

ECONOMIC METRICS FOR THE PRIORITIZATION OF CRITICAL FREIGHT INFRASTRUCTURE NEEDS

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Jeremy L. Schroeder

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APPROVAL SHEET

The dissertation
is submitted in partial fulfillment of the requirements
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Doctor of Philosophy, Civil Engineering

Jeremy L. Schroeder, Author

This dissertation has been read and approved by the examining committee:

Dr. Michael J. Demetsky, Advisor
Civil and Environmental Engineering

Dr. Brian L. Smith, Committee Chairperson
Civil and Environmental Engineering

Dr. Steven B. Chase, Committee Member
Civil and Environmental Engineering

Dr. John S. Miller, Committee Member
Virginia Center for Transportation
Innovation and Research

Dr. James H. Lambert, Committee Member
Systems and Information Engineering

Accepted for the School of Engineering and Applied Science:

Dr. James H. Aylor, Dean
School of Engineering and Applied Science

May 2013

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
Abstract	x
Chapter 1: Introduction	1
1.1 Research Needs	2
1.2 Purpose and Scope	2
Chapter 2: Research Plan	4
Chapter 3: Task 1 – Literature Review	8
3.1 Infrastructure Improvement Prioritization State of Practice	8
3.1.1 <i>Collected data</i>	8
3.1.2 <i>Existing Prioritization Frameworks</i>	10
3.1.3 <i>Proposed Frameworks and Tools</i>	11
3.2 Designated Highway Networks	11
3.3 Literature Review Discussion	12
Chapter 4: Task 2 – Investigate Performance Measures	13
4.1 Structural Integrity of Bridges	14
4.2 Pavement Quality	14
4.3 Safety	15
4.4 Mobility	15
Chapter 5: Task 3 – Measuring Highway Economic Importance	17
5.1 Economic Impact of Freight	17
5.2 Performance Measures of Economic Impacts of Transportation	18
5.3 Input-Output Modeling	19
5.4 Measuring Highway Economic Importance Discussion	20
Chapter 6: Task 4 – Link Economic Importance and Freight Highway Infrastructure Needs	23
6.1 State of Practice	23
6.2 Developing a Decision Model to Prioritize Freight Highway Infrastructure Needs	24
Chapter 7: Task 5 – Conduct concept demonstrations	26
7.1 Developing the Inoperability Input-Output Model	26
7.2 Gathering Safety Data	32
7.3 Concept Demonstration #1: U.S. 460 Expressway – Hampton Roads to Petersburg, VA	34
7.3.1 <i>Calculating U.S. 460 Economic Importance</i>	36
7.3.2 <i>Calculating U.S. 460 Excess Trucking Costs</i>	39
7.3.3 <i>Calculating U.S. 460 Economic Hindrance</i>	42
7.3.4 <i>Summary of U.S. 460 Findings</i>	44
7.4 Concept Demonstration #2: U.S. 29 Bypass – Charlottesville / Albemarle County, VA	44
7.4.1 <i>Calculating U.S. 29 Economic Importance</i>	46
7.4.2 <i>Calculating U.S. 29 Excess Trucking Costs</i>	48

7.4.3 Calculating U.S. 29 Economic Hindrance	51
7.4.4 Summary of U.S. 29 Findings	54
7.5 Decision Model	54
7.6 Concept Demonstrations Discussion	56
Chapter 8: Task 6 – Implementation, Discussion, Conclusions, and	
Recommendations	57
8.1 Implementation	57
8.2 Discussion Points	59
8.3 Conclusions	61
8.4 Recommendations	64
References	65
Appendix A – Intra-statewide Sample Demonstration of Proposed Economic Metric	
Development Methodology Using 12 Commodities in Virginia	A-1
Appendix B – Input-Output Data Tables Used in Concept Demonstrations	B-1
Appendix C – Crash Data Used in Concept Demonstrations	C-1

LIST OF FIGURES

Figure 1. Flow of Inputs and Outputs of Proposed Methodology	5
Figure 2. Proposed setup for Freight Infrastructure Prioritization Methodology	6
Figure 3. Example of integrating new metrics into an existing asset management system	24
Figure 4. Steps for development of inoperability input-output model and calculation of impacts of an industry disruption (e.g., trucking) to other industrial sectors	27
Figure 5. Map of eastern Virginia showing U.S. 460 (existing and proposed “new” in red) and other major routes in the region	35
Figure 6. Freight Analysis Framework region groupings for origin-destination route assignment designation to/from the Hampton Roads area given available, selected routes.....	37
Figure 7. Map of U.S. 29 corridor with proposed bypass and other major alternate routes	45
Figure 8. Freight Analysis Framework region groupings for origin-destination route assignment designation through central Virginia	47
Figure A-1. Example vectors and Leontif coefficient matrix of the I-O model.....	A-2
Figure A-2. Deriving the inoperability model, A^*	A-2
Figure A-3. Demonstrating interdependence of sectors.....	A-2
Figure A-4. Freight Analysis Framework – Virginia regions, network and example nodes.....	A-5
Figure A-5. Relative Economic Importance of Virginia Freight Highways.....	A-8
Figure A-6. Estimate of Excess Trucking Costs per day based on AADTT, Detour Length & Relative Capacity of Detour.....	A-9

LIST OF TABLES

Table 1. Traditional Performance Measures recommended for Prioritizing Infrastructure Improvement for Freight Transportation Needs	14
Table 2. Demonstration of freight module with sample values of expected improvement	25
Table 3. National Impact to BEA industries with a 100% disruption to the trucking sector	28
Table 4. Virginia’s Top Critical Commodities Handled by Truck	30
Table 5. Selected Freight Analysis Framework Commodities and BEA Industries for the Concept Demonstrations, and relative economic impact values from the inoperability input-output model	31
Table 6. Example products of Freight Analysis Framework Commodities	32
Table 7. Daily Truck Vehicle-Miles Traveled by Federal Vehicle Class on Virginia Primary and Interstate Roadways	33
Table 8. 2005-2007 Truck Crashes on Virginia Primary and Interstate Roadways	34
Table 9. 2005-2007 Truck Crash Rates on Virginia Primary and Interstate Roadways ..	34
Table 10. Kilotons of Commodities by grouped Freight Analysis Framework region	38
Table 11. Route assignment estimations by grouped Freight Analysis Framework region	38
Table 12. Total Commodity Tonnage by Route for U.S. 460 Concept Demonstration ...	39
Table 13. 2005-2010 Truck Crashes by Crash Type on U.S. 460 Study Corridor	40
Table 14. Measures required for Safety Calculations for U.S. 460 Study Corridor	40
Table 15. 2005-2010 Truck Crash Rates by Crash Type on U.S. 460 Study Corridor	41
Table 16. Comparison of Average Crash Rates for U.S. 460 Study Corridor to All Virginia Primary and Interstate Roadways	42
Table 17. Economic hindrance by industry based on calculated excess trucking costs to the trucking sector on U.S 460	43
Table 18. Summary Table of U.S. 460 Measures	44
Table 19. Total Commodity Tonnage by Route for U.S. 29 Concept Demonstration	48

Table 20. 2005-2010 Truck Crashes by Crash Type on U.S. 29 Study Corridor	49
Table 21. Measures used for Safety Calculations for U.S. 29 Study Corridor	50
Table 22. 2005-2010 Truck Crash Rates by Crash Type on U.S. 29 Study Corridor	50
Table 23. Comparison of Average Crash Rates for U.S. 29 Study Corridor to All Virginia Primary and Interstate Roadways	51
Table 24. Economic hindrance by industry based on calculated mobility-based excess trucking costs to the trucking sector on U.S. 29	53
Table 25. Summary Table of U.S. 29 Measures	54
Table 26. Comparison of Key Metrics for U.S. 460 and U.S. 29 Study Corridors	55
Table 27. Three decision model approaches to prioritize improvements	55
Table 28. Existing truck-based road user fee deployments and characteristics	58
Table A-1. Example Leontif (A) coefficient matrix, \mathbf{b} vector, and calculated \mathbf{x} vector.....	A-3
Table A-2. Normal and Reduced Industrial Output by a 20% reduction to the 6 th industrial sector using Inoperability Input-Output Model.....	A-3
Table A-3. Matched sectors and economic rank given by inoperability Input-Output Model Example.....	A-4
Table A-4. Freight truck flows in kilotons for industrial sectors 1-5, 7-12.....	A-6
Table A-5. Aggregated FAF O-D Table after scaling.....	A-6
Table A-6. Disaggregated O-D Table by Selected Nodes.....	A-7
Table A-7. Economic Value of Links between Selected Nodes.....	A-7
Table A-8. Example of Link for Route Assignment.....	A-7
Table B-1. BEA Make Table: The Make of Commodities by Industries, Annual Input- Output Accounts, 2007.....	B-5
Table B-2. BEA Use Table: The Use of Commodities by Industries, Annual Input-Output Accounts, 2007.....	B-8
Table B-3. Normalized Make Table.....	B-11
Table B-4. Normalized Use Table.....	B-14
Table B-5. Input-Output Model: Leontif industry-by-industry technical coefficient matrix, A	B-17

Table B-6. Input-Output Model vectors \mathbf{Ax} , \mathbf{x} , and \mathbf{c}	B-20
Table B-7. Inoperability Input-Output Model \mathbf{A}^* matrix.....	B-21
Table B-8. Inoperability Input-Output Model Results: Perturbation Vector, \mathbf{c}^* ; Percent Disruption Vector, \mathbf{q} ; and associated costs associated with the given disruption, \$.....	B-24
Table B-9. Standard Classification of Transported Goods (SCTG) Commodities matched to Bureau of Economic Analysis (BEA) Industries.....	B-25
Table B-10. Economic Hindrance by BEA Industry due to Calculated Mobility-based Excess User Costs to the Trucking Sector.....	B-27

LIST OF ABBREVIATIONS

AADT	Average annual daily traffic
AADTT	Average annual daily truck traffic
ADMS	Archived Data Management System
ANPR	Automatic number plate recognition
BEA	Bureau of Economic Analysis
CD	Compact Disc
DSRC	Dedicated short-range communications
DOT	Department of Transportation
FAF	Freight Analysis Framework
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
GNSS	Global Navigation Satellite System
GPS	Global positioning systems
GSM	Global System for Mobile Communications
GHG	Greenhouse gases
GDP	Gross domestic product
HGV	Heavy goods vehicles
HDM-4	Highway Development and Management Tool
HERS	Highway Economic Requirements System
HERS-ST	Highway Economic Requirements System for States
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Plans
HSIS	Highway Safety Information System
IRI	International Roughness Index
IHS	Interstate Highway System
MPO	Metropolitan planning organization
NBI	National Bridge Inventory ()
NBIAS	National Bridge Investment Analysis System
NCHRP	National Cooperative Highway Research Program
NCFRP	National Cooperative Freight Research Program
NHS	National Highway System
PSR	Present serviceability rating
PPP	Public-private partnership
RIMS-II	Regional Input-Output Modeling System
RSA	Road safety assessments or road safety audits
SHRP 2	Second Strategic Highway Research Program
TIFA	Trucks Involved in Fatal Accidents
VMT	Vehicle-miles traveled
VDOT	Virginia Department of Transportation
V/C	Volume to capacity ratio

ABSTRACT

Fully operational highways are necessary for efficient freight movements by the trucking industry. Yet, the combination of limited funding and aging infrastructure creates a grim scenario for states, which are dependent upon the economic benefits of goods movements. This research develops a comprehensive, freight-based prioritization framework to identify freight infrastructure needs critical to maintaining economic vitality by incorporating economic metrics associated with infrastructure performance and level of service. Framework outputs are a prioritized list of infrastructure needs to sustain economically critical highway infrastructure with consideration to regional economic impacts and safety and mobility improvements. In summary, the framework first evaluates infrastructure needs on a specified highway network, then prioritizes those needs using a decision model to balance developed economic metrics that estimate regional corridor-wide benefits of the local improvement with severity of needs as quantified with conditional performance measures. The developed metrics and prioritization methods are consistently applicable to any region within the United States, and two concept demonstrations examine data from the Virginia highway system to demonstrate the methodology.

A review of literature documents existing and proposed highway improvement prioritization frameworks to incorporate best practices into the methodology developed for this research. While the literature discounts use of economic development performance measures and the economic importance of a corridor is typically taken for granted, this research adds the dimension of economic significance of a corridor into the prioritization process for infrastructure improvements to generate motivation for private sector investment. An input-output model is used to identify the most transportation dependent industrial sectors, which are then linked with commodity flows using the Federal Highway Administration's Freight Analysis Framework. A set of readily available conditional performance measures are selected to identify critical locations meriting improvements. The prioritization methodology is demonstrated by applying the three developed economic metrics to two concept demonstrations in Virginia: the U.S. 460 expressway between Petersburg and Hampton Roads and the U.S. 29 bypass in Charlottesville.

CHAPTER 1: INTRODUCTION

Highways are essential for efficient freight movements and economic activity. In 2007, trucks hauled 40% of freight ton-miles in the United States, while their market share continued to grow (BTS, 2011). Further, freight ton-miles carried on highways increased 31% between 1997 and 2007, bolstering the reliance of commerce on and necessity for efficient, uncongested highways (BTS, 2011). Yet, the state of transportation infrastructure in the United States has reached a critical point such that closures and congestion cause an immeasurable adverse effect on already suffering regional and national economies.

Bridge and pavement degradation occurs even faster than expected since freight tonnage on the highways has become much higher than was originally planned and continues to increase (ASCE, 2009). When the interstate system was constructed, beginning in the late 1950s, bridges were typically designed for a fifty-year lifespan; today, the average age of a bridge is 43 years old (AASHTO, 2008). According to the American Society of Civil Engineers (2009), 26% of bridges in the United States are classified as either structurally deficient or functionally obsolete. With so many bridges in need of replacement, the cost of a new bridge so high, and inherent limitations with bridge inspections, unexpected closures or bridge failures are inevitable, such as that on I-35W in Minneapolis in 2007.

Such a road closure would be more economically detrimental to certain highways, depending on variables such as the number of trucks impacted, the commodities transported on that highway, additional delays, and adverse effects on alternate routes. While research has been conducted on infrastructure asset management (Cambridge Systematics et al., 2009; Dicedican et al., 2004; Shufon et al., 2003), often an inherent importance of a highway is assumed by its classification, e.g., interstate, national highway, etc., with minimal guidance to identify the most significant corridors. Although, there are no universal metrics to accurately describe the economic significance of a corridor or the magnitude and range of economic impacts by transportation investments (Peters et al., 2008; Meyer, 2001), performance-based planning should include wider measures than just operations, such as economic metrics (Meyer, 2001).

Moreover, despite the dominance of trucking in commerce and the economy, planning for freight is still an emerging area, even though truck-related issues represent a major part of what transportation planning attempts to address (Rodrigue et al., 2009; Chase et al., 2013). In general, the Second Strategic Highway Research Program (SHRP 2) notes the lack of tools for regional and local freight planning and the need for these tools to incorporate economic trends and freight activity, emphasizing that decisions related to freight can carry major implications for economic costs and regional competitive advantages (more so than those related to passenger transportation) (Chase, et al., 2013). Some tools and guidelines are available to assist freight analysis, including the Freight Analysis Framework (FHWA, 2010-a) to estimate and project freight flows between states and regions. Further, several state departments of transportation (DOTs) have performed studies on freight and infrastructure including the Virginia DOT's (VDOT) "Virginia Statewide Multimodal Freight Study" (Cambridge Systematics, 2009-b; Cambridge Systematics, 2010) and Ohio DOT's, "Freight Impacts on Ohio's Roadway System" (2002). However, the minority of states that actually utilize freight performance

measures use only a handful of disparate metrics, most of which are not even used to calibrate performance of specific state programs (Gordon Proctor & Associates, 2011). Further, SHRP 2 underscores the need for methods that go beyond traditional financial measures to include other direct and indirect impacts, benefits, and costs (Chase et al., 2013).

Simply having a freight-based infrastructure prioritization framework in place may help DOTs secure funding for projects from public and private sectors. It has been shown that having an asset management plan in place can help secure funds from legislatures (Cambridge Systematics & Meyer, 2007).

In spite of the current trend for tolling roadways to make up for funding shortfalls from the fuel tax, the trucking industry has indicated a passionate opposition to toll roads, with over half of truckers surveyed in one study citing a willingness to travel far distances out of the way to avoid tolls (Wood, 2011). However, this study also indicated trucking sector acceptance of tolling for new capacity, and a large need for better communicating the benefits of a facility for increased acceptance (Wood, 2011). With a freight-based infrastructure prioritization methodology in place to guide DOT investments to needs critical to goods movements, the trucking industry also may be more inclined to contribute funds through innovative payment strategies.

1.1 Research Needs

The combination of limited funding and aging infrastructure creates a grim scenario for states, which are even more dependent upon the economic benefits of freight movements in the current suffering economy. Economic metrics of highway infrastructure needs are required for a comprehensive, freight-based prioritization methodology to ultimately be integrated into strategic statewide and metropolitan planning organization (MPO) planning to identify and guide funds to infrastructure and operations improvements on critical corridors with regard to regional economic impacts, and structural, safety and mobility improvements. Freight needs merit consideration due to the significant role trucking plays in the economy. Prioritizing freight needs in this way may generate financial support from the private sector to promote their interests, while at the same time focused funds to specific freight corridors may draw truck traffic, easing truck-induced degradation on parallel highways.

