0.198	4	480
Route 2-4: Janesville-Milwaukee(Via Whitewater)	0.198	5	480
Route 2-5: La Crosse-Madison (via Tomah)	0.198	6	480
Phase 3			
Route 3-1: Stevens Point-Marshfield	0.198	2	480
Route 3-2: La Crosse-Stevens Point-Wausau (via Tomah, Wisconsin Rapids)	0.198	7	480
Route 3-3: Green Bay-Sturgeon bay-Gills Rock	0.198	4	480
Route 3-4: Wausau-Hurley (via Merrill, Rhinelander, Minoqua)	0.198	6	480


Point - Marshfield
Dubuque - Madison
Wausau - Hurley
Madison - Wausau
Madison - Sheboygan
LaCrosse - Wausau
LaCrosse - Madison
Janesville - Milwaukee
Janesville - kenosha
Green Bay - Madison
Green Bay - Gillsrock
Eau Claire - Green Bay
Dubuque - Eau Claire

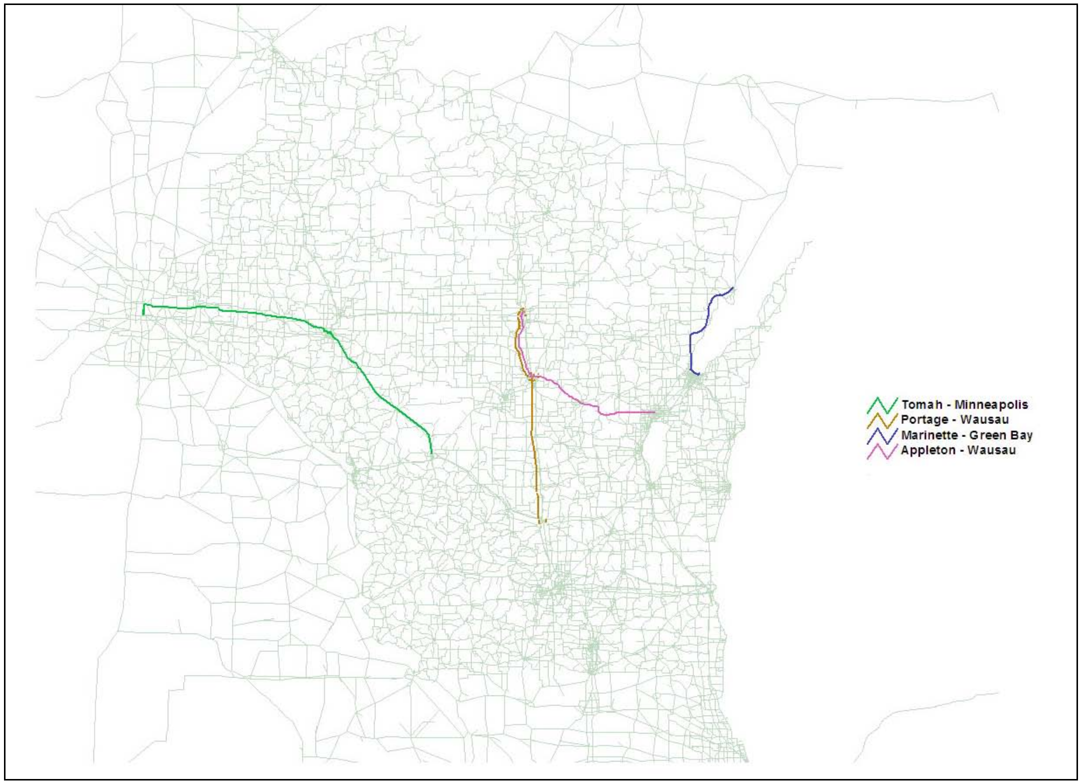
APPENDIX D. STATUS QUO (2008) TRANSIT NETWORK