1.2 Purpose and Scope

The purpose of this research is to develop economic metrics to assist with prioritization of infrastructure needs on critical freight corridors to maintain economic vitality. This research can inform a variety of stakeholders and decision-makers to make sustainable, informed decisions to support freight and economic activity, and is intended to be used as a tool to help leverage funding from the private sector based on derived benefits for projects not yet able to be subsidized by the public sector. This research builds on existing asset management strategies, identifying and prioritizing specific infrastructure needs on highways based on freight-based factors, such as the structural rating, economic

importance, safety, and mobility. Developed economic metrics identify corridors critical to freight transport, quantifying potential corridor-wide benefits to be gained by investing in specific infrastructure needs. The developed metrics and prioritization methods are consistently applicable to any region within the United States, and concept demonstrations examine data from the Virginia freight network to demonstrate the developed methods.

CHAPTER 2: RESEARCH PLAN

The following tasks fulfill the study objectives:

1. *Conduct review of literature.* Literature is examined on infrastructure needs identification and prioritization techniques and guidelines. A review of literature found numerous studies for asset management, but less work that helps to quantify the economic importance, based on freight movements, of aging bridges and pavements to the freight network for repair or replacement prioritization. The state of practice for prioritizing infrastructure needs in the United States and internationally is documented. Sources for the literature review include, but are not limited to the Virginia Center for Transportation Innovation and Research Library, Transport Research International Documentation, Worldcat, TLcat, and University of Virginia Engineering Library databases.
2. *Investigate freight-specific performance measures to identify infrastructure needs.* Based on the literature review and current DOT state of practice, a set of performance measures reflecting freight-based needs such as the structural soundness of bridges and pavements are identified, as well as measures to consider truck safety and mobility. Typical measures considered include truck speed, bridge load rating and deficiency rating, international roughness index (IRI) and present serviceability rating (PSR) pavement scores, and truck crashes.
3. *Investigate strategies to measure economic importance.* Economic importance of the freight network is established using Bureau of Economic Analysis (BEA) input-output multipliers that identify industrial sectors that are most dependent upon the transportation network. The flows of these sectors are linked to commodities in the Federal Highway Administration's (FHWA) Freight Analysis Framework, providing tonnage of these flows between and within selected regions. An origin-destination model is incorporated to disaggregate these interregional flows to the existing network, given by the Freight Analysis Framework. This prioritizes infrastructure needs by weighting the importance of corridors, specifically identifying those most critical to freight movements based on the commodities hauled on those corridors. Other economic metrics, specifically excess trucking costs derived from mobility and safety data are developed. Given the industries impacted based on the commodities on specific links, another economic metric is generated by inputting these excess trucking costs to the input-output model. These metrics are designed for private sector interests, quantifying potential benefits resulting from specific infrastructure investments.
4. *Link economic importance and freight infrastructure needs.* The use of VDOT's Asset Management System and Statewide Planning System are investigated to assist with infrastructure needs identification based on freight-based structural soundness, safety, and mobility performance measures selected in step 2. Economic metrics developed in step 3 can be applied to prioritize the needs. A decision model is developed to balance economic priorities with the relative severity of safety, mobility,

and structural needs, which can be translated into excess trucking costs. The output is a list of infrastructure needs for a specified highway network listing current excess trucking costs, projected regional economic benefits, and the prioritized ranking. The relationship between the required inputs and generated outputs of data to execute the prioritization methodology model are illustrated in Figure 1. Individual steps necessary to run the proposed prioritization methodology model are illustrated in Figure 2, where ovular substeps represent the need for data collection.

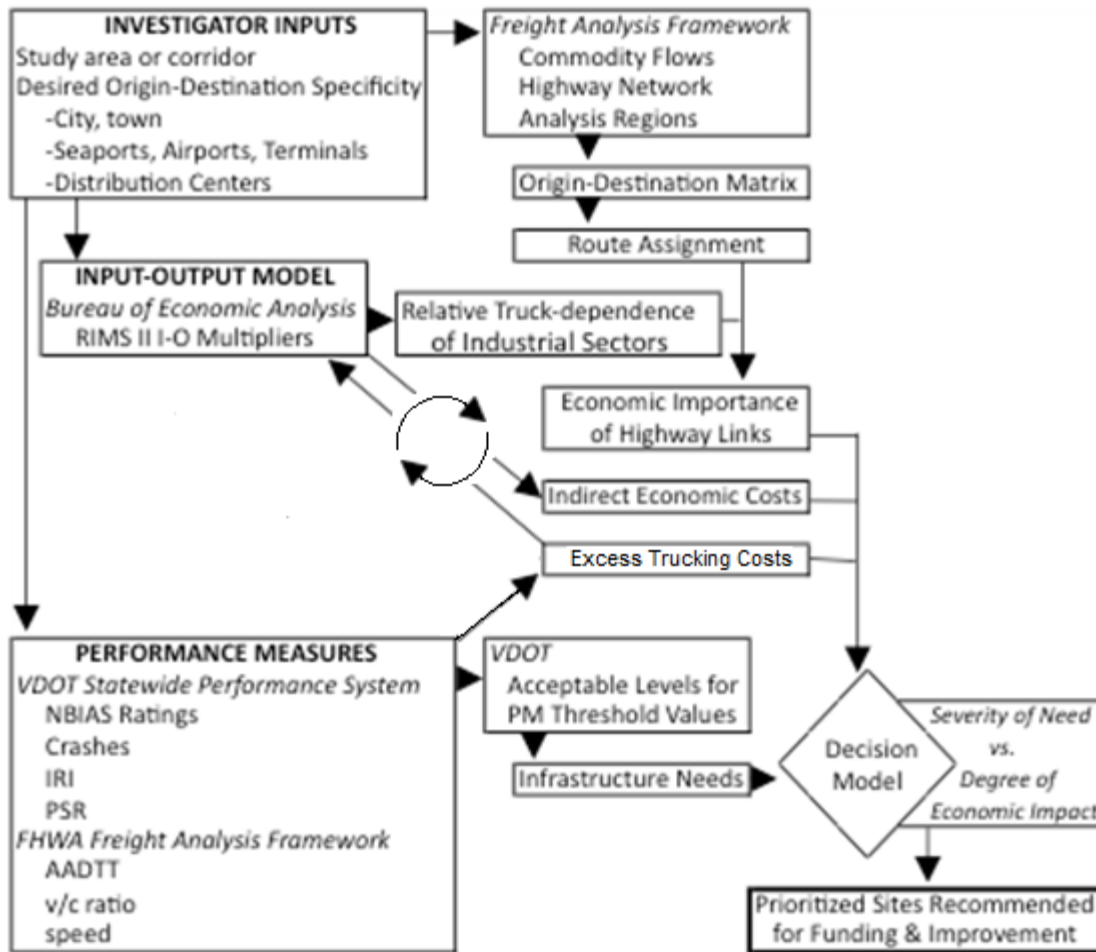


Figure 1. Flow of Inputs and Outputs of Proposed Methodology

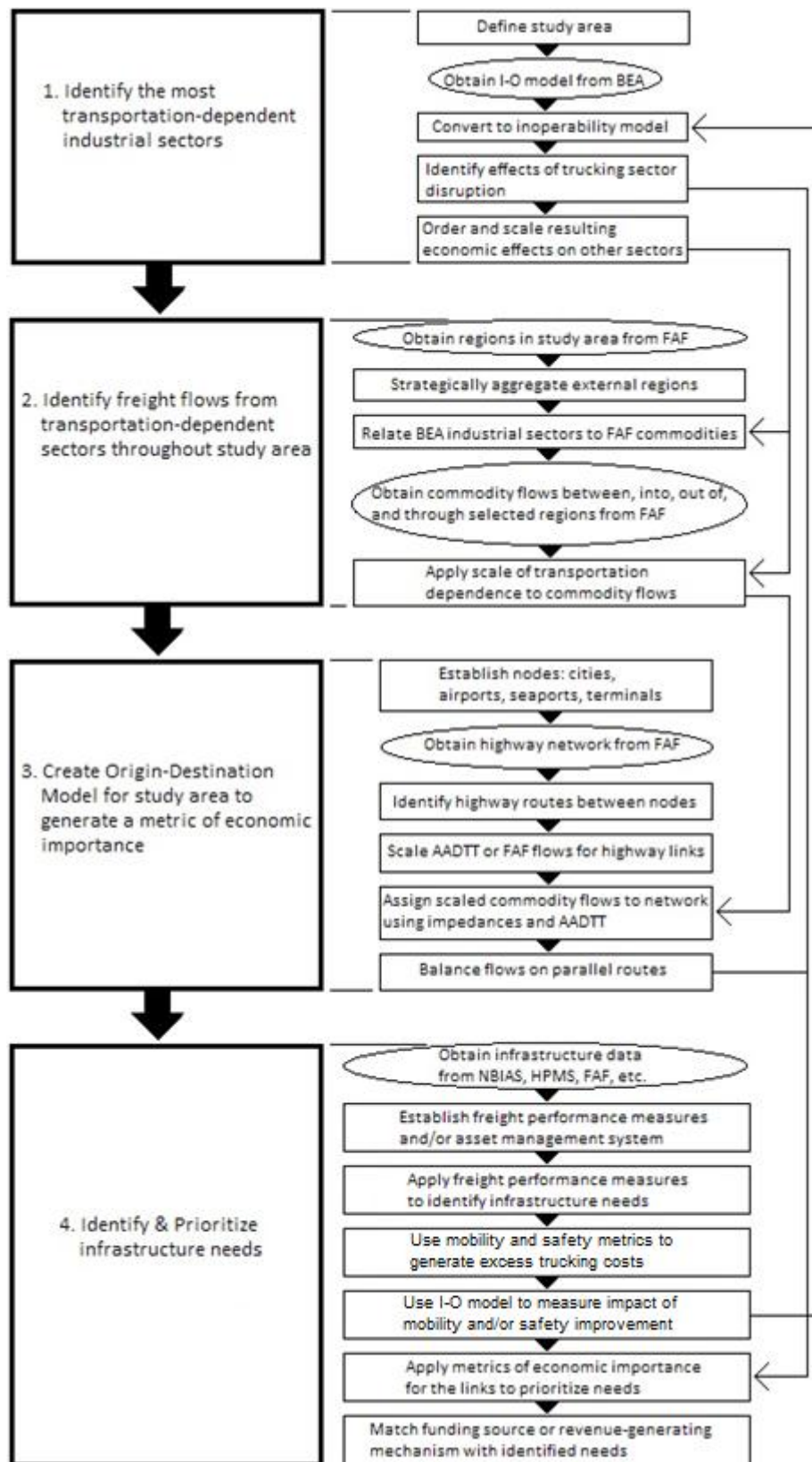


Figure 2. Proposed setup for Freight Infrastructure Prioritization Methodology

5. *Conduct concept demonstrations.* To demonstrate the model developed in step 4, data from the Virginia freight network is used, although measured economic benefits extend to out-of-state freight stakeholders as well. Prioritization of infrastructure needs for selected corridors is made, that include economic costs associated with safety and mobility issues. Selected corridors will be U.S. 460 and U.S. 29 for which corridor studies have been conducted that can be used in this research for validation purposes. Specifically, proposed projects on these corridors: a limited-access highway for U.S. 460 and a Charlottesville bypass for U.S. 29 north, are evaluated for their economic benefits along the corridors. Both of these projects provide benefits to other routes from which traffic may be diverted by creating a cost savings for trucks, providing indirect economic benefits locally. Further, this research examines whether the proposed projects on these corridors have the potential to enhance economic development opportunities along the corridors due to improved access to markets; the corridor study areas extend beyond immediate the local improvement areas to include benefits to out-of-state markets.
6. *Draw conclusions and recommendations.* Based on concept demonstration results and analysis, conclusions and recommendations are provided for successful implementation of this research.
7. *Prepare final report.* This final report attempts to clearly outline the developed prioritization methodology and document the findings of the study. This document can assist stakeholders to make sustainable, informed decisions to support freight and economic activity, and help leverage funding from the private sector based on derived benefits for projects not yet able to be subsidized by the public sector. This tool is intended to help with difficult decisions during times of shrinking budgets and increasing costs to insure the preservation of infrastructure vital to freight flows and economic prosperity.

CHAPTER 3: TASK 1 – LITERATURE REVIEW

3.1 Infrastructure Improvement Prioritization State of Practice

Asset management has become a major component of transportation agencies in recent years as increasing need for improvements is met with budget limitations (FHWA, 2008-a). The FHWA (2008-a) defines asset management as: “a business process and a decision-making framework that covers an extended time horizon, draws from economics as well as engineering, and considers a broad range of assets [...that...] incorporates the economic assessment of trade-offs among alternative investment options and uses this information to help make cost-effective investment decisions.”

Consequently, numerous studies have been performed to guide agencies and document best practices; the FHWA Asset Management website (FHWA, 2008-a) and the American Association of State Highway and Transportation Officials (AASHTO) Transportation Asset Management Today knowledge site (AASHTO, 2010) both serve as forums for contemporary asset management guidance, state of practice, and research, while Varma (2008) lists a comprehensive list of data sources for freight performance measures. Subsequent sections investigate data that is collected annually and available for input to existing and proposed infrastructure improvement frameworks.

3.1.1 Collected data

National databases currently contain information from every state on the condition of bridges and highways. The National Bridge Inventory (NBI) is federally mandated to monitor sub-structure, super-structure, deck, channel and channel protection, and culvert conditions for every structure over 20 feet (Cambridge Systematics et al., 2009; FHWA, 1995). For highway conditions, the Highway Performance Monitoring System (HPMS) includes data on highway condition, performance, use, and operating characteristics (FHWA, 2009-b). While certain information is maintained for all public roads, more data is collected for higher functional class roadways (FHWA, 2009-b). Additionally, over 40 states use the Pontis Bridge Management System, which includes NBI plus more detailed data (FHWA, 2008-a).

Other relevant databases exist but do not contain uniformly collected records for the entire country. Pavement management systems, for example, vary by state as there is no standard format (Cambridge Systematics et al., 2009).

Regarding safety data, a number of systems report a variety of information in ways that usually vary by state. There are no standards or consistency between states for reporting data on safety features like lighting, pavement markings or signage (Markow, 2007). One exception is the Fatality Analysis Reporting System (FARS), which documents all fatal crashes nationally, including truck-related crashes (NHTSA, 2010). The University of Michigan Transportation Research Institute (2010) maintains the Trucks Involved in Fatal Accidents (TIFA) database with extensive records dating to 1980 on fatal truck-related crashes nationally. State crash data systems, however, vary by state and are based on police accident reports. The National Accident Sampling System or General Estimates System contains an annual sample of crashes from these State Crash Data Systems, and extrapolates from this sample to estimate total crashes and their severity (Cambridge Systematics et al., 2009). The Highway Safety Information System

(HSIS) is used by nine states and has crash records, roadway inventory, and traffic volume data (FHWA, 2010-c). It is used to study current safety issues, direct research efforts and evaluate the effectiveness of countermeasures (Cambridge Systematics et al., 2009). Finally, State Highway Safety Improvement Plans (HSIP) are reported annually to the federal government for the funding of safety-related enforcement and public awareness programs (Cambridge Systematics et al., 2009). These documents assist in identifying trends and safety improvement needs.

Mobility data can be obtained from several sources. The FHWA Freight Analysis Framework includes average annual daily traffic (AADT) and average annual daily truck traffic (AADTT), estimated capacity, volume-capacity ratio, speed, and delay information for a large freight highway network for 2007 and 2040 projections (FHWA, 2010-a). In addition, HPMS, Highway Economic Requirements System for States (HERS-ST), American Transportation Research Institute's FPMweb, and DOTs collect mobility measures (Cambridge Systematics et al., 2009; American Transportation Research Institute, 2010).

Environmental concern is a newer area of focus for state DOTs, thus little data is consistently collected and available for monitoring performance (Cambridge Systematics et al., 2009). The level of greenhouse gas (GHG) emissions can be estimated based on average fuel economies from vehicles at given speeds from available data. Additionally, since energy usage is a function of congestion, eliminating bottlenecks would improve mobility, while also reducing fuel consumption and emissions.

Detailed economic data from the private sector is difficult to gather, as it is not readily shared. However, some data sources, such as the United States Census Bureau and Bureau of Commerce have quality economic data on employment and businesses, as well as freight statistics like operation costs, revenue and employment (Cambridge Systematics et al., 2007). The Freight Analysis Framework estimates trucking commodity movements and the volume of long-distance trucks for specific highways (2010-a). Also, the Virginia Freight Study highlights "freight-intensive" industry reliance on transportation services and employment in those sectors (Cambridge Systematics, 2009-b).