Route	Operator	Unit fare ($ per mile)	No. of Stops	Headway (minutes)
Milwaukee-Chicago, IL (non-stop service)	Megabus	0.084	2	360
Chicago-Milwaukee-Minneapolis	Megabus	0.053	3	480
Waukesha-Milwaukee-Racine-Kenosha-Chicago, IL	WI Coach Lines	0.135	5	103
Milwaukee-Chicago (non-stop service)	Greyhound	0.117	2	720
Milwaukee-Racine-Kenosha-Chicago, IL	Greyhound	0.117	4	1440
Milwaukee-Racine-Kenosha	WI Coach Lines	0.091	3	180
Oconomowoc-Waukesha-Milwaukee	WI Coach Lines	0.081	3	720
Delafield-Brookfield-Milwaukee	WI Coach Lines	0.106	3	240
Mukwonago-Big Bend-New Berlin-Milwaukee	WI Coach Lines	0.102	4	480
Madison-Johnson Creek-Brookfield-Milwaukee	Badger Bus	0.205	4	360
Madison -Beloit-Rockford-Chicago, IL	Van Galder	0.156	4	240
Madison-Beloit-Chicago, IL	Van Galder	0.156	3	288
Janesville-Beloit-Rockford-Chicago	Van Galder	0.200	4	720
Janesville-Beloit-Chicago	Van Galder	0.200	3	1440
Madison-LaCrosse-Rochester, MN-Twin Cities, MN	Jefferson Lines	0.141	4	1440
Minneapolis/St.Paul, MN-Eau Claire-Tomah-Wisconsin Dells-Madison-Milwaukee-Racine-Kenosha-Chicago, IL	Greyhound	0.126	9	360
Minneapolis/St.Paul, MN-Eau Claire-Tomah-Wisconsin Dells-Madison-Beloit-Rockford-Chicago, IL	Greyhound	0.136	8	1440
Madison-Milwaukee-Kenosha-Chicago, IL	Greyhound	0.134	4	1440
Green Bay-Appleton-Oshkosh-Fond du Lac-Milwaukee-Chicago	Greyhound	0.194	6	1440
Calumet, MI-Escanaba, MI-Marinette-Peshtigo-Oconto-Green Bay-Manitowoc-Sheboygan-Milwaukee	Indian Trails	0.181	9	1440
Duluth, MN/Superior, WI - Minneapolis/St. Paul, MN	Jefferson Lines	0.150	2	1440
Duluth, MN/Superior, WI - Minneapolis/St. Paul, MN	Greyhound	0.172	2	1440
Ironwood, MI-Florence, WI-Spread Eagle, WI, Escanaba, MI-St. Ignace, MI	Indian Trails	0.169	5	1440
Wausau-Stevens Point-Waupaca-New London-Appleton-Oshkosh-Fond du Lac-Milwaukee	Lamers	0.188	7	1440


Mukwonago-Milwaukee
Delafield-Milwaukee
Oconomowoc-Milwaukee
Kenosha-Milwaukee
Chicago-Milwaukee
Chicago-Milwaukee
Waukesha-Chicago
Milwaukee-Wausau
St. Ignace-Ironwood
Duluth-Minneapolis
Duluth-Minneapolis
Calumet-Milwaukee
Minneapolis-Chicago
Chicago-Madison(via Milwaukee)
Chicago-Green Bay
Chicago-Minneapolis
Minneapolis-Chicago(via Milwaukee)
Minneapolis-Madison
Janesville-Chicago
Janesville-Chicago
Chicago-Madison
Chicago-Madison
Milwaukee-Madison
Chicago-Milwaukee