A variety of freight data can be obtained for the aforementioned categories in general databases including HPMS, Freight Analysis Framework and FARS, including truck crash data, truck volumes, and truck fuel economy. The Freight Analysis Framework also contains commodity flow information by tonnage and value between 131 traffic analysis zones nationwide (FHWA, 2010-a). Numerous freight studies contribute additional information, also. The estimated costs of freight delays and bottlenecks caused by freeway or signalized intersections or steep grades are presented in a FHWA study (2008-b) and the TTI Urban Mobility Report (Schrack et al., 2010), while a study by ATRI (2010) identified the 100 most congested freight bottlenecks. A study by Hajek and Billing (2002) tracks trends in freight volume, size, weight and truck technology that affect pavement design; generally, policy & law changes have allowed increasing weights and sizes over time, as truck volumes increase. Finally, state-conducted studies, such as the "Virginia Statewide Multimodal Freight Study" (Cambridge Systematics, Inc., 2009-b), document additional information like locations of distribution centers and their square footage, state bottlenecks, key intermodal connectors, truck parking availability at rest areas, truck accident numbers and locations,

and current and projected level of service on the highway network. In general, freight data from the private sector are available, but difficult to compile due to costs and confidentiality issues arising from the numerous disparate sources that collect and maintain the information (Varma, 2008).

3.1.2 Existing Prioritization Frameworks

The FHWA utilizes the National Bridge Investment Analysis System (NBIAS) to prioritize bridge investments. The NBIAS views all input bridges as equally important, and uses only NBI data to model maintenance, repair, rehabilitation, and functional improvement investment needs, with a modeling approach derived from the Pontis Bridge Management System (Cambridge Systematics et al., 2005; Robert & Gurenich, 2008); specific rules may be applied to measures to set minimum acceptable conditions that would trigger the system to recommend replacement of the bridge (Robert & Gurenich, 2008). The NBIAS then simulates a budget allocation for bridge projects over time to maximize user benefits while minimizing agency costs (Robert & Gurenich, 2008).

The FHWA's Highway Economic Requirements System (HERS) optimizes highway investments based on HPMS travel forecasts, vehicle speeds, crashes, improvement costs, and predicted pavement and capacity deficiencies (Cambridge Systematics et al., 2005; FHWA, 2008-a; USGAO, 2001); a state version of this tool, HERS-ST is also available. Alternate improvements to highway segments are economically compared with a benefit-cost analysis for potential benefits derived from travel time reductions, crash reductions, vehicle operating costs, and agency maintenance, while costs include capital expenditures necessary to construct the improvement (Cambridge Systematics et al., 2005; FHWA, 2008-a; USGAO, 2001). In analysis, candidate projects are identified to correct pavement, width, and/or alignment deficiencies of a highway segment; performance criteria and/or specified funding constraints prioritize the selected candidate projects (Cambridge Systematics et al., 2005).

Further, many state DOTs use their own prioritization frameworks for infrastructure investments. Many of these have been documented through various studies to highlight innovative or best practices (Cambridge Systematics & Meyer, 2007; Guerre et al., 2005; Li et al., 2005; Lownes & Zofka, 2008; Pagano et al., 2005; Richardson et al., 2009; Shufon & Adams, 2003; Stephanos et al., 2002).

Research has documented ways to streamline prioritization for diverse assets. A strategy used by Maryland for pavement project selection first groups similar projects by traffic volume, road type and class, condition, etc. before optimizing to select projects (Stephanos et al., 2002). Conversely, Ontario has found more consistency by combining numerous regional asset management outputs for bridges and pavements, scaling the cost-benefit outputs, and generating various what-if scenarios for an array of funding thresholds (Guerre et al., 2005). The New York State DOT uses trade-off analysis for pavements, bridges, safety, and mobility, based on project benefits versus excess user costs, which include costs of delaying travelers and freight, accident costs, and vehicle-operating costs (Shufon & Adams, 2003).

Internationally, the Highway Development and Management Tool (HDM-4) has been successfully used in more than 100 countries to prioritize highway pavement

investments (Cambridge Systematics et al., 2005). Requiring extensive calibration, it has seen limited application in the United States (Cambridge Systematics et al., 2005); HDM-4 was successfully calibrated for Washington State DOT use, however, to supplement the existing Washington State Pavement Management System for long-term pavement performance and investment needs (Li et al., 2005).

3.1.3 Proposed Frameworks and Tools

In addition to a wide array of frameworks that currently serve the purposes of many DOTs, other approaches and general guidelines for handling agency assets have also been proposed.

Fundamentally, the International Infrastructure Management Manual (2006) provides guidance for developing a general asset management framework. It utilizes an optimized decision making algorithm for individual projects, and includes benefit-cost analysis and multi-criteria analysis.

Recognizing the need for better asset management guidance, NCHRP Report 545 (Cambridge Systematics et al., 2005) developed analytical tools for decision-making. The tools are designed to show short-term consequences of implementing various projects within one to three years, and 10-20 year simulations resulting from various magnitudes of investments into each of the asset management classes.

The National Cooperative Highway Research Program (NCHRP) Report 632 recognizes the importance of the Interstate Highway System (IHS) specifically, as vital to the competitiveness of the United States economy (Cambridge Systematics et al., 2009). The report develops a framework for managing interstate assets, including those other than pavements and bridges. Further, performance measures are provided, alongside details on collecting, managing and using data, as well as tools to support the program and risk management guidelines. Guidance to successfully implement the framework is also detailed.

3.2 Designated Highway Networks

The framework developed in this research could be applied over a wide range of highway systems, incorporating local and state roadways to capture the ends of freight trips, or only the major highways that are included in the Interstate and National Highway System.

The IHS includes 46,726 miles of limited access highways nationally as of 2002 (FHWA, 2009-a), and carries the highest freight volumes per mile.

The National Highway System (NHS) incorporates a 160,000-mile network of roadways, including the IHS, that are important to the nation's economy, defense and mobility (FHWA, 2010-b). The NHS contains only 4% of the nation's roads, but carries approximately 75% of heavy truck traffic (Slater, 1996). Further, it complements other freight transportation modes by offering efficient intermodal connections to 198 ports, 207 airports, 190 rail/truck terminals, and 58 pipeline terminals (Slater, 1996).

Additionally, the National Network is a companion to the NHS, a distinct 200,000-mile network of freight highways that include all of the IHS and 65,000 miles not on the NHS, while the NHS includes 50,000 miles not in the National Network

(FHWA, 2010-a). The National Network supports interstate commerce through regulation on the size of trucks (FHWA, 2010-a).

To focus investment efforts for freight infrastructure, both the American Road and Transportation Builders Association (ARTBA, 2010) and AASHTO (2007) are lobbying for the establishment of Critical Commerce Corridors. These corridors would likely include most or all of the IHS, portions of the NHS, new multimodal trade corridors and new designated truck-only lanes (ARTBA, 2010).

The Freight Analysis Framework includes a network of over 447,400 miles of highways including rural arterials, urban principal arterials, all of the IHS, NHS, and National Network, and intermodal connectors (FHWA, 2010-a).

3.3 Literature Review Discussion

Existing asset management tools used by state DOTs, i.e., VDOT, are recommended for use in the framework model, which will ease analysis and barriers to future implementation. If access to these resources is restricted, the asset management recommendations put forth in NCHRP Report 632 are recommended as an alternative.

Numerous sources for data collected nationally have been identified, including the NBIAS, FARS, HPMS, and Freight Analysis Framework. Incorporating nationally collected data to the framework model will facilitate use across multiple agencies.

Because the Freight Analysis Framework provides reliable freight data and forecasts for the most important freight highways, this network is recommended for use of the framework model in broader applications. If necessary, additional links to commercial hubs of freight activity including major distribution centers could also be included.

CHAPTER 4: TASK 2 – INVESTIGATE PERFORMANCE MEASURES

The FHWA (2010-a) defines performance measures as: “evidence to determine progress toward specific defined organizational objectives. This includes both quantitative evidence (such as the measurement of customer travel times) and qualitative evidence (such as the measurement of customer satisfaction and customer perceptions).” A multitude of performance measures are used or proposed domestically and internationally by DOTs and private firms to monitor a variety of assets and activities from truck fleet operations, costs and efficiency to infrastructure integrity and pavement quality, detailed in the following subsections (AASHTO, 2007-a; Cambridge Systematics, 2000, 2009-a; Cambridge Systematics et al., 2005, 2006-b, 2009; Czerniak et al., 1996; Forkenbrock & Weisbrod, 2001; FHWA, 2004; Hagler Bailly Services, Inc., 2000; Harrison et al., 2006; Hedlund, 2008; Li & Sinha, 2004; Lownes & Zofka, 2008; Miller et al., 2002; Neumann, 1997; Poister, 1997; Reed et al., 1993; Shaw & PBS&J, 2003; Shufon & Adams, 2003; TransTech Management, Inc., 2003; Varma, 2008).

The National Cooperative Freight Research Program (NCFRP) Report 3 aims to establish a “comprehensive, objective, and consistent set of measures of performance of the U.S. freight transportation system” (Proctor, 2010). That research found private freight sector and state DOTs to measure highly variable sets of performance measures, due in part to differing priorities in costs and network performance, respectively (Proctor, 2010).

Many state DOTs already record performance measures on their highways that include or affect freight transportation movements, such as pavement, structural, mobility, and safety measures. However, the minority of states that actually utilize freight performance measures use only a handful of disparate metrics, most of which are not even used to calibrate performance of specific state programs (Gordon Proctor & Associates, 2011).

A Minnesota study highlighted a number of freight performance measures, most of which required further development for use, including travel times for intercity routes, to intermodal terminals and to global markets, shipping rate competitiveness, crash rates by mode, and bottleneck information (Larson & Berndt, 1999); data was more readily available for measures of mobility, transportation investment, and economic cost-benefits for most freight projects. A report prepared for FHWA (Hagler Bailly Services, Inc., 2000) reviews potential performance measures and recommends seven indicators for measuring freight performance. However, not all of these indicators, such as customer satisfaction, can be readily accessed from available data sources.

A report by Shufon and Adams (2003) demonstrated a method prototyped by New York State DOT in which performance across all categories is converted to excess user costs; for example, pavement degradation leads to increased user costs from tire and parts consumption, while accidents, detours, and congestion create added user costs from wasted time and fuel.

A number of traditional performance measures are already widely collected and used in many existing asset management systems, which directly apply to the infrastructure needs of freight transportation. These performance measures quantify the structural integrity of bridges, pavement quality, safety, and mobility, and are described in the sections below and presented in Table 1.

Table 1. Traditional Performance Measures recommended for Prioritizing Infrastructure Improvement for Freight Transportation Needs

Focus	Performance Measure	Unit/Rating
Structural Integrity of Bridges	Structural Evaluation	0-9
	Deck Geometry	0-9
	Underclearances, Vertical & Horizontal	0-9
	Bridge Load Limits Posting	0-5
Pavement Quality	International Roughness Index	inches/mile
	Present Serviceability Rating	0-5
Safety	Truck Crash Rate	truck crashes/mil-VMT
	Truck Fatality Crash Rate	truck crash fatalities/mil-VMT
	Adverse Safety Geometric Deficiencies	0-9
Mobility	Volume/Capacity Ratio	unitless
	Truck VMT	mil-VMT
	Average Travel Speed	miles/hour

4.1 Structural Integrity of Bridges

A variety of measures are collected to assess the performance of bridges; many of these measures are maintained as part of the NBI. Geometric characteristics such as bridge deck width, vertical and horizontal clearances, and lane and shoulder widths are recorded and can indicate restrictions imposed upon freight traffic. Some agencies monitor network performance by tracking the average health index of bridges, the percentage of bridges with a sufficiency rating less than 50 or the percentage of bridges with deck, superstructure, or substructure NBI rating of four or less. Load ratings are also measured and are critical to freight transport. Finally, excess user costs for each bridge can be measured based on the probability of incidents and closures due to traffic volumes and lane geometry, the resulting detour length and added costs of fuel and time delay.

Recommended traditional performance measures for a freight prioritization framework are based on the NBIAS outputs, which use NBI data. Specific rules might be applied to NBIAS analysis to specify more stringent NBI Appraisal Ratings, Items 67-70, which measure the adequacy of the structure by the type of highway it is serving by structural evaluation based on loads and traffic volumes, deck geometry, vertical and horizontal clearances, and bridge restrictions (FHWA, 1995). These measures directly apply to freight flows based on limitations they may impose, or soon impose, on trucks.

4.2 Pavement Quality

Many measures are collected nationwide for the HPMS. The IRI is a standard measure of ride quality, while PSR attempts to assess the structural integrity of the pavement. Using IRI, excess user costs can be calculated based upon tire wear and parts consumption given rougher surfaces. Pavement geometrics of lane and shoulder width are also documented, as well as skid resistance and structural adequacy. A number of indices exist that utilize IRI and pavement distress data such as the Pavement Quality Index,

Rideability Index, Distress Index, and a vehicle-miles traveled (VMT) weighted pavement condition. States also monitor network performance using a number of metrics such as the percentage of miles in good, fair or poor condition, the percentage of miles below a threshold acceptable condition level, the average condition, percentage of miles with weight restrictions due to structural limitations, and the percentage of truck VMT or tonnage affected by weight restrictions.

For the purposes of a freight prioritization framework, traditional performance measures recommended to incorporate the structural adequacy of pavement should be the IRI and PSR. Selection of these measures is based on their nationwide availability and general acceptance for measuring pavement quality and structural integrity, particularly due to the importance to freight transportation.

4.3 Safety

Typical performance measures for highway safety are based on the crash rate or fatality rate. Data on vehicles involved in an incident are recorded such that the truck crash rate and truck fatality rate are also available, as well as causes attributable to construction zone, speed, and/or traffic violation crashes. Many factors can have negative safety affects, including geometrics like grade, alignment, horizontal and vertical clearances and shoulder, lane, and bridge deck widths, skid resistance, travel speed, railroad crossing adequacy, luminance, and sight distance. Safety performance can also be measured in terms of the costs associated with crashes, injuries and fatalities, or delay, and the costs to implement safety countermeasures. Further, network performance can be measured by the percentages of reduction in motor carrier crash rates, traffic exceeding the speed limit, VMT in various ranges of volume/capacity, commercial vehicles weighed, overweight commercial vehicles, commercial vehicles undergoing safety inspections, and commercial vehicles passing those safety inspections. Seat belt usage by drivers and passengers is also relevant, measured either by the number of law enforcement citations, unrestrained driver and passenger fatalities, or surveys. Finally, the Hazard Index, measured by crash/VMT by severity, and Accident Risk Index, or Safety Index also serve as metrics to a highway segment's relative safety.

For a freight-based framework, the most relevant safety performance metrics are truck crash rate, truck fatality crash rate, and geometric deficiencies that contribute to crashes.

4.4 Mobility

Mobility is often measured by travel time, delay, and speed. Related measures include standard deviation of travel time, volume/capacity ratio or level of service, density, customer ratings of trip time, reliability, congestion severity and travel cost, relative delay rate versus other routes, excess user costs due to person or freight shipment delay, intersection delay, detour length, delay due to incidents and/or congestion, percentage of highways or lane-miles congested during peak period, travel rate in minutes per mile, and variation in average speed. VMT is another common measure of mobility, including the

amount or percent VMT in congestion, VMT/lane-mile per capita, and truck VMT by light duty, heavy duty, and through trips. Indices of mobility include the congestion severity index (hours of delay/million VMT), roadway congestion index (cars/road space), buffer time index (percentage of extra time needed to be on-time 95% of the time), mobility index (ton-miles * average speed), speed reduction index (ratio of speed declines across facilities), travel rate index (ratio of peak travel-time to off-peak travel time, the additional time to congestion), and misery index (a measure of the severity of congestion on the worst 20% of trips). Additional freight-related measures of mobility include the percentage of on-time shipments, the shipper's ability to reliably reach desired suppliers or markets within specified service parameters like time, cost, etc., average circuitry for truck trips between selected origins and destinations, ton-miles travelled by congestion level, line-haul speed, capacity restrictions, and miles of freight routes with adequate capacity.

For the purposes of a freight highway infrastructure needs prioritization, recommended traditional freight-relevant mobility measures include: volume/capacity ratio and truck VMT, again because of the potential for more widespread collection and use of these measures, as presented in Table 1.

CHAPTER 5: TASK 3 – MEASURING HIGHWAY ECONOMIC IMPORTANCE

5.1 Economic Impact of Freight

According to the United States DOT Bureau of Transportation Statistics, transportation services provide more than 5% to the production of the United States gross domestic product (GDP), with more than half of that attributable to for-hire or in-house trucking (FHWA, 2010-a). The Freight Analysis Framework estimates for 2002 indicate that trucks carried almost 60% of freight tonnage, of a total 53 million tons daily, and over two-thirds of the value of goods that totaled \$36 billion per day (FHWA, 2010-a).

There are several types of economic benefits that stem from highway infrastructure projects as described by the FHWA (1996). First, industry productivity can increase as a result of cost savings caused by infrastructure improvements, which in turn may stimulate the economy (FHWA, 1996; Nadiri and Mamuneas, 1996). Highway construction projects provide employment to workers, and thus benefit the local economy. Finally, by improving mobility and safety, direct benefits are provided to drivers.

Determining the comprehensive dollar value of economic benefits is difficult. Potts (2008) notes how little information exists regarding the dependence of each state's economic prosperity on transportation services provided by highways in other states. Thus, it is complicated to estimate the economic value of individual transportation projects given the established corridor's value, as a whole.