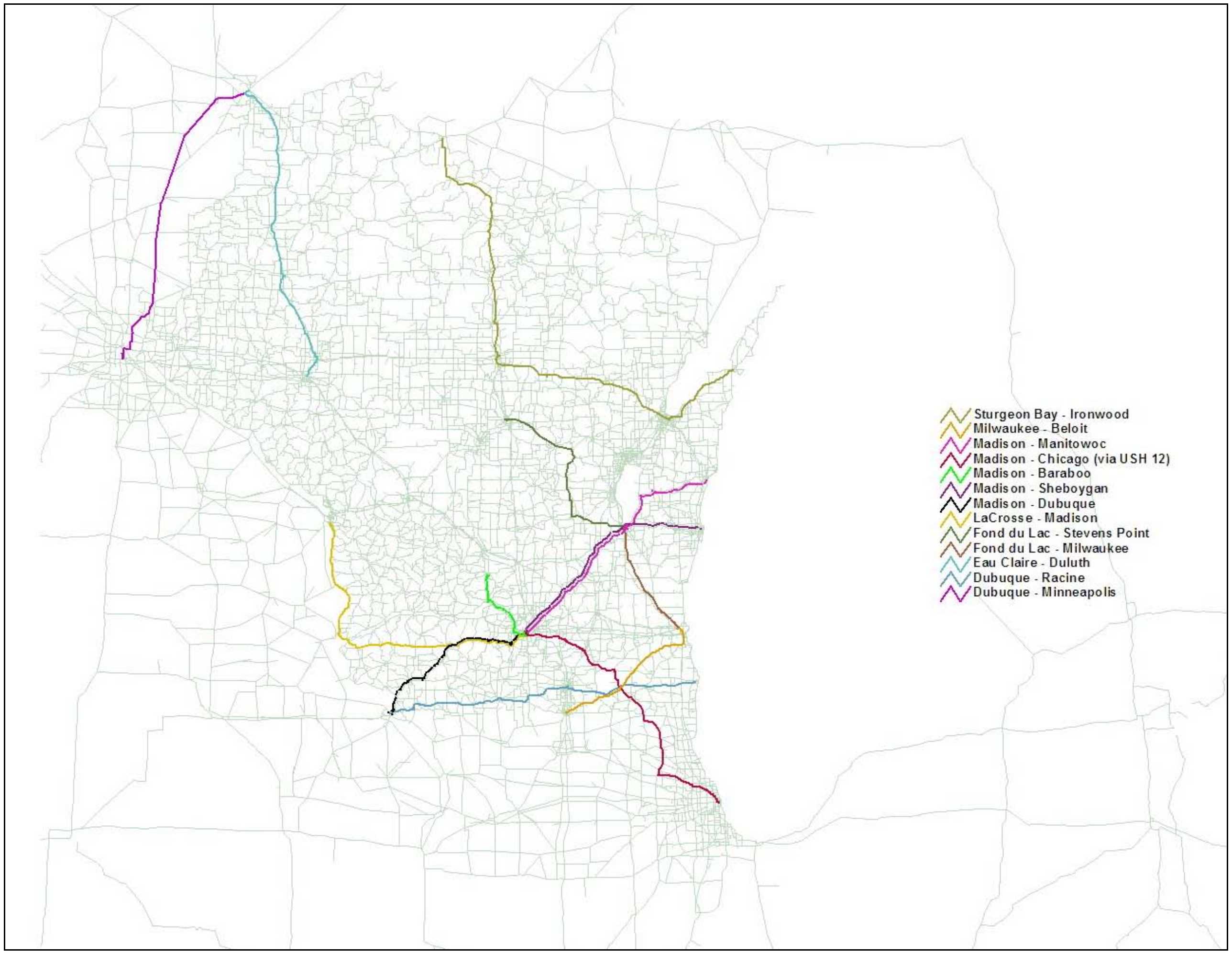
APPENDIX E. FEEDER BUS ROUTES AS PART OF THE HIGH-SPEED RAIL NETWORK

Route	Operator	Unit fare ($ per mile)	No. of Stops	Headway (Minutes)
Portage- Wausau	Greyhound	0.190	3	1440
Tomah- Minneapolis	Greyhound	0.237	3	288
Appleton- Wausau	Greyhound	0.196	3	1440
Marinette- Green Bay	Greyhound	0.291	2	720



APPENDIX F. FUTURE ESSENTIAL BUS ROUTES

Route	Operator	Unit fare ($ per mile)	No. of Stops	Headway (minutes)
Fond du Lac- Milwaukee	Greyhound	0.235	2	360
Duluth, MN-Minneapolis, MN	Greyhound	0.169	2	480
La Crosse - Madison via Prairie Du Chien	Greyhound	0.133	3	1440
Milwaukee -Beloit	Greyhound	0.284	2	1440
Sturgeon Bay - Ironwood via Greenbay and Wausau	Greyhound	0.210	5	1440
Dubuque -Racine	Greyhound	0.231	3	1440
Sheboygan- Madison	Greyhound	0.263	4	1440
Madison- Manitowoc	Greyhound	0.241	4	1440
Eau Claire-Duluth	Greyhound	0.212	4	1440
Fond du Lac- Stevens Point	Greyhound	0.200	2	1440
Madison-Baraboo	Greyhound	0.250	2	1440
Madison-Chicago via USH 12	Greyhound	0.208	2	1440
Madison-Dubuque	Greyhound	0.326	2	1440


Sturgeon Bay - Ironwood
Milwaukee - Beloit
Madison - Manitowoc
Madison - Chicago (via USH 12)
Madison - Baraboo
Madison - Sheboygan
Madison - Dubuque
LaCrosse - Madison
Fond du Lac - Stevens Point
Fond du Lac - Milwaukee
Eau Claire - Duluth
Dubuque - Racine
Dubuque - Minneapolis

APPENDIX G. NETWORK CONFIGURATIONS USED TO GENERATE TRAVEL FORECASTS FOR THE TEST ROUTE ANALYSES

Note: 'X' indicates that the transportation element is included in the network used to produce the corresponding travel forecast

Future-Year Travel Forecasts	Transportation Network Elements															
	Status Quo Bus Network	High-Speed Rail Network	Essential Bus Network	Thirteen Proposed Intercity Bus Routes[3]												
				1-1	1-2	1-3	1-4	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3	3-4
A-0	x															
A-1	x			x												
A-2	x				x											
A-3	x					x										
A-4	x															x
B-0	x			x	x	x	x	x	x	x	x	x	x	x	x	x
B-1	x				x	x	x	x	x	x	x	x	x	x	x	x
B-2	x			x		x	x	x	x	x	x	x	x	x	x	x
B-3	x			x	x		x	x	x	x	x	x	x	x	x	x
B-4	x			x	x	x	x	x	x	x	x	x	x	x	x	
C-0	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
C-1	x	x			x	x	x	x	x	x	x	x	x	x	x	x
C-2	x	x		x		x	x	x	x	x	x	x	x	x	x	x
C-3	x	x		x	x		x	x	x	x	x	x	x	x	x	x
C-4	x	x		x	x	x	x	x	x	x	x	x	x	x	x	
D-0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
D-1	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
D-2	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
D-3	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x

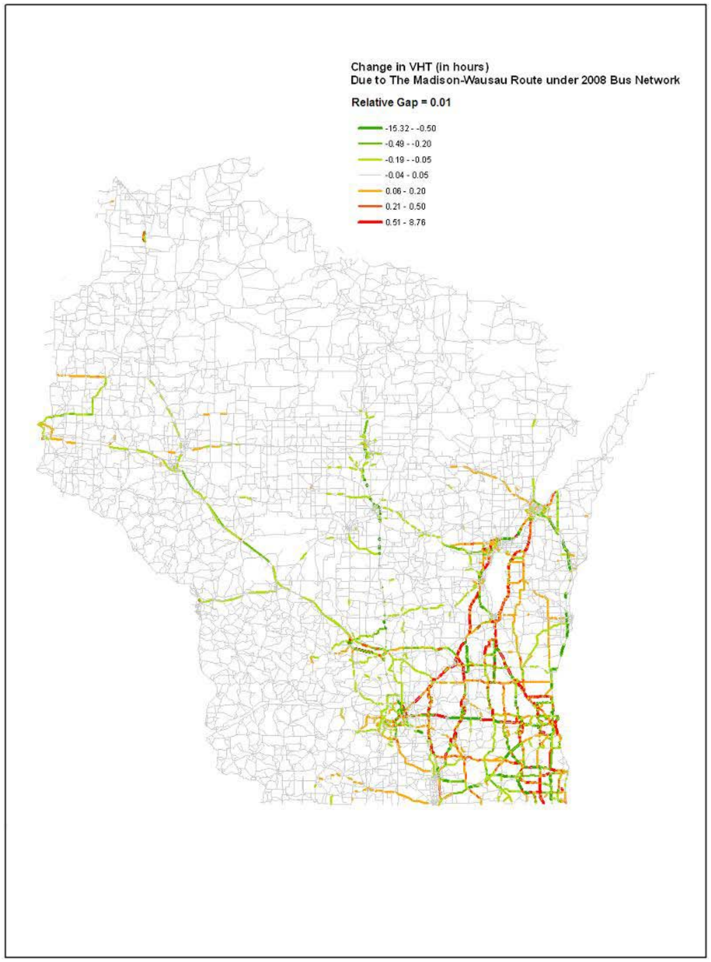
[3] The routes are denoted by the route numbers used in Appendix C.