The United States Census Bureau's Commodity Flow Survey (2007), used in the Freight Analysis Framework, maintains information on the tonnage, ton-miles, and dollar value of goods shipped within and between states and metropolitan areas by truck. Studies by Nadiri and Mamuneas (1996, 1998) and NCHRP Project 20-24(23) (2007) have quantified the macroscopic influence between major industries, transportation, and national productivity growth.

It has been argued that most transportation investments have no significant impact on economic activity (Meyer, 2001; VTPI, 2009). Indeed, while transportation investment can increase accessibility or mobility in an area, taxes, labor laws, social amenities, or other regional conditions also affect economic growth (ECMT, 2002; Peters et al., 2008; Rodrigue et al., 2009). Yet, having an efficient and modern transportation network will favor many economic changes that are, for the most part, positive (Rodrigue et al., 2009). Even so, with an already weak causal link between transportation investment and economic growth, that link is inclined to level off after reaching a certain investment threshold, e.g., the mature United States highway systems (ECMT, 2002).

However, failure to maintain investment in transportation can cause a decline in private investment in an area, resulting in declining economic conditions (Eno Transportation Foundation, 1996; Peters et al., 2008; Rodrigue et al., 2009). But in general, transportation investments have the potential to provide broad benefits to regional economies over time if made at the right time for the right locations to nurture future growth, though no guarantee of economic development can ever be predicted (ECMT, 2002; Eno Transportation Foundation, 1996; Rodrigue et al., 2009).

Calculating the economic impact of an infrastructure investment is full of uncertainty and while numerous models have been developed for this purpose, all have

faults, e.g., problems with double counting benefits (ECMT, 2002). Therefore, a transportation project must be merited on the basis of transportation benefits and not just economic projections, lest inferior transportation projects be built (ECMT, 2002). Besides, even primary transportation benefits like increased safety, emissions reductions and reduced travel time can promote economic growth (ECMT, 2002).

Measuring the precise indirect economic impacts of a project may be difficult, but even a qualified one-to-five ranking can be useful, since some projects are more inclined to promote economic development than others, as demonstrated by the Oregon DOT (McMullen, 2010).

A study by Rico, Mendoza, and Mayoral (1996) recognizes the merit of identifying the economic importance of highway and rail corridors due to their contribution to national prosperity. Data was gathered at weigh stations and through the use of surveys, and then extrapolated. Four differing categories of prioritization were generated for a corridor based on truck volume, tonnage, cargo value, and a benefit-cost ratio; emphasis is placed on the notion that highways carrying a higher economic value of freight are more important than others transporting higher tonnages of low-value freight.

Another strategy examines individually the freight flows of a region's most significant commodities, then layers them together to identify the most important corridors allowing for a less data-intensive, better understood model (Souleyrette et al., 1998). Corridor importance is noted as those carrying the most tonnage of the selected commodities, however the methodology for commodity selection is not detailed.

It is important to note that fuel prices, a major component of trucking costs, are linked to the costs of almost all consumer goods (Emerson, 2012). Businesses that operate on a small profit margin, such as groceries, are impacted by anything that affects costs, including shipping costs; businesses may absorb excess shipping costs to a certain point, but pass them along to consumers if costs rise significantly (Emerson, 2012).

5.2 Performance Measures of Economic Impacts of Transportation

Studies have shown that transportation investments impact economic activity directly and indirectly, but measuring that impact can be hard to assess due to the many factors that can influence the economy (Meyer, 2001; Peters et al., 2008). A review of performance measures for the impact of transportation investment on local and regional economies found a variety of measures developed to measure economic impact, but little consistency between agencies (AASHTO, 2007-a; Cambridge Systematics, 2000; Cambridge Systematics et al., 2005, 2006-b; Miller et al., 2002; Neumann, 1997; Peters et al., 2008; VTPI, 2009). These measures include freight mobility, relative unemployment, direct or indirect number of jobs created by transportation projects, job retention, whether a transportation project supports of in-state jobs, number of jobs, high-paying jobs, or licensed businesses within 'x' minutes of 'y,' economic indicators of goods movements, percent of manufactures or shippers who relocated for transportation purposes, regional truck VMT per unit of regional economic activity, shipping costs, value of goods shipped on a route, and tonnage originating or terminating in a region. Further, economic models include the use of GIS to list and classify businesses and a REMI model to show changes in business output, personal income, employment, and population as the result of

infrastructure investments. Despite this diverse array of measures, there are no universally accepted metrics to accurately describe the magnitude and range of economic impacts of transportation investments (Meyer, 2001; Peters et al., 2008). Further, economic performance measures face substantial challenges in application due to the time lag associated with assessing the measure and the complexities involved with confirming the cause-effect relationship with transportation investment (Meyer, 2001).

While mobility and accessibility measures are a common indicator of economic impacts, it has been found that the reduction of delays, vehicle operating costs, and accident costs have a positive impact only in areas that are already economically strong (Meyer, 2001). Regarding mobility, maximum economic benefits are derived from increased system efficiency (VTPI, 2009)

Further, job creation is often measured as an economic impact of transportation investment. This is a contentious measure, however; job creation in one area has been suggested to come at the expense of jobs or job growth elsewhere in the region (Meyer, 2001), but others argue that economic benefits are not so balanced (Eno Transportation Foundation, 1999). Moreover, direct jobs are likely to be generated as the result of any infrastructure investment, while many factors influence unemployment figures besides transportation investments (Peters et al., 2008).

Shipping costs are included as a performance measure based on analysis revealing that projects that reduce industrial transportation costs, e.g., shipping costs, will also increase productivity (VTPI, 2009). At the same time, it is argued that highway investments are not the most fruitful way to increase productivity (VTPI, 2009).

Despite all these potential performance measures, however, the Second Strategic Highway Research Program (SHRP 2) underscores the need for methods that go beyond traditional financial measures to include other direct and indirect impacts, benefits, and costs (Chase et al., 2013).

5.3 Input-Output Modeling

Input-output data is another readily available source of economic data. The Bureau of Economic Analysis (BEA) maintains regional input-output multipliers called the Regional Input-Output Modeling System (RIMS II) for areas encompassing at least one county (BEA, 2010). Multiregional input-output models have been used for transportation and freight issues (Cascetta, 2001; Hoel et al., 1967; Mahady and Lahr, 2008; Voigtlaender, 2002).

The input-output model was developed by Leontief in the middle of the 20th century (Hoel et al., 1967). In its basic form, economic data from various industries within a region are displayed in a table to show the relationships between those industries (Hoel et al., 1967; Isard, 1960). Industrial sectors are listed both in row and column headings; the production and distribution characteristics of these sectors are presented with the input to a sector from other industries displayed along a column, while that sector's output to other industries is recorded along the row (Hoel et al., 1967; Isard, 1960). Total inputs will balance total outputs when households and capital losses or profits are also included into the table (Hoel et al., 1967; Isard, 1960). The table can be expanded to include other regions and show interregional as well as intraregional

economic flows (Hoel et al., 1967; Isard, 1960).

Multipliers are created by calculating percentages of the totals for the column/row; these multipliers can then be used to create projections based on speculative inputs for select industries using an iterative process where row sums are used as inputs to unknown columns, then balanced again until inputs equal outputs.

The inoperability input-output model is derived from the Leontif input-output model and shows the economic interdependencies of different industrial sectors. Thus, it can show the economic impact to all sectors due to a disruption to one or more sectors. The inoperability input-output model was first presented by Haines and Jiang (2001) and further refined and related to highway applications (Crowther, et al., 2004; Haggerty, et al. 2008; Haines et al., 2005-a; Haines et al., 2005-b).

Haines and Jiang (2001) develop an application of the inoperability input-output model to infrastructure instead of commodities, for instance between power plants, the transportation sector, and hospitals. However, the methodology might be able to show, for example, the dependence of “Bridge A” upon “Bridge B” in the network. The authors emphasize, however, extensive data collection and data mining would be necessary to assemble the Leontif matrix, showing the relations and reliance between various pieces of infrastructure. While this application focuses on the interdependence of the infrastructure, it is my opinion that it would not adequately demonstrate the dependence of industrial sectors on the trucking sector, and thus highway infrastructure.

In the context of terrorism, the inoperability input-output model has been applied to Hampton Roads tunnels in Virginia (Haines et al., 2004). This study examined the impact of a closure or reduced capacity in the tunnel. Although the inoperability input-output model is a demand-based model, it can be applied in this case because a reduction in supply necessitates reduced demand; in other words, consumption will adjust from “normal” levels in the event that supply is reduced (Haines et al., 2004).

In a 2004 study, Crowther et al. directly link infrastructure performance to specific economic sectors from the inoperability input-output model. Specifically, the trucking sector is linked to highway infrastructure performance (i.e., roads and bridges).

In conjunction with the link between trucking costs, e.g., fuel costs, and costs of goods, Mahady and Lahr (2008) note in their use of the input-output model that transportation cost reductions are likely going to lower producer costs, however these benefits can also be interpreted as production increases. Thus, in their study they justify the conversion of travel time reductions to cost savings. This cost savings reduces industries’ input to the trucking sector and translates to increased productivity in other sectors of the economy.

5.4 Measuring Highway Economic Importance Discussion

Perhaps because of the difficulty in determining the comprehensive dollar value of economic benefits, no universal metrics accurately describe the economic significance of a corridor or the magnitude and range of economic impacts by transportation investments. This research seeks to develop freight-highway economic performance measures to address this need.

For this study, input-output multipliers are obtained from the BEA. An inoperability input-output model is developed to identify those industrial sectors most dependent upon the trucking sector, specifically highway infrastructure. Then using national commodity flow information available from the FAF regions, specific route assignments can be made to the selected freight highway network. Links used to transport more commodities of the more truck transportation-dependent industrial sectors are designated a higher rank of economic importance.

Excess trucking costs can be calculated for a highway link based on a number of factors. This study will utilize AADTT from FAF to estimate excess trucking costs for mobility based on potential travel time saving, and for safety based on a potential reduction in truck crashes. Additional measures of excess trucking costs might be derived using AADTT and detour length, and estimated congestion based on capacity of alternate route given a closure due to infrastructure (structural) failure.

Finally, the economic hindrance from inefficiency of excess trucking costs estimates a value of increased economic productivity that is otherwise spent on transportation costs, and can be calculated separately for each highway link. Based on the commodities on each highway link, the trucking sector input can be recalibrated in the input-output model based on the sectors that use the link to determine the economic impacts to other sectors given excess trucking costs for each highway link in the network for a given period (Mahady and Lahr, 2008).

The development of these three economic metrics is detailed in a demonstration methodology in Appendix A. In short, these three economic metrics are:

1. *Relative economic importance* of highway links based on sectors most dependent upon the trucking sector, according to a disruption to the trucking sector using the inoperability input-output model, and an origin-destination model with route assignments for specific commodities of those truck-dependent sectors.
2. *Excess trucking costs* of highway links based on the given AADTT and A) estimated reduction in delay based on potential travel time improvements (mobility) and B) potential reduction in truck crashes given an infrastructure improvement. Additional measures that might be considered include excess trucking costs based on the degree of congestion and delays expected from a closure due to infrastructure (structural) failure given AADTT and detour length of an alternate route. Trucking costs for mobility purposes are based on TTI's Urban Mobility Report value of commercial vehicle time at \$105.67/hour (Schrack et al., 2010).
3. *Economic hindrance from inefficiency of excess trucking costs* estimates a value of increased economic productivity that is otherwise spent on transportation costs, and can be calculated separately for each highway link. As an example, changes in fuel prices are linked with changes in the costs of goods (Emerson, 2012). Other excess trucking costs likewise require industries to pay costs on shipping that might otherwise be invested elsewhere and spurn economic development, such as expanding business, increasing employment, etc. Based on the commodities on the highway links (from metric 1), the trucking sector input can

be recalibrated in the input-output model based on the sectors that use the link to determine the economic impacts to other sectors given excess trucking costs (from metric 2) for each highway link in the network for a given period (Mahady and Lahr, 2008).

One concern with the use of multiple economic metrics is that some of the benefits or costs that are measured with one metric might already be included in the benefit or cost of a separate metric; this would constitute double counting and should be avoided. For the economic metrics proposed here, double counting among these metrics could occur if all are considered simultaneously, particularly metrics 1 and 3. Thus, it is recommended these two measures be applied separately.

CHAPTER 6: TASK 4 – LINK ECONOMIC IMPORTANCE AND FREIGHT HIGHWAY INFRASTRUCTURE NEEDS

Following the development of the economic performance measures in the previous section, the next step is to incorporate these measures into an asset management system. This will provide a method to prioritize freight highway infrastructure needs for selected corridors.

6.1 State of Practice

States already use asset management tools to prioritize infrastructure needs as identified in Section 3. However, these tools are primarily based on passenger movements (Chase, et al., 2013). In general, the Second Strategic Highway Research Program (SHRP 2) notes the lack of tools for regional and local freight planning and the need for these tools to incorporate economic trends and freight activity, emphasizing that decisions related to freight can carry major implications for economic costs and regional competitive advantages (more so than those related to passenger transportation) (Chase, et al., 2013).

Thus, this research builds upon existing tools for smoother integration with current practice, rather than building an entirely new comprehensive asset management tool. The decision model for this research is detailed below as a module within an existing state DOT asset management tool.

Currently, VDOT uses the Asset Management System to identify infrastructure needs for existing pavement and bridge assets. For safety needs, the Virginia Highway Safety Program, a part of the federal HSIP conducts road safety assessments (RSA, also known as road safety audits) and uses crash rates to prioritize locations with safety needs. Many freight relevant performance measures are already captured by these systems, including those related to structural soundness, pavement quality, and mobility, which are housed in the VDOT Archived Data Management System (ADMS).

Additional freight measures identified in Sections 4 and 5 might be integrated as a separate freight module. The distinction of truck-related crashes and fatalities from total crashes and fatalities, for instance, may lead to the identification of hotspots in need of specialized safety treatments for trucks. Alternatively, these freight metrics might be incorporated into the decision-making process for specific functional classifications in the network, such as interstates and principal arterials. The resulting output will be a list of infrastructure needs for specified freight corridors listing current excess trucking costs, projected regional economic benefits, and the prioritized ranking. A proposed schematic for incorporating additional freight-relevant measures from the Freight Analysis Framework, as well as those proposed in this research, are shown below in Figure 3, where dashed lines represent proposed links for inclusion of freight considerations to the existing asset management system.

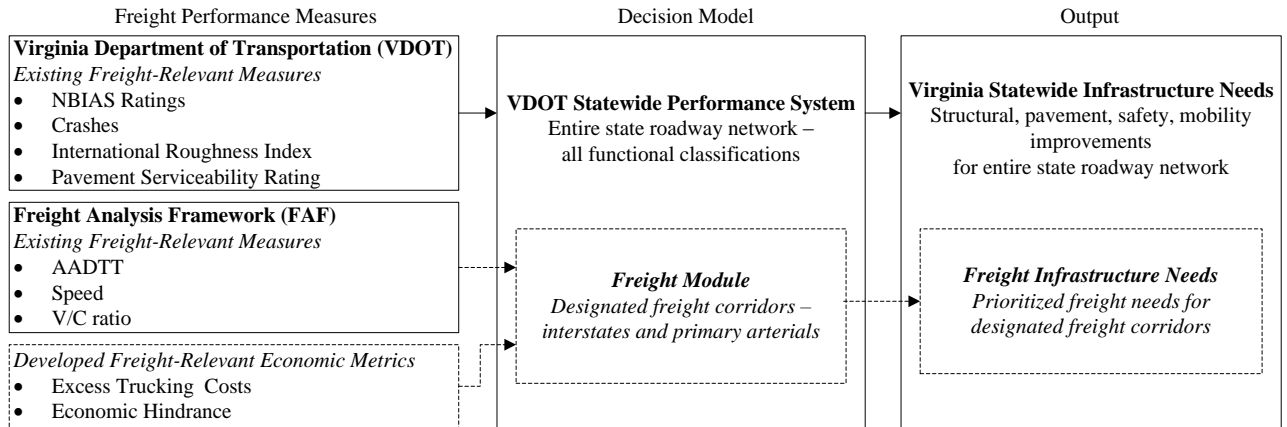


Figure 3. Example of integrating new metrics into an existing asset management system

6.2 Developing a Decision Model to Prioritize Freight Highway Infrastructure Needs

As mentioned for the Virginia Statewide Planning System, it is likely that a given asset management tool will already incorporate some freight-relevant performance measures. To avoid duplication, the inclusion of these performance measures in the freight highway infrastructure decision model is discouraged. Instead, the focus should be placed upon freight-relevant performance measures that are readily available for relevant freight corridors, such as those detailed in Section 4.

It cannot be expected that all freight-relevant performance measures will be consistently available for all regions, or even for specific corridors or areas within a region. Thus, where data is unavailable for all corridors or areas to be evaluated in the decision model, either default or qualified values may be employed as a placeholder or best guess for comparison.

The Virginia Statewide Planning System, as depicted in Figure 3 already collects a number of freight-relevant performance measures. These measures include NBIAS ratings for structures, IRI and PSR for pavement quality, and crashes for safety, among others.

For the purposes of this research, the freight module that will be developed and demonstrated includes additional freight measures gathered from the Freight Analysis Framework, VDOT crash database, and freight-relevant economic metrics developed herein. Measures to be recommended from the Freight Analysis Framework include volume to capacity (V/C) ratio, speed, and AADTT. As mentioned in Section 5.4 above, to eliminate double counting only select measures developed in this research, namely excess user costs for trucks and economic hindrance are recommended to be used.

Necessarily, the output from the freight module of the decision model will be a prioritized list of freight highway infrastructure needs. This research will examine several possibilities for the decision model, including an equal weighting approach, where prioritization will be determined based on the sum of equally scaled performance measures for each identified need, and weighted approach for both mobility and safety measures, in which more emphasis is placed on a specific goal, e.g., improving mobility. This approach is detailed further in Sinha and Labi (2007). For example, given a list of

freight infrastructure needs, for each performance measure, the “best” measured value would be assigned a value of 1, and the “worst” measured value would be assigned the value of 5, and each measure in between would be scaled accordingly.

For instances where not all identified needs contained values for all performance measures, a value might be estimated using professional judgment. Less preferably, a default neutral value of 3 for a scale of 1 to 5 might be assigned for missing values.

Note that when an agency wishes to emphasize certain values more than others, to accomplish specified mobility or safety-related objectives, for example, the scale of those values might be adjusted accordingly by multiplying by a constant or using a larger scale.

A sample of how the freight module could function is given in Table 2, and will be demonstrated further in the concept demonstrations in Section 7. This table gives an example where five performance measures (i.e., PM 1, PM 2, PM 3, PM 4, PM 5) are given for three identified needs (i.e., Route 1, Route 2, and Route 3). The performance measures are rated accordingly on a scale of 1 to 5 with the “best” measures receiving a 1.0 rating, and the “worst” measures receiving a 5.0 rating, unknown measures would be assigned a 3.0, and remaining measures being interpolated.

Table 2. Demonstration of freight module with sample values of expected improvement

Corridor with Identified Need for Improvement:		Route 1	Route 2	Route 3
Performance Measures	PM 1: Structural Integrity	0.6	0.9	1.4
	PM 2: Pavement Quality	190	103	84
	PM 3: Annual Truck Crashes	5	3	4
	PM 4: Daily Excess Truck Costs	1800	2500	2400
	PM 5: Daily Economic Inefficiencies	2000	2600	2700
Scaled Rating (1-5)	PM 1: Structural Integrity	1.0	2.5	5.0
	PM 2: Pavement Quality	5.0	1.7	1.0
	PM 3: Annual Truck Crashes	5.0	1.0	3.0
	PM 4: Daily Excess Truck Costs	1.0	5.0	4.4
	PM 5: Daily Economic Inefficiencies	1.0	4.4	5.0
Sum		13.0	14.6	18.4
Rank		3	2	1

CHAPTER 7: TASK 5 – CONDUCT CONCEPT DEMONSTRATIONS

In this section, the methodology, as described in previous sections, shown in Figure 1 and Figure 2 above and detailed in Appendix A, is demonstrated for two case study corridors in Virginia: U.S. 460 and U.S. 29. Both concept demonstrations weigh the prospects of building new highway infrastructure and capacity against conditions on the existing roadways. The example contained in Appendix A utilizes a much smaller (and sample) dataset to allow for more step-by-step explanations and visualization of the data tables that is not possible here, given the size of the dataset used for the two concept demonstrations presented below.

Specifically, the first concept demonstration investigates the potential economic impact of a new tolled expressway roughly paralleling U.S. 460 from Suffolk to Petersburg in eastern Virginia. The second concept demonstration examines the economic impact to areas within the U.S. 29 corridor of a new bypass around a heavily developed area on the north side of Charlottesville.

7.1 Developing the Inoperability Input-Output Model

The steps described in this section are based on the methodology presented in Figure 4 below, and more specifically described in Appendix A. “Make” and “use” tables (which respectively show monetary values of column commodities produced by various row industries, and monetary values of row commodities consumed by various column industries) were obtained from the BEA. These tables, as well as all the calculated tables described below derived, are shown in Appendix B.

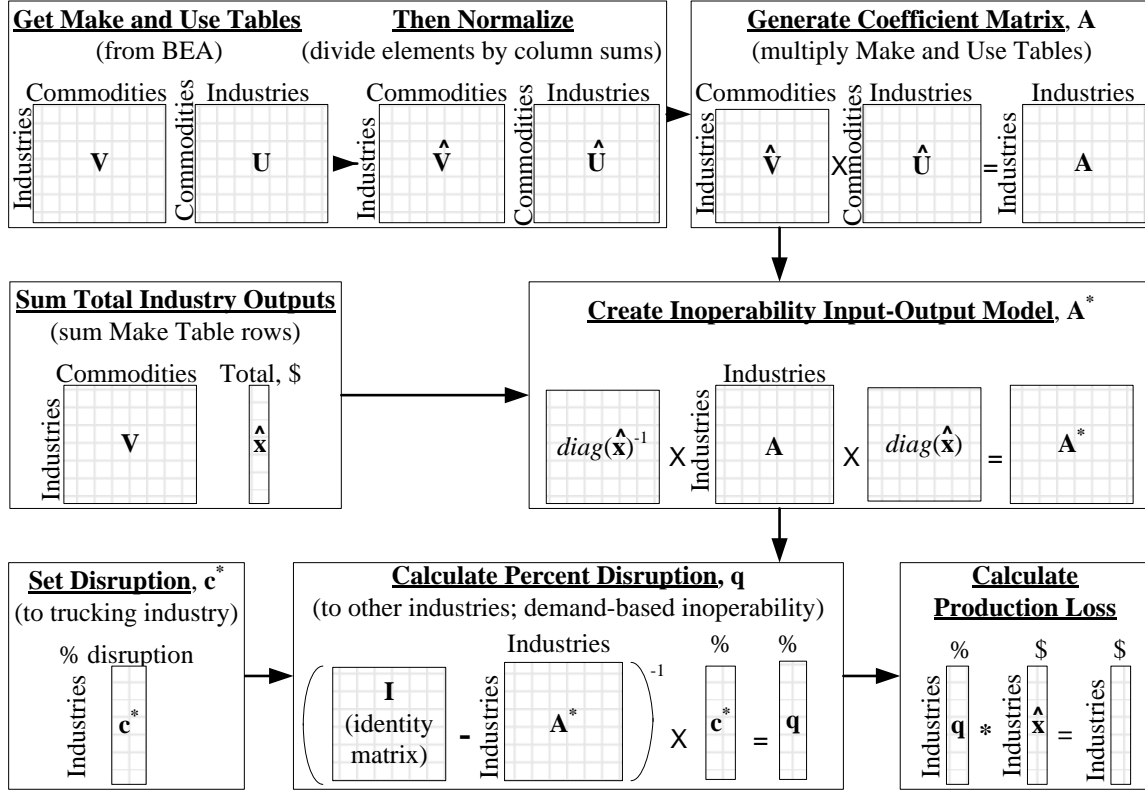


Figure 4. Steps for development of inoperability input-output model and calculation of impacts of an industry disruption (e.g., trucking) to other industrial sectors

Following the procedure more specifically described in Appendix A, the “make” and “use” tables were normalized and multiplied to create an industry-by-industry technical coefficient matrix, A , which gives the proportion of industry i inputs to j relative to the total production output of industry j .

Next, the total industry outputs, that is, the “normal” total production vector \hat{x} were calculated by multiplying the “make” table with a unity vector (whose elements are all ones and is also known as a summation vector).

Using these input-output tables, a demand-based model, the inoperability input-output model, was derived. A complete disruption to the trucking sector ($c^* = -1$, i.e., -100% for the trucking sector) reveals the assumptions made by the inoperability input-output model in regards to the reliance of each industry on the trucking sector, specifically as it relates to infrastructure performance, i.e., highway infrastructure that includes roads and bridges. This follows the work of Crowther et al. (2004) where trucking sector disruptions in the inoperability input-output model were directly linked to highway infrastructure performance in the context of terrorism.

Table 3 shows the percent disruption of each industry due to the complete disruption of the trucking sector, as well as the dollar loss (in millions of dollars) that each industry would incur. Further reflection on various industry relationships with a trucking sector disruption will be discussed further in Section 8.2 Conclusions.

Table 3. National Impact to BEA industries with a 100% disruption to the trucking sector

Industry	c*	% Industry Disruption	Dollar Loss (million \$)
Farms	0	0.15	471
Forestry, fishing, and related activities	0	0.12	72
Oil and gas extraction	0	9.52	26,000
Mining, except oil and gas	0	0.25	193
Support activities for mining	0	0.26	327
Utilities	0	0.99	4606
Construction	0	0.50	6508
Food and beverage and tobacco products	0	0.23	1650
Textile mills and textile product mills	0	0.15	98
Apparel and leather and allied products	0	0.05	15
Wood products	0	0.21	211
Paper products	0	0.63	1047
Printing and related support activities	0	0.40	409
Petroleum and coal products	0	11.51	67,706
Chemical products	0	2.33	15,115
Plastics and rubber products	0	1.72	3555
Nonmetallic mineral products	0	0.28	327
Primary metals	0	1.55	3648
Fabricated metal products	0	1.84	5897
Machinery	0	0.70	2244
Computer and electronic products	0	0.66	2578
Electrical equipment, appliances, and components	0	0.65	798
Motor vehicles, bodies and trailers, and parts	0	3.60	17,373
Other transportation equipment	0	0.11	247
Furniture and related products	0	0.05	39
Miscellaneous manufacturing	0	0.16	244
Wholesale trade	0	6.30	80,226
Retail trade	0	1.67	24,272
Air transportation	0	0.60	898
Rail transportation	0	1.01	700
Water transportation	0	0.10	37
Truck transportation	-1	114.28	313,551
Transit and ground passenger transportation	0	0.05	16
Pipeline transportation	0	0.26	88
Other transportation and support activities	0	5.10	6790
Warehousing and storage	0	2.43	1217
Publishing industries (includes software)	0	0.55	1665
Motion picture and sound recording industries	0	0.18	174
Broadcasting and telecommunications	0	3.66	30,050
Information and data processing services	0	0.89	1645

Industry	c*	% Industry Disruption	Dollar Loss (million \$)
Federal Reserve banks, credit intermediation, & related activities	0	2.65	20,722
Securities, commodity contracts, and investments	0	0.98	4648
Insurance carriers and related activities	0	2.08	14,147
Funds, trusts, and other financial vehicles	0	0.04	49
Real estate	0	3.08	75,452
Rental and leasing services and lessors of intangible assets	0	2.54	7282
Legal services	0	0.91	2534
Miscellaneous professional, scientific & technical services	0	4.93	56,514
Computer systems design and related services	0	0.90	1941
Management of companies and enterprises	0	3.35	15,141
Administrative and support services	0	2.23	13,813
Waste management and remediation services	0	0.58	434
Educational services	0	0.12	251
Ambulatory health care services	0	0.07	511
Hospitals and nursing and residential care facilities	0	0.01	98
Social assistance	0	0.00	4
Performing arts, spectator sports, museums, & related activities	0	0.20	198
Amusements, gambling, and recreation industries	0	0.04	42
Accommodation	0	0.23	463
Food services and drinking places	0	0.36	1872
Other services, except government	0	2.24	13,679
Federal government enterprises	0	0.31	313
Federal general government	0	0.04	357
State and local government enterprises	0	0.68	1582
State and local general government	0	0.29	5235

To facilitate analysis here, a unit value of \$1 to the trucking sector is used in the inoperability input-output model to represent changes in truck user costs caused by a disruption (or an improvement). The inoperability input-output model then shows sector disruptions that are proportional to the value of the original disruption, which is possible since the input-output model is linear; thus, the relative economic impact to a sector is based on an impact to the trucking sector (for example, a \$1 disruption to the trucking sector will disrupt \$.05 of sector A, \$.25 of sector B, etc.). Note that the unit disruption is not intended to represent any specific incident or congestion for any specific point; instead, it is used to show the various industrial sectors' dependence on the trucking sector for the study area. Thus, for any given incidents or congestion on specific highways in Virginia, it can be known what sectors will be most impacted by a disruption. Also, since the input-output model is linear, these relative values can be multiplied by a specific value representing a trucking disruption event to show indirect impacts for an event.

For these concept demonstrations, ten Freight Analysis Framework commodities were selected for analysis, based on their top rankings as Virginia critical commodities handled by truck in the state according to the Virginia Statewide Multimodal Freight

Study, as shown in Table 4 (Cambridge Systematics, 2010).

Table 4. Virginia's Top Critical Commodities Handled by Truck

Leading Virginia Truck Tonnage Commodities (2004)	Truck-hauled Tonnage	Truck Mode Share, % Tonnage	Concept Demonstration Inclusion
Nonmetallic Minerals	99,947,446	89%	✓
Secondary Traffic (warehouse dist.)	62,524,254	100%	
Clay, Concrete, Glass, or Stone	36,171,451	92%	✓
Lumber or Wood Products	32,867,249	95%	✓
Food or Kindred Products	31,112,374	93%	✓
Petroleum or Coal Products	27,883,789	80%	
Chemicals or Allied Products	24,248,272	86%	
Pulp, Paper, or Allied Products	9,957,320	80%	
Transportation Equipment	9,922,172	87%	
Farm Products	9,728,832	81%	

Source: Virginia Statewide Multimodal Freight Study (Cambridge Systematics, 2010)

These selected commodities are represented by disparate Freight Analysis Framework commodities and BEA industries used in the input-output model, as shown in Table 5. Examples of products that are classified as these commodities are listed in Table 6. Also shown are values from the inoperability input-output model relating to the percent disruption and relative dollar loss for a unit disruption to the trucking sector for BEA industries, and the relative dollar loss values for Freight Analysis Framework commodities used in the concept demonstrations. The connections shown in Table 5 between BEA industries and Freight Analysis Framework commodities are based on the relations used for the development of the Freight Analysis Framework model (Southworth, et al., 2011).

Because it is representative of the entire state of Virginia, this developed inoperability input-output model is applicable for both concept demonstrations examples presented below.

Table 5. Selected Freight Analysis Framework Commodities and BEA Industries for the Concept Demonstrations, and relative economic impact values from the inoperability input-output model

Freight Analysis Framework Commodity	BEA Industry (inoper. input-output model)	Percent disruption (q)	\$ loss, ratio	Derived Commodity \$ loss ratio
Cereal grains	Farms	7.77E-11	0.00153	0.00193
	Food and beverage and tobacco products	1.15E-10	0.00233	
Meat/seafood	Farms	7.77E-11	0.00153	0.00193
	Food and beverage and tobacco products	1.15E-10	0.00233	
Milled grain prods.	Farms	7.77E-11	0.00153	0.00193
	Food and beverage and tobacco products	1.15E-10	0.00233	
Other foodstuffs	Farms	7.77E-11	0.00153	0.00193
	Food and beverage and tobacco products	1.15E-10	0.00233	
Building stone	Mining, except oil and gas	1.25E-10	0.00245	0.00250
	Support activities for mining	1.31E-10	0.00257	
Natural sands	Mining, except oil and gas	1.25E-10	0.00245	0.00250
	Support activities for mining	1.31E-10	0.00257	
Gravel	Mining, except oil and gas	1.25E-10	0.00245	0.00250
	Support activities for mining	1.31E-10	0.00257	
Nonmetallic minerals	Mining, except oil and gas	1.25E-10	0.00245	0.00250
	Support activities for mining	1.31E-10	0.00257	
Logs	Forestry, fishing, and related activities	6.06E-11	0.00118	0.00165
	Wood products	1.09E-10	0.00213	
Wood products	Furniture and related products	2.49E-11	0.00049	0.00130
	Wood products	1.09E-10	0.00213	

Table 6. Example products of Freight Analysis Framework Commodities

Freight Analysis Framework Commodity	Examples of Products
Cereal grains	Wheat, Corn (except sweet corn), Rye, Barley, Oats
Meat/seafood	Fresh or chilled poultry, beef, pork fish, and aquatic invertebrates
Milled grain prods.	Wheat flour, milled rice, corn flour, pasta, baked snack foods, baked products – frozen, perishable, or dry,
Other foodstuffs	Dairy products - milk and cream, cheese and curds, and ice cream; coffee, tea, and spices; processed or prepared vegetables, fruit, or nuts – potato chips, jams and jellies, frozen fruit and vegetable juices; sugars; and carbonated soft drinks
Building stone	Monumental or building stone
Natural sands	Silica sands and quartz
Gravel	Limestone flux, agricultural limestone, and other gravel and crushed stone
Nonmetallic minerals	Table salt, sulfur, dolomite, natural calcium phosphates, clays, and asbestos
Logs	Logs for pulping, lumber, and fuel
Wood products	Wood chips or particles, treated and untreated lumber, shingles or shakes, plywood, and fiberboard

Source: BTS and U.S. Census Bureau, 2011.

7.2 Gathering Safety Data

Baseline safety data was gathered to use for both concept demonstrations examples. All of this data is publically available through VDOT (2012-a). Both concept demonstrations examples are included in the Virginia Primary Roadway system and so this statewide data was used for a baseline for current conditions. Interstate highway crash data was selected to assist with estimating crashes on the proposed improved roadways in the concept demonstrations, since each of these are to be limited access facilities built to similar standards. Because crash data includes several years of latency, the latest available data is only through 2007.