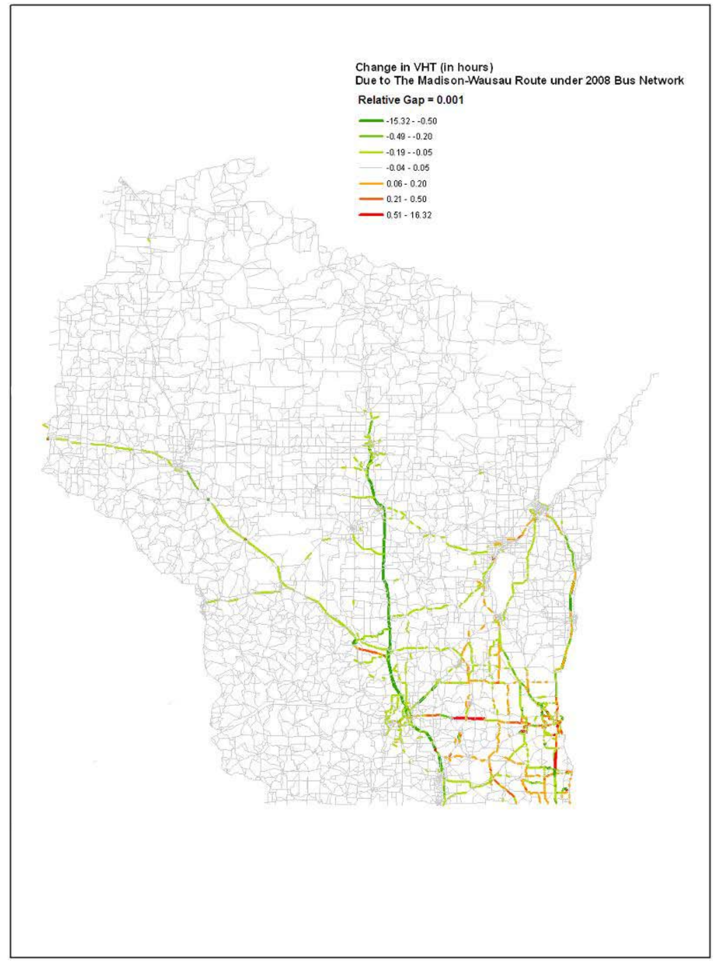
D-4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

APPENDIX H. TRAVEL FORECASTS GENERATED USING THE WI TRAVEL DEMAND MODEL FOR BENEFIT/COST ANALYSIS

Travel Forecast	Variable			
	PMT by Bus (1000 mi/year)	PMT by Rail (1000 mi/year)	PMT by Auto (1000 mi/year)	VMT by Truck (1000 mi/year)
A-0	279,268	38,087	16,485,608	6,504,411
A-1	294,979	38,034	16,452,281	6,504,447
A-2	289,837	38,054	16,465,341	6,504,440
A-3	286,503	38,087	16,471,538	6,504,384
A-4	280,659	38,087	16,483,061	6,504,297
B-0	347,604	37,578	16,347,973	6,504,706
B-1	338,162	37,590	16,365,661	6,504,814
B-2	337,760	37,602	16,369,875	6,504,762
B-3	336,486	37,578	16,368,602	6,504,398
B-4	342,706	37,578	16,356,205	6,504,691
C-0	324,953	308,218	15,869,927	6,507,675
C-1	316,369	308,598	15,885,947	6,507,836
C-2	315,589	308,484	15,890,003	6,508,457
C-3	314,088	307,704	15,892,176	6,508,072
C-4	320,092	308,220	15,879,254	6,508,242
D-0	335,243	306,296	15,856,014	6,507,954
D-1	327,260	306,726	15,872,055	6,508,718
D-2	325,189	306,551	15,876,630	6,507,419
D-3	325,519	305,787	15,876,064	6,508,391
D-4	330,847	306,293	15,863,937	6,508,138

APPENDIX I. COMPARISON OF THE FORECASTED CHANGES IN LINK IN-VEHICLE TRAVEL TIME (HOURS) DUE TO THE ADDITION OF THE MADISON-WAUSAU ROUTE UNDER RELGAP=0.01 AND RELGAP=0.001 CONVERGENCE CONDITIONS