In order to normalize crash data, 2005-2007 daily VMT data was gathered for each Federal vehicle class, as shown in Table 7 for both primary and interstate roadways. Daily VMT was summed for vehicle classes 5-14, which represent daily truck VMT (ODOT, 2012), as shown below, to discern the total daily truck VMT for each year. This value was multiplied by 365 to have a value of total annual truck VMT per year for both primary and interstate roadways.

Table 7. Daily Truck Vehicle-Miles Traveled by Federal Vehicle Class on Virginia Primary and Interstate Roadways

Federal Vehicle Class	Federal Vehicle Class Description	Primary Roadways			Interstate System		
		2005	2006	2007	2005	2006	2007
5	2-axle, 6-tire, single unit trucks	819005	817560	840478	514412	465642	444266
6	3-axle, single-unit trucks	620369	625110	625405	394680	355206	347305
7	4 or more axle, single-unit trucks	157314	162354	161749	71596	69916	74096
8	4 or fewer axle, single-trailer trucks	352059	341296	316065	295770	364727	429139
9	5-axle, single-trailer trucks	2467536	2655747	2605762	6748732	6850638	6932382
10	6 or more axle, single trailer trucks	68557	83784	85092	83064	80175	84523
11	5 or fewer axle, multi-trailer trucks	66048	71646	72254	293672	299597	302182
12	6-axle, multi-trailer trucks	14890	15620	14280	106773	104581	98867
13	7 or more axle multi-trailer trucks	574	201	167	591	525	616
Total Daily Truck VMT		4566352	4773318	4721252	8509290	8591007	8713376
Total Annual Truck VMT (x100 million)		16.7	17.4	17.2	31.1	31.4	31.8

Source: VDOT, 2012-b.

Next, truck crash statistics for 2005-2007 were gathered for both primary and interstate roadways for the entire state of Virginia, and are organized by crash type in Table 8. In order to more easily compare the number of crashes across multiple years while still accounting for severity, a method from Garber and Hoel (2009) was applied that weights fatal, injury, and property damage crashes on a scale of 12:3:1. These values are shown in the bottom row of Table 8. All values in this table are then averaged across 2005-2007 separately for primary and interstate roadways.

Table 8. 2005-2007 Truck Crashes on Virginia Primary and Interstate Roadways

Truck Crash Type	All Truck Crashes on Virginia Primary Roadways				All Truck Crashes on the Interstate System in Virginia			
	2005	2006	2007	2005-2007 Average	2005	2006	2007	2005-2007 Average
Fatal Crash	55	48	48	52	28	32	31	30
Persons Killed	64	51	57	58	29	38	36	34
Injury Crash	1001	848	795	925	952	919	779	936
Persons Injured	1448	1220	1122	1334	1446	1325	1141	1386
PDO Crash	1757	1577	1412	1667	1973	1790	1685	1882
Total Crash	2813	2473	2255	2643	2953	2741	2495	2847
Crash Severity Number (12:3:1)	5420	4697	4373	5059	5165	4931	4394	5048

Source: VDOT, 2012-a.

Truck crash values shown in Table 8 were normalized using the total annual truck VMT values for each year from Table 7. The resultant truck crash rates were divided by 100 million in order to give Truck crash rates per 100 million truck VMT, as depicted in Table 9.

Table 9. 2005-2007 Truck Crash Rates on Virginia Primary and Interstate Roadways

Truck Crash rates per 100 million Truck VMT	Truck Crash Rates on Virginia Primary Roadways				Truck Crash Rates on the Interstate System in Virginia			
	2005	2006	2007	2005-2007 Average	2005	2006	2007	2005-2007 Average
Fatal Crash Rate	3.3	2.8	2.8	2.9	0.9	1.0	1.0	1.0
Persons Killed Rate	3.8	2.9	3.3	3.4	0.9	1.2	1.1	1.1
Injury Crash Rate	60.1	48.7	46.1	51.6	30.7	29.3	24.5	30.0
Persons Injured Rate	86.9	70.0	65.1	74.0	46.6	42.3	35.9	44.4
PDO Crash Rate	105.4	90.5	81.9	92.6	63.5	57.1	53.0	60.3
Total Crash Rate	168.8	141.9	130.9	147.2	95.1	87.4	78.4	91.2
Crash Severity Rate (12:3:1)	253.8	269.6	325.2	261.7	166.3	157.3	138.2	161.8

7.3 Concept Demonstration #1: U.S. 460 Expressway – Hampton Roads to Petersburg, VA

The U.S. 460 corridor stretches west from Hampton Roads as a four-lane non-divided highway with numerous ground-level crossings, including 12 signalized intersections before connecting with Interstates 295, 95, and 85 in Petersburg, then continuing west into central and western Virginia as a two-lane roadway. The seaports in Hampton Roads generate significant volumes of truck traffic into and out of that area via the primary

interregional highways of the region, which include Interstate 64, U.S. 13, U.S. 17, U.S. 58, and U.S. 460. Each of the Hampton Roads Bridge-Tunnels, i.e., Interstate 64 and Interstate 664, are severe bottlenecks in the region for north-south traffic in the area. As depicted in Figure 5, while Interstate 64 enters the Hampton Roads area from the northwest as the only limited-access highway for the region, U.S. 460 enters from the west on the south side of Hampton Roads, serving as a bypass to the bridge-tunnels for traffic to destinations on the southern side of the harbor.



Figure 5. Map of eastern Virginia showing U.S. 460 (existing and proposed “new” in red) and other major routes in the region

As of 2012, the Virginia Department of Transportation (VDOT) continues to explore an agreement to develop a four-lane divided, limited-access tolled expressway that would parallel the existing four-lane U.S. 460 between Suffolk in the east near Hampton Roads to the junction with Interstate 295 in the west near Petersburg. This project is intended to address increased freight volumes and support local economic development plans, as well as address general corridor deficiencies, improve safety, reduce travel delay, and improve hurricane evacuation capabilities (VDOT, 2012-c; FHWA & VDOT, 2005).

Specifically, travel demand forecasts show increased demand for an improved expressway versus the existing highway in 2026 forecasts, ranging from 160% to 425% over existing demand for various segments (FHWA & VDOT, 2005). While the travel time on the existing highway was 73 minutes in 2003, it is forecast to be 81 minutes and 60 minutes on the existing and proposed highways, respectively, in 2026; in other words, the proposed expressway is projected to have a 21 minute or 26% travel time savings in 2026 for the length of the route (FHWA & VDOT, 2005). Truck percentage is also

expected to increase from 23%-30% in 2003 to 30%-36% in 2026 on the existing highway, or 28%-38% on an improved highway in 2026 (FHWA & VDOT, 2005). Additionally, the proposed expressway would be a safer facility type than the existing roadway, which has historically had a disproportionately high crash rate for its facility type (FHWA & VDOT, 2005).

While this 55-mile toll road would provide a better connection to the region, the proposed truck toll is \$.21 per mile (\$11.72 for a complete one-way trip), with a 3.5% annual toll escalation (VDOT, 2012-c).

7.3.1 Calculating U.S. 460 Economic Importance

Due to the geographic position of Hampton Roads on the east coast, this study assumed that through traffic on the east-west U.S. 460 would have its origin or destination in the Hampton Roads Freight Analysis Framework region. Freight tonnage origin-destination data retrieved from the FHWA Freight Analysis Framework was organized and sorted into three major geographic groups for route assignment purposes; two individual Freight Analysis Framework regions, Richmond and Remainder of Virginia, were retained as separate groups as shown in Figure 6, due to close proximity to the Hampton Roads Freight Analysis Framework region, for a total of five geographic groups. The three major groupings, shown in Figure 6 alongside the two individual Virginia regions, are likely to have differing route splits between the choices offered by Interstate 64 and U.S. 13, U.S. 17, U.S. 58, and U.S. 460.

Route assignment for the five regions was estimated based on travel time estimations from Google Maps, and empirical knowledge of the quality of the route, i.e., two-lane vs. four-lane vs. four-lane limited access between the Freight Analysis Framework commodity origin-destination pairs. This was validated and further refined by summing kilotons of selected commodities for each route (see Table 10), then comparing the proportional Freight Analysis Framework AADTT, i.e., truck volume, estimations given for those routes, as shown in Table 11.

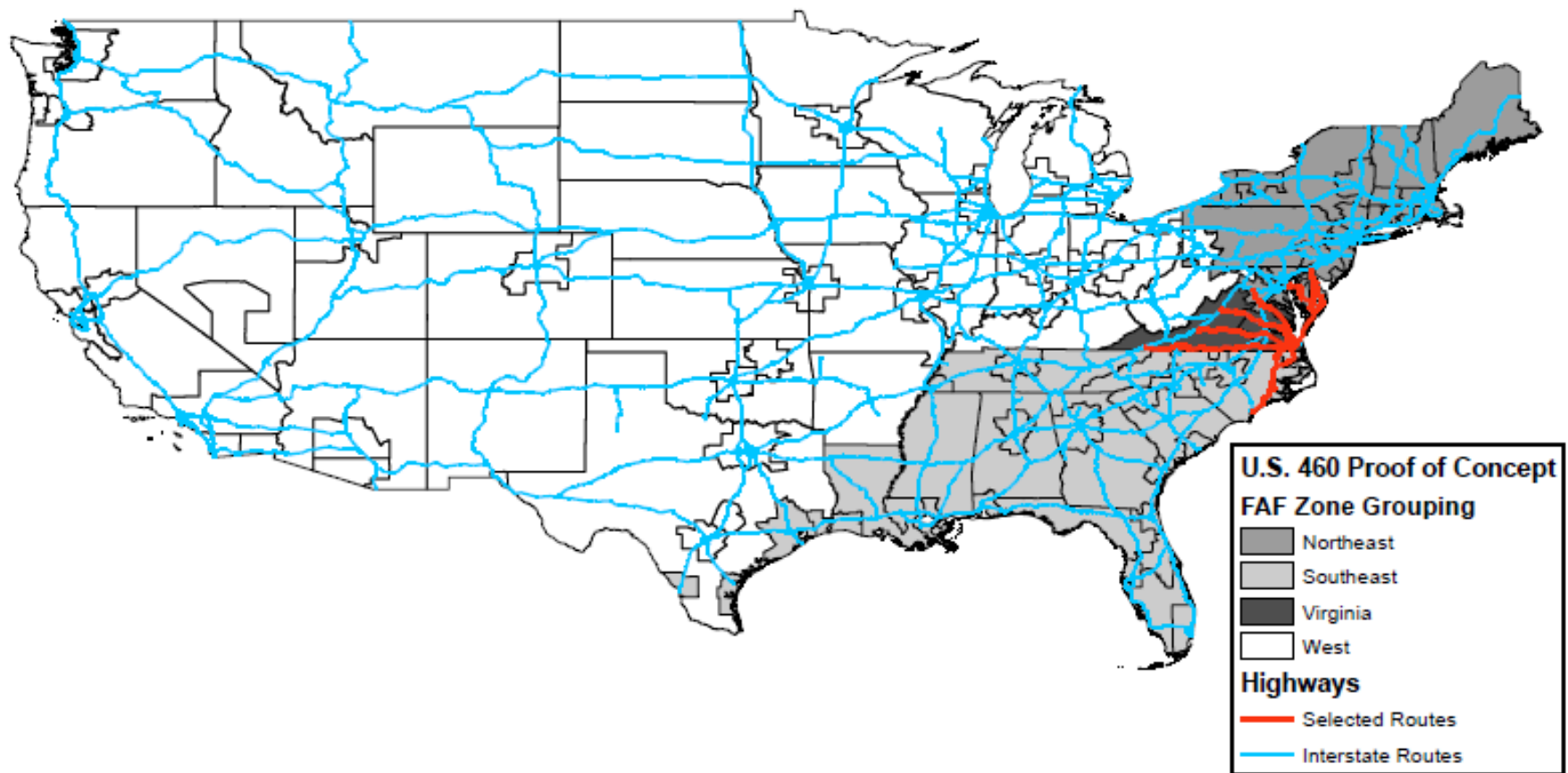


Figure 6. Freight Analysis Framework region groupings for origin-destination route assignment designation to/from the Hampton Roads area given available, selected routes

Table 10. Kilotons of Commodities by grouped Freight Analysis Framework region

Commodity	North	South	West	Richmond	Remainder of Virginia
Building stone	44.7	24.0	19.7	15.7	2.1
Cereal grains	127.0	216.0	213.8	354.2	147.9
Gravel	291.7	14.2	0.2	441.9	113.2
Logs	52.6	13.1	6.6	56.1	93.9
Meat/seafood	224.5	404.3	137.5	31.0	65.7
Milled Grain Products	57.8	77.9	37.2	9.9	0.5
Natural Sands	2.3	658.1	26.2	8.3	4.5
Nonmetallic minerals	281.6	599.0	25.7	74.2	10.3
Other foodstuffs	771.1	330.2	279.8	260.8	254.5
Wood Products	367.0	703.3	234.4	200.0	446.1
Total for Region	2220.4	3040.2	981.2	1452.0	1138.7

Table 11. Route assignment estimations by grouped Freight Analysis Framework region

Route	AADTT 2007		Grouped region origin-destination direction from Hampton Roads (% of total KiloTons)					
	Volume	% of total	North	West	South	Richmond	Virginia remainder	Route Total
Interstate 64	3870	34.9	12.2	6.4	1.0	10.9	4.1	34.6
U.S. 13 (north)	743	6.7	5.6	0	0	0	1.1	6.7
U.S. 13 (south)	262	2.4	0	0	2.4	0	0	2.4
U.S. 17 (north)	172	1.5	0.9	0.4	0	0	0.2	1.5
U.S. 17 (south)	1224	11.0	0	0	11.0	0	0	11.0
U.S. 58	2562	23.1	0	1.1	17.6	0	4.1	22.8
U.S. 460	2271	20.5	6.1	3.2	2.1	5.4	4.1	20.9
Total	11,104	100	24.9	11.0	34.1	16.3	13.7	100

It might be expected that a new, improved expressway paralleling U.S. 460 would serve not only the truck traffic on the existing route, but also attract truck traffic from other, more congested neighboring routes I-64 and U.S. 58, particularly trucks that might have to cross one of the Hampton Roads Bridge-Tunnels to reach their origin or destination. However, for the purposes of this study, despite the potential benefit that existing truck traffic on I-64 and U.S. 58 might derive from the new expressway, only existing truck volumes are analyzed. For instance, in uncongested conditions, I-64 will still provide a faster travel time than the proposed U.S. 460 expressway to northern region destinations; however, given congestion at the Hampton Roads Bridge-Tunnels, the U.S. 460 expressway may offer a shorter travel time. Accurately determining the specific volume or proportionate of truck traffic that not only might experience faster travel times on U.S. 460 given congestion levels at the bridge-tunnels, but also would make that choice as a result of traveler information would be difficult and was not estimated for the purposes of this demonstration. The percentages in Table 11 above

were applied to the commodity tonnage values in Table 10 to give the commodity tonnage values for this concept demonstration in Table 12. The values generated from the inoperability input-output model are applied to this commodity tonnage to provide values of economic importance, which are shown in Table 12; as highlighted in bold text, the value of economic importance for U.S. 460 is 3.560.

Table 12. Total Commodity Tonnage by Route for U.S. 460 Concept Demonstration

Commodity	Kilotons by route			Input-Output Economic Importance by route		
	I-64	U.S. 460	U.S. 58	I-64	U.S. 460	U.S. 58
Building stone	45.2	24.0	14.9	0.113	0.060	0.037
Cereal grains	473.4	268.9	176.8	0.914	0.519	0.341
Gravel	472.7	254.1	41.5	1.186	0.637	0.104
Logs	95.9	62.7	35.7	0.159	0.104	0.059
Meat/seafood	242.6	149.7	241.9	0.469	0.289	0.467
Milled Grain Products	59.0	33.1	43.9	0.114	0.064	0.085
Natural Sands	43.1	52.2	343.8	0.108	0.131	0.862
Nonmetallic minerals	224.1	140.9	315.0	0.562	0.353	0.790
Other foodstuffs	801.6	454.2	274.3	1.548	0.877	0.530
Wood Products	605.2	401.9	520.4	0.790	0.525	0.680
Total for Region	3062.9	1841.7	2008.3	5.963	3.560	3.956
Ratio with I-64 Regional Total	1	0.6013	0.656	1.000	0.597	0.663

7.3.2 Calculating U.S. 460 Excess Trucking Costs

Excess trucking costs for mobility and safety are calculated for this concept demonstration based on travel time savings and potential truck crash reduction for a scenario comparing the existing U.S. 460 with the projected benefits of a completed U.S. 460 expressway.

A conservative estimate of total excess trucking costs due to travel time savings can be derived using 2007 AADTT values from the Freight Analysis Framework and the U.S. 460 Environmental Impact Statement estimates of travel times. An hourly value of commercial vehicle time to calculate excess costs is \$105.67 as reported in TTI's Urban Mobility Report (Schrack et al., 2010). Assume that with existing conditions, the new expressway would have a travel time of 60 minutes versus 73 minutes for the existing route, as reported in the U.S. 460 Environmental Impact Statement. Thus, trucks incur costs due to an additional 13 minutes of travel, resulting in an excess trucking cost of almost \$23 per truck, or using the 2007 AADTT of 2271 trucks, a total excess trucking cost of nearly \$52,000 per day, totaling over \$19 million annually for only travel time savings on the new expressway alone.

Excess trucking costs can similarly be calculated from other measures, such as projected safety benefits. Crash data on a compact disc (CD) for the entire state of Virginia for 2005-2010 were obtained directly from the VDOT Central Office, by request. Crash data on this CD were organized in a series of tables. In order to glean

relevant truck crash data specifically for the U.S. 460 study corridor, two tables (i.e., “crash document” and “crash vehicle”) from this CD had to be joined by the crash document number. Several filters were applied to this data. Data were limited to crashes that:

- Include vehicle classes that identify trucks;
- Occurred on U.S. 460; and
- Occurred between Latitude/Longitude points of either end of the study area (37.188083,-77.323837 and 36.767225,-76.603681), or
- Occurred between state designated mileposts of the study area (324.09 to 373.89).

Note that both latitude/longitude coordinates and mileposts were used to locate relevant crash data since neither of these fields was consistently completed for all crash data for all years. This raw crash data for the U.S. 460 study corridor is presented in Table C-1 of Appendix C. The filtered crash data relevant to the U.S. 460 study corridor for years 2005-2010 is presented in Table 13.

Table 13. 2005-2010 Truck Crashes by Crash Type on U.S. 460 Study Corridor

Truck Crash Type	Truck Crashes on U.S. 460 Study Corridor						2005-2010 Average
	2005	2006	2007	2008	2009	2010	
Fatal Crash	1	4	4	4	0	3	2.7
Persons Killed	3	4	4	4	0	3	3.0
Injury Crash	13	15	12	10	13	6	11.5
Persons Injured	16	22	20	11	15	8	15.3
PDO Crash	19	33	22	10	32	11	21.2
Total Crash	33	52	38	24	45	20	35.3
Crash Severity Number (12:3:1)	70	126	106	88	71	65	87.7

To normalize the data, the distance of the existing segment to be replaced was determined to be 50 miles based on the farthest endpoints of crash data. The 2007 AADTT of the existing segment was gathered for each segment within the study corridor from the Freight Analysis Framework and, using the mileage of each segment, converted to a daily truck VMT of 119,020 for the total length of the study corridor (this raw data is shown in Table C-3 of Appendix C). This value was multiplied by 365 to get annual truck VMT. These values are presented in Table 14.

Table 14. Measures required for Safety Calculations for U.S. 460 Study Corridor

Measures	U.S. 460 Study Corridor
Distance	50 miles
Freight Analysis Framework AADTT 2007	2377 (weighted average)
Daily Truck VMT	119020
Total Annual Truck VMT (x100 million)	0.434423

Truck crash rates for the U.S. 460 corridor were derived simply by dividing values presented in Table 13 by the value for total annual truck VMT presented in Table 14. The calculated truck crash rates for the years 2005-2010 by crash type for the U.S. 460 study corridor are presented in Table 15.

Table 15. 2005-2010 Truck Crash Rates by Crash Type on U.S. 460 Study Corridor

Truck Crash Rate per 100 million Truck VMT	Truck Crash Rates on U.S. 460 Study Corridor						
	2005	2006	2007	2008	2009	2010	2005-2010 Average
Fatal Crash Rate	2.3	9.2	9.2	9.2	0.0	6.9	6.1
Persons Killed Rate	6.9	9.2	9.2	9.2	0.0	6.9	6.9
Injury Crash Rate	29.9	34.5	27.6	23.0	29.9	13.8	26.5
Persons Injured Rate	36.8	50.6	46.0	25.3	34.5	18.4	35.3
PDO Crash Rate	43.7	76.0	50.6	23.0	73.7	25.3	48.7
Total Crash Rate	76.0	119.7	87.5	55.2	103.6	46.0	81.3
Crash Severity Rate (12:3:1)	161.1	290.0	244.0	202.6	163.4	149.6	201.8

Compared with truck crash rates on other Virginia Primary Roadways that were presented in Table 9, only the average truck fatality crash and persons killed rates are higher on the U.S. 460 study corridor at a ratio of 6.1 to 2.9 and 6.9 to 3.4, respectively. Similarly, when compared with crash rates on the Virginia interstate highways in Table 9, which have similar characteristics as the proposed U.S. 460 expressway, only average truck fatality crash and person killed rates on the existing roadways are higher. These comparisons are presented in Table 16 below.

The difference between the current and interstate-grade proposed expressway are presented for fatality crash and persons killed rates, alongside the potential annual reduction in the number of fatal crashes and persons killed, given the existing truck VMT in the study corridor. Using a value of \$7.2 million given by the Federal Motor Carrier Safety Administration (FMCSA, 2008) as the cost of each medium/heavy vehicle fatality crash, it can be estimated by multiplying with the potential 2.2 crashes reduced that \$15.8 million in annual excess trucking costs (or \$43,400 per day) can be potentially eliminated with the construction of the proposed U.S. 460 expressway.

Table 16. Comparison of Average Crash Rates for U.S. 460 Study Corridor to All Virginia Primary and Interstate Roadways

Average Annual Virginia Truck Crash Rates per 100 million Truck VMT					Potential Annual Crash Reduction
Truck Crash Rate Type	U.S. 460 Study Corridor 2005-2010	Interstate System 2005-2007	Primary Roadways 2005-2007	U.S. 460 to Interstate System Difference	
Fatal Crash Rate	6.1	1.0	2.9	5.2	2.2
Persons Killed Rate	6.9	1.1	3.4	5.8	2.5
Injury Crash Rate	26.5	30.0	51.6	-	-
Persons Injured Rate	35.3	44.4	74.0	-	-
PDO Crash Rate	48.7	60.3	92.6	-	-
Total Crash Rate	81.3	91.2	147.2	-	-
Crash Severity Rate (12:3:1)	201.8	161.8	261.7	40.0	n/a

Several notes must be made regarding the presented crash rates. First, many confounding factors influence crash rates and simply improving or upgrading a roadway is no guarantee that potential crash reduction numbers will be realized. Higher truck volumes, or even higher volumes of other vehicles, on the new roadway could reduce the projected safety benefits, for example. Additionally, because the proposed U.S. 460 expressway would include a new interchange at either end, it is worth noting that interchanges often include higher incident rates due to factors like merges, curves, and slowing traffic; thus, while the roadway itself may see reduced crash numbers, the new interchanges may experience a higher number of crashes than before. Finally, a major assumption has been made regarding truck volumes in that trucks in particular would shift from the old highway onto the new tolled expressway, thus transferring truck crashes to the new expressway from the existing alignment.

7.3.3 Calculating U.S. 460 Economic Hindrance

The calculated values of excess trucking costs can now be used in the derived inoperability input-output model to determine a value of economic hindrance caused to other industries due to excess trucking costs incurred by the trucking sector. Note that this value clearly should not be used in conjunction with the first economic metric calculated, as it would be double counting.

The calculated consequences of the economic hindrance incurred by an excess trucking cost based on travel time savings of \$52,000 per day and truck fatality crash savings of \$43,400 per day to the trucking sector are shown in Table 17 below. This value is calculated by simply multiplying the individual excess trucking costs calculated above with the BEA dollar loss ratio calculated previously in the inoperability input-output model and presented again in Table 17. Note that for the trucking sector, the model shows a loss of 114%, however in order to not double count, only a value of 14% is shown, because the remaining 100% is already tabulated as the excess trucking cost above.

Table 17. Economic hindrance by industry based on calculated excess trucking costs to the trucking sector on U.S 460

BEA Industry Labels (Input-Output Model)	BEA \$ loss, ratio	Daily Economic Hindrance, \$	
		Mobility (travel time)	Safety (truck crashes)
Truck transportation	1.1428	7423	6195
Petroleum and coal products	0.1169	6080	5075
Oil and gas extraction	0.0952	4951	4132
Wholesale trade	0.0661	3436	2867
Motor vehicles, bodies and trailers, and parts	0.0364	1892	1579
Warehousing and storage	0.0240	1249	1042
Chemical products	0.0237	1232	1029
Fabricated metal products	0.0184	959	800
Retail trade	0.0177	919	767
Plastics and rubber products	0.0172	892	745
Primary metals	0.0154	802	670
Utilities	0.0100	520	434
Computer systems design and related services	0.0090	466	389
Information and data processing services	0.0089	462	385
Machinery	0.0070	364	303
Computer and electronic products	0.0066	346	288
Electrical equipment, appliances, and components	0.0064	335	280
Paper products	0.0063	328	274
Waste management and remediation services	0.0058	300	251
Publishing industries (includes software)	0.0055	286	238
Construction	0.0052	272	227
Printing and related support activities	0.0040	208	174
Food services and drinking places	0.0036	189	158
Nonmetallic mineral products	0.0028	144	120
Support activities for mining	0.0026	133	111
Mining, except oil and gas	0.0025	127	106
Food and beverage and tobacco products	0.0023	121	101
Wood products	0.0021	111	92
Miscellaneous manufacturing	0.0016	82	68
Farms	0.0015	80	67
Textile mills and textile product mills	0.0015	78	65
Forestry, fishing, and related activities	0.0012	61	51
Other transportation equipment	0.0011	59	49
Furniture and related products	0.0005	25	21
Apparel and leather and allied products	0.0005	24	20
Other (services, government, etc.)	varies	20,168	16,831
Daily Total		55,125	46,005
Daily Total per Mile		1103	920
Annual Total		20,120,618	16,791,749

Thus, it is shown that current mobility constraints on U.S. 460 cause additional economic hindrances of approximately \$55,000 per day, totaling over \$20 million annually to industry, which has the potential to be reduced or eliminated with the construction of the U.S. 460 expressway, depending on the amount of the toll that is charged. Additionally, about \$46,000 per day, or \$16.8 million per year, in excess trucking costs due to truck fatality crashes in the U.S. 460 study corridor might be reduced if the interstate-grade U.S. 460 expressway were constructed.

7.3.4 Summary of U.S. 460 Findings

A summary of the values for U.S. 460 expressway concept demonstration presented in the tables above is given below in Table 18, many of which are presented later in the 7.5 Decision Model section.

Table 18. Summary Table of U.S. 460 Measures

Corridor Metrics	Length of Corridor		50 miles
	AADTT		2377 daily trucks
Travel Time Savings	Entire Corridor Length per Truck		13 minutes per truck
	Rate Per Truck		0.26 minutes per truck per mile
	Annual Savings, Entire Corridor		30,900 minutes
	Annual Savings, Rate Per Mile		618 minutes per mile
Truck Crash Severity 2005-2010 (Fatal:Injury: Property Damage Only ratio of 12:3:1)	Rate per 100 million VMT		201.8 crashes per 100 million VMT
	Rate Difference with Improvement		40 less crashes per 100 million VMT
	Annual Reduction per Mile (Rate*VMT / 50)		0.35 less crashes per mile
Proposed Economic Metrics	Economic Importance		3.56
	Excess Trucking Cost, \$	Mobility – daily	\$52,000 per day
		Mobility – daily per mile	\$1040 per day per mile
		Safety – daily	\$43,400 per day
		Safety – daily per mile	\$868 per day per mile
	Economic Hindrance, \$	Mobility – daily per mile	\$1103 per day per mile
		Safety – daily per mile	\$920 per day per mile

7.4 Concept Demonstration #2: U.S. 29 Bypass – Charlottesville / Albemarle County, VA

The U.S. 29 corridor serves central Virginia and north-central North Carolina from the Washington, DC metropolitan area south to Greensboro, North Carolina via Gainesville, Warrenton, Culpeper, Charlottesville, Lynchburg, and Danville, Virginia. Between I-66 in Northern Virginia and Greensboro, North Carolina, the U.S. 29 corridor is, at a minimum, a four-lane divided highway with numerous at-grade crossings, many of which are signalized. For longer distance trips, truckers might conceivably select roughly parallel Interstate 81 and U.S. 220 or Interstate 85 and Interstate 95 for a higher level of

service route, as depicted in Figure 7. However, approximately 67% of tonnage on the U.S. 29 corridor in Virginia is pass-through freight (Cambridge Systematics, 2010).

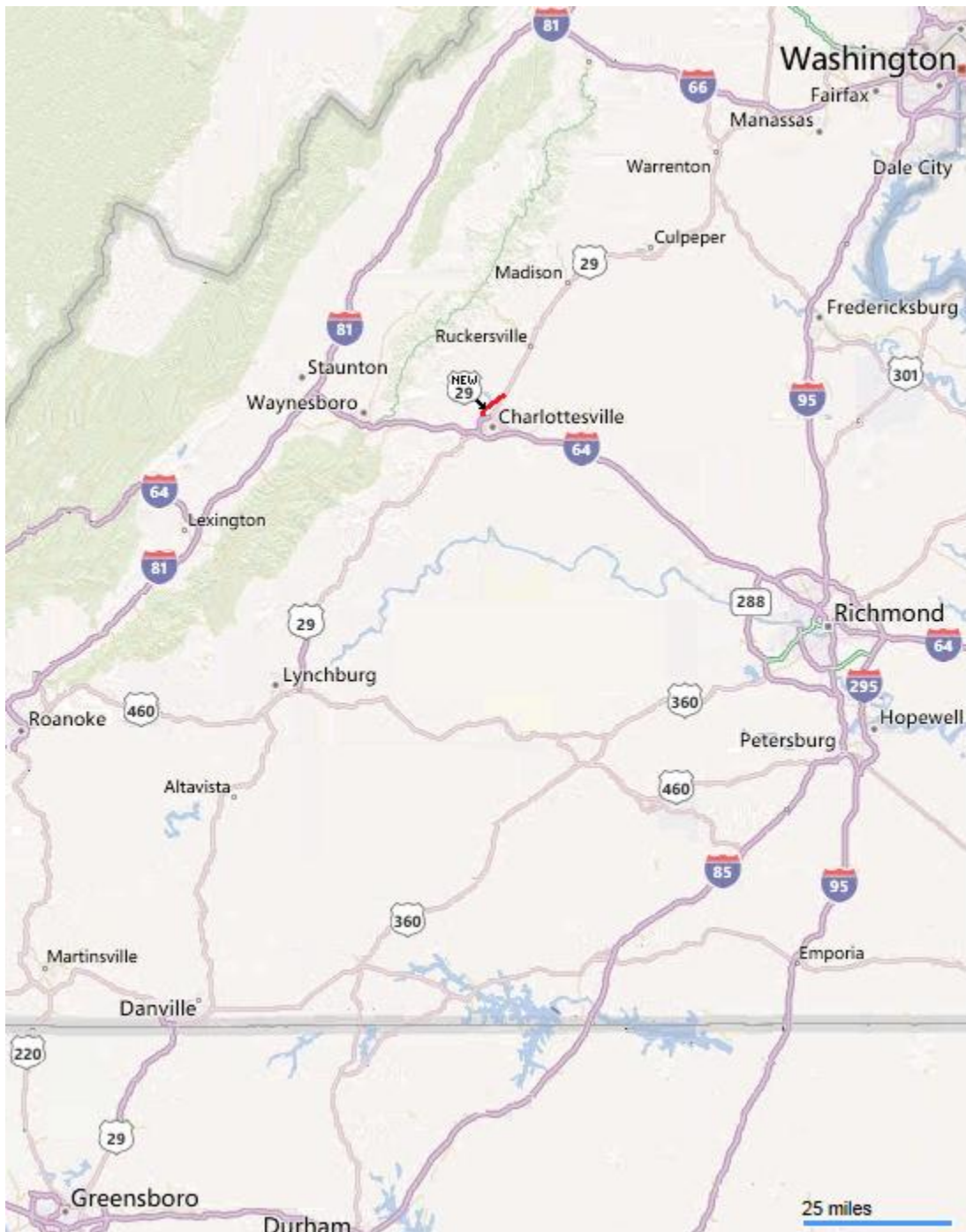


Figure 7. Map of U.S. 29 corridor with proposed bypass and other major alternate routes

Regionally, in central Virginia, there is much debate on whether stoplights on the U.S. 29 corridor, specifically a segment with a reduced speed of 45 mile per hour and a sequence of 13 traffic lights just north of Charlottesville impede mobility such that they serve as a bottleneck to reduce economic activity in Lynchburg and Danville with the

Northeast Corridor, i.e., Washington, DC; New York City; etc., and thus hinder economic growth in that area of southern Virginia. As a result, a 6.2-mile bypass is proposed for construction north of Charlottesville in Albemarle County as an alternate route to avoid this heavily commercially developed area (VDOT, 2012-d).

7.4.1 Calculating U.S. 29 Economic Importance

Estimates of freight tonnage carried on the U.S. 29 corridor was performed slightly differently than for the U.S. 460 corridor, in part to demonstrate alternate methods, but also because of the difference in alignment of the corridors. First, as above, Freight Analysis Framework region groupings were developed, given the directionality of U.S. 29 and natural flow for traffic from northeast to the south and west, as well as the positioning of other parallel routes. Unlike the U.S. 460 concept demonstration in which routes are less parallel and branch out in different directions, the U.S. 29 corridor has a number of parallel corridors that serve similar Freight Analysis Framework region origins and destinations (e.g., I-81, I-95, and connecting routes such as U.S. 220 and I-85, respectively), as shown in Figure 7. Thus, route assignment based on origin-destination regions, even those that are the size of the Freight Analysis Framework regions, are much more difficult for this corridor.