APPENDIX J. IMPACTS OF THE FOUR TEST ROUTES AS COMPUTED USING THE IBBCA MODEL

Scenario	A			
Analysis Index	**1**	**2**	**3**	**4**
Route Name	*Madison – Green Bay*	*Madison – Wausau*	*Eau Claire – Green Bay*	*Wausau – Hurley*
Impact Category				
User Benefit	10,969,272	6,868,839	3,828,206	-778,351
Option Value Benefit	-	-	-	-
Chauffeuring Reduction	-	-	-	-
Environmental Impact	767,746	469,362	316,512	45,435
Economic Impact	-	-	-	-
Safety Impact	1,819,886	601,447	797,765	125,731
Annualized Transit Capital Cost	191,529	186,431	254,944	211,390
Transit Operating Cost	1,171,614	1,140,428	1,559,529	1,293,106
Total Benefits	13,556,904	7,939,648	4,942,483	-607,186
Total Costs	1,363,143	1,326,859	1,814,473	1,504,496
Net Benefits	12,193,761	6,612,789	3,128,010	-2,111,682
Benefits/Costs Ratio	9.95	5.98	2.72	-0.40

Scenario	**B**			
Analysis Index	**5**	**6**	**7**	**8**
Route Name	*Madison – Green Bay*	*Madison – Wausau*	*Eau Claire – Green Bay*	*Wausau – Hurley*
Impact Category				
User Benefit	5,039,331	7,196,601	5,717,473	2,172,910
Option Value Benefit	-	-	-	-
Chauffeuring Reduction	-	-	-	-
Environmental Impact	422,635	508,944	469,906	178,618
Economic Impact	-	-	-	-
Safety Impact	997,059	565,272	1,189,893	298,786
Annualized Transit Capital Cost	191,529	186,431	254,944	211,390
Transit Operating Cost	1,171,614	1,140,428	1,559,529	1,293,106
Total Benefits	6,459,025	8,270,817	7,377,272	2,650,313
Total Costs	1,363,143	1,326,859	1,814,473	1,504,496
Net Benefits	5,095,882	6,943,958	5,562,799	1,145,817
Benefits/Costs Ratio	4.74	6.23	4.07	1.76

Scenario	**C**			
Analysis Index	**9**	**10**	**11**	**12**
Route Name	*Madison – Green Bay*	*Madison – Wausau*	*Eau Claire – Green Bay*	*Wausau – Hurley*
Impact Category				
User Benefit	5,229,572	7,702,774	8,597,692	3,539,628
Option Value Benefit	-	-	-	-
Chauffeuring Reduction	-	-	-	-
Environmental Impact	379,607	466,508	508,313	204,972
Economic Impact	-	-	-	-
Safety Impact	877,630	642,886	1,314,516	488,378
Annualized Transit Capital Cost	191,529	186,431	254,944	211,390
Transit Operating Cost	1,171,614	1,140,428	1,559,529	1,293,106
Total Benefits	6,486,808	8,812,168	10,420,521	4,232,979
Total Costs	1,363,143	1,326,859	1,814,473	1,504,496
Net Benefits	5,123,665	7,485,309	8,606,048	2,728,483
Benefits/Costs Ratio	4.76	6.64	5.74	2.81

Scenario	D			
Analysis Index	**13**	**14**	**15**	**16**
Route Name	*Madison – Green Bay*	*Madison – Wausau*	*Eau Claire – Green Bay*	*Wausau – Hurley*
Impact Category				
User Benefit	5,452,743	6,451,652	6,591,960	2,036,232
Option Value Benefit	-	-	-	-
Chauffeuring Reduction	-	-	-	-
Environmental Impact	381,134	479,937	456,527	171,601
Economic Impact	-	-	-	-
Safety Impact	942,121	573,871	1,230,903	380,292
Annualized Transit Capital Cost	191,529	186,431	254,944	211,390
Transit Operating Cost	1,171,614	1,140,428	1,559,529	1,293,106
Total Benefits	6,775,998	7,505,460	8,279,390	2,588,125
Total Costs	1,363,143	1,326,859	1,814,473	1,504,496
Net Benefits	5,412,856	6,178,601	6,464,917	1,083,629
Benefits/Costs Ratio	4.97	5.66	4.56	1.72