Commodity flows through the region were determined using Freight Analysis Framework data. Origins and destinations of commodity flows were sorted into several main groups: the Northeast, where traffic travels through or around DC for points to or from the south and west; Virginia, which includes the Remainder of Virginia Freight Analysis Framework region around Charlottesville; a South region; and a West region that is conceivably connected to the U.S. 29 corridor via I-64 at Charlottesville. A final group, the Northwest region, was discarded from analysis, since the U.S. 29 corridor seems to be an unlikely route given its directionality. These groupings are shown in Figure 8 with the Interstate Highway System to show connections from the U.S. 29 corridor to these regions.

Using a screenline across central Virginia, 2007 AADTT volumes were taken from the Freight Analysis Framework for I-81, the U.S. 29 bypass segment, and I-95. These AADTT volumes were used to assign tonnage values for each corridor. Specifically, approximately 1744 trucks per day travel on the U.S. 29 corridor segment of the proposed bypass, while AADTT for I-95 and I-81 are 15,000 and 12,000 trucks, respectively, as shown in Table 19. Thus, approximately 6% of the total tonnage of selected commodities was assigned to the U.S. 29 corridor. The values generated from the inoperability input-output model are applied to this commodity tonnage to provide a value of economic importance, which is also shown in Table 19, in bold text; the value of economic importance for the U.S. 29 corridor is 16.43. In this concept demonstration, because the regional origin-destination groups are the same for all three corridors, the value of economic importance will be exactly proportional to the AADTT volumes for the three corridors.

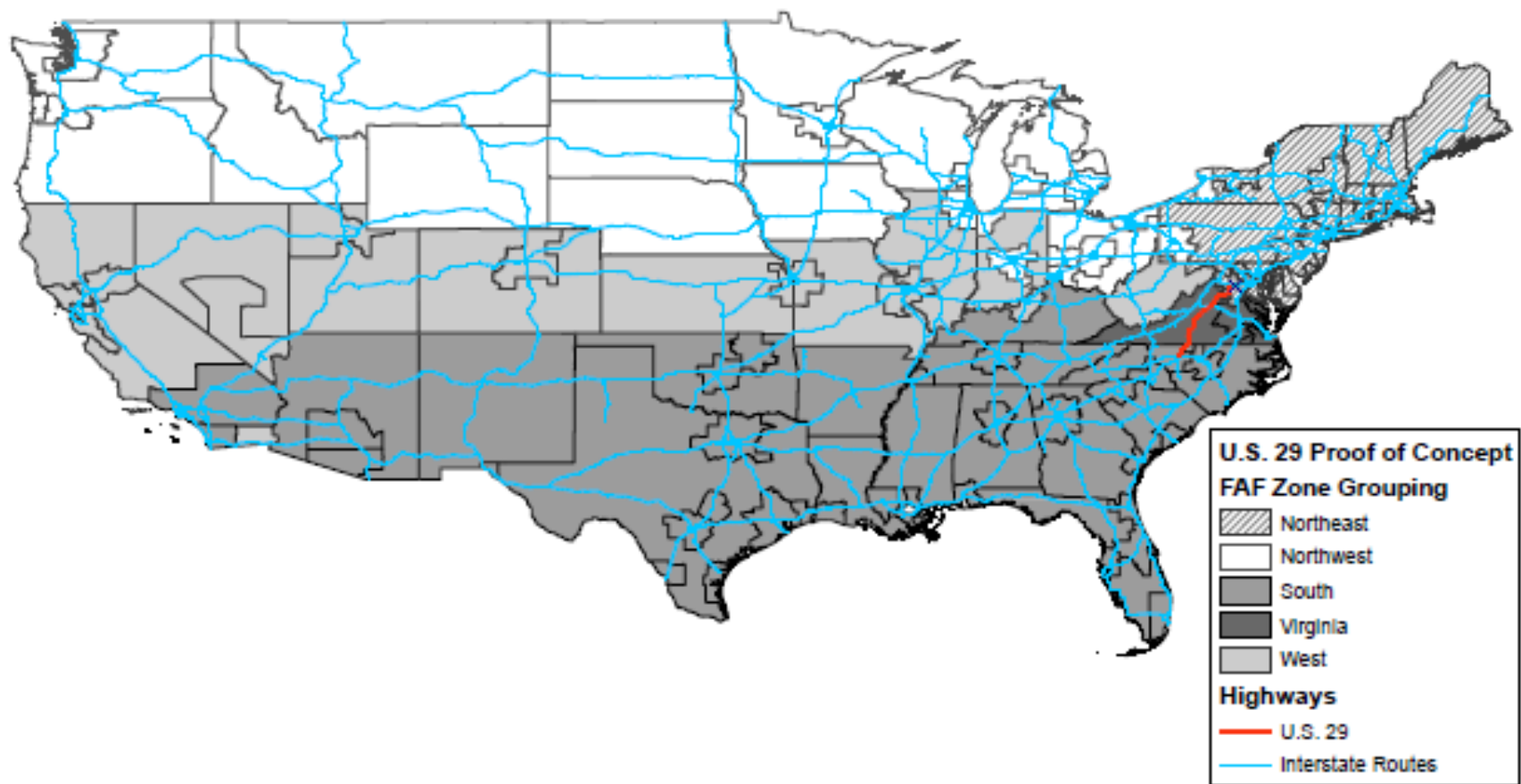


Figure 8. Freight Analysis Framework region groupings for origin-destination route assignment designation through central Virginia

Table 19. Total Commodity Tonnage by Route for U.S. 29 Concept Demonstration

Commodity	Kilotons by route for Concept Demonstration				Input-Output Economic Importance by route for Concept Demonstration		
	Total	US 29	I-95	I-81	US 29	I-95	I-81
Cereal Grains	18334	1112	9567	7654	2.15	18.48	14.78
Meat/Seafood	7947	482	4147	3318	0.93	8.01	6.41
Milled grain prods.	5421	329	2829	2263	0.64	5.46	4.37
Other foodstuffs	25754	1563	13440	10752	3.02	25.96	20.76
Building Stone	714	43	373	298	0.11	0.94	0.75
Gravel	30442	1847	15886	12709	4.63	39.85	31.88
Natural sands	1937	118	1011	809	0.29	2.54	2.03
Nonmetallic minerals	10524	639	5492	4394	1.60	13.78	11.02
Logs	14873	902	7761	6209	1.49	12.84	10.27
Wood Prods.	19758	1199	10311	8248	1.57	13.46	10.77
Total	135703	8234	70817	56653	16.43	141.30	113.04
AADTT	28744	1744	15000	12000			
Percentage of total	100	6	52	42			

It is possible that a new, improved U.S. 29 bypass will alleviate a bottleneck in the regions such that it would not only serve existing U.S. 29 truck traffic on the existing route, but also attract truck traffic from other, more congested neighboring routes like I-81, for example (NCHRP 365 presents a traffic shift methodology for corridors that might be used to estimate the amount of diversion [Martin and McGuckin, 1998]). Additionally, the cities of Lynchburg and Danville could benefit from new industry with this improved connection to markets in the north. All of these possibilities would increase truck volumes on U.S. 29, and thus potentially provide added significance to the corridor and benefit to the trucking industry as a whole. However, for the purposes of this concept demonstration, only existing truck volumes were analyzed.

7.4.2 Calculating U.S. 29 Excess Trucking Costs

Excess trucking costs calculated for mobility and safety are calculated for this concept demonstration based on travel time savings and potential truck crash reduction for a scenario comparing the existing U.S. 29 with the projected benefits of a completed U.S. 29 bypass.

A conservative estimate of total excess trucking costs can be derived using 2007 AADTT and truck speed values from the Freight Analysis Framework. The hourly value of commercial vehicle time used to calculate excess costs is \$105.67 as reported in TTI's Urban Mobility Report (Schrang et al., 2010). Given 2007 truck speeds on the existing U.S. 29 corridor is 47.3 miles per hour, and will be compared to an estimated truck speed for the new bypass of 55 miles per hour, the expected posted speed limit. It should be noted that the former value is likely high considering the speed limit of the existing U.S. 29 is only 45 miles per hour, and there is great likelihood of truck traffic being further

hindered by traffic lights; however, this value, as given by the Freight Analysis Framework is used for consistency, and provides a conservative estimate. The difference in current and new truck speeds result in a travel time savings of 0.7 minutes per truck. With a 2007 AADTT of 1744 trucks per day, this results in 20 hours of delay and excess trucking costs per day of \$2150, or \$785,000 per year.

Excess trucking costs can similarly be calculated from other measures, such as projected safety benefits. Crash data on a CD for the entire state of Virginia for 2005-2010 were obtained directly from the VDOT Central Office, by request. Crash data on this CD were organized in a series of tables. In order to glean relevant truck crash data specifically for the U.S. 29 study corridor, two tables (i.e., “crash document” and “crash vehicle”) had to be joined by the crash document number. Several filters were applied to this data. Data were limited to crashes that:

- Include vehicle classes that identify trucks;
- Occurred on U.S. 29; and
- Occurred between Latitude/Longitude points of either end of the U.S. 29 study area (38.057148,-78.495598 and 38.112477,-78.453026), or
- Occurred between state designated U.S. 29 mileposts of the study area (139.404 to 143.417).

Note that both latitude/longitude coordinates and mileposts were used to locate relevant crash data since neither of these fields was consistently completed for all crash data for all years. This raw crash data for the U.S. 29 study corridor is presented in Table C-2 of Appendix C. The filtered crash data relevant to the U.S. 29 study corridor for years 2005-2010 is presented in Table 20.

Table 20. 2005-2010 Truck Crashes by Crash Type on U.S. 29 Study Corridor

Crash Type	Truck Crashes on U.S. 29 Study Corridor						2005-2010 Average
	2005	2006	2007	2008	2009	2010	
Fatal Crash	0	0	0	0	0	0	0.0
Persons Killed	0	0	0	0	0	0	0.0
Injury Crash	8	5	1	3	3	3	3.8
Persons Injured	14	5	2	4	5	5	5.8
PDO Crash	11	9	11	16	12	22	13.5
Total Crash	19	14	12	19	15	25	17.3
Crash Severity Number (12:3:1)	35	24	14	25	21	31	25.0

To normalize the data, the distance of the existing segment to be replaced was determined to be 4 miles based on the farthest endpoints of crash data. The 2007 AADTT of the existing segment was gathered for the study corridor segment from the Freight Analysis Framework and converted to a daily truck VMT of 6976 for the total length of the study corridor. This value was multiplied by 365 to get annual truck VMT. These values are presented in Table 21.

Table 21. Measures used for Safety Calculations for U.S. 29 Study Corridor

Measures	U.S. 29 Study Corridor
Distance	4 miles
Freight Analysis Framework AADTT 2007	1744 vehicles
Daily Truck VMT	6976
Total Annual Truck VMT (x100 million)	0.025462

Truck crash rates for the U.S. 29 corridor were derived simply by dividing values presented in Table 20 by the value for total annual truck VMT presented in Table 21. The calculated truck crash rates for the years 2005-2010 by crash type for the U.S. 460 study corridor are presented in Table 22.

Table 22. 2005-2010 Truck Crash Rates by Crash Type on U.S. 29 Study Corridor

Crash rates per 100 million Truck VMT	Truck Crash Rates on U.S. 29 Study Corridor						
	2005	2006	2007	2008	2009	2010	2005-2010 Average
Fatal Crash Rate	0	0	0	0	0	0	0
Persons Killed Rate	0	0	0	0	0	0	0
Injury Crash Rate	314.2	196.4	39.3	117.8	117.8	117.8	150.5
Persons Injured Rate	549.8	196.4	78.5	157.1	196.4	196.4	229.1
PDO Crash Rate	432.0	353.5	432.0	628.4	471.3	864.0	530.2
Total Crash Rate	746.2	549.8	471.3	746.2	589.1	981.8	680.7
Crash Severity Rate (12:3:1)	1374.6	942.6	549.8	981.8	824.7	1217.5	981.8

Compared with truck crash rates on other Virginia Primary Roadways that were presented in Table 9, only the average truck fatality crash and persons killed rates are lower on the U.S. 29 study corridor, with zero fatal crashes recorded for the six years presented. Similarly, when compared with crash rates on the Virginia interstate highways in Table 9, which have similar characteristics as the proposed U.S. 29 bypass, only average truck fatality crash and person killed rates on the existing roadway is lower. In fact, perhaps due to the more urban nature of the U.S. 29 corridor with slower speeds and frequent traffic signals, the truck crash rate is notably higher than the state average for other primary roadways. These comparisons are presented in Table 23 below.

Table 23. Comparison of Average Crash Rates for U.S. 29 Study Corridor to All Virginia Primary and Interstate Roadways

Average Annual Virginia Truck Crash Rates per 100 million Truck VMT					Potential Annual Crash Reduction
Truck Crash Rate Type	U.S. 29 Study Corridor 2005-2010	Interstate System 2005-2007	Primary Roadways 2005-2007	U.S. 29 to Interstate System Difference	
Fatal Crash Rate	0.0	1.0	2.9	-	-
Persons Killed Rate	0.0	1.1	3.4	-	-
Injury Crash Rate	150.5	30.0	51.6	120.6	3.1
Persons Injured Rate	229.1	44.4	74.0	184.7	4.7
PDO Crash Rate	530.2	60.3	92.6	469.9	12.0
Total Crash Rate	680.7	91.2	147.2	589.5	15.0
Crash Severity Rate (12:3:1)	981.8	161.8	261.7	820.1	n/a

The difference between the current and interstate-grade proposed expressway are presented for injury, PDO, and total crash rates and persons injured, alongside the potential annual reduction in the number of these crashes and persons injured, given the existing truck VMT in the study corridor. Using a value of \$331,108 given by the Federal Motor Carrier Safety Administration (FMCSA, 2008) as the average cost of each injury crash involving a medium/heavy vehicle, it can be estimated by multiplying with the potential 3.1 crashes reduced that over \$1 million in annual excess trucking costs (or \$2800 per day) can be potentially eliminated with the construction of the proposed U.S. 29 bypass. Likewise, FMCSA (2008) gives a value of \$148,279 as the average cost for a truck-involved crash for all medium/heavy vehicles. From this, it can be estimated by multiplying with the potential 12 crashes reduced that about \$1.8 million in annual excess trucking costs (or \$4900 per day) can be potentially eliminated with the construction of the proposed U.S. 29 bypass.

7.4.3 Calculating U.S. 29 Economic Hindrance

The calculated values of excess trucking costs can be used in the derived inoperability input-output model to determine a value of economic hindrance caused to other industries due to excess trucking costs incurred by the trucking sector. Note, this value clearly should not be used in conjunction with the first value calculated, as it would be double counting.

The calculated consequences of the economic hindrance incurred by an excess trucking cost based on travel time savings of \$2150 per day and truck fatality crash savings of \$7700 per day to the trucking sector are shown in Table 24 below. This value is calculated by simply multiplying the individual excess trucking costs calculated above with the BEA dollar loss ratio calculated previously and presented again in Table 24. Note that for the trucking sector, the model shows a loss of 114%, however in order to

not double count, only a value of 14% is shown, since the remaining 100% is already tabulated above as a part of the excess trucking cost.

Thus, it is shown that current mobility constraints on U.S. 29 cause additional economic hindrances of nearly \$2300 per day, totaling over \$830,000 annually to industry, which has the potential to be reduced or eliminated with the construction of the U.S. 29 bypass. Additionally, over \$8100 per day, or almost \$3 million per year, in excess trucking costs due to truck crashes in the U.S. 29 study corridor might be reduced if the interstate-grade U.S. 29 bypass were constructed.

Several notes must be made regarding the presented crash rates. First, many factors influence crash rates and simply improving or upgrading a roadway is no guarantee that potential crash reduction numbers will be realized. Higher truck volumes, or even higher volumes of other vehicles, on the new roadway could reduce the projected safety benefits, for example. Additionally, because the proposed U.S. 29 bypass would include a new interchange at either end, including one involving a stop light with a left turn for through traffic, it is worth noting that interchanges often include higher incident rates due factors like merges, curves, and slowing traffic; thus, while the roadway itself may see reduced crash numbers, the new interchanges may experience a higher number of crashes than the old alignment. At the same time, other programmed projects, such as that which involves adding a second lane to the southbound U.S. 29 on-ramp at the junction with U.S. 250, could potentially achieve similar safety benefits, which would necessarily be included in the final decision model for comprehensive comparison of potential derived benefits. Finally, because the existing U.S. 29 corridor has numerous businesses, many trucks will likely still travel on the existing roadway, thus reducing the full projected benefits for potential reduction of truck crashes of the proposed U.S. 29 bypass.

Table 24. Economic hindrance by industry based on calculated mobility-based excess trucking costs to the trucking sector on U.S. 29

BEA Industry Labels (Input-Output Model)	BEA \$ loss, ratio	Daily Economic Hindrance, \$	
		Mobility (travel time)	Safety (truck crashes)
Truck transportation	1.1428	307	1097
Petroleum and coal products	0.1169	251	899
Oil and gas extraction	0.0952	205	732
Wholesale trade	0.0661	142	508
Motor vehicles, bodies and trailers, and parts	0.0364	78	280
Warehousing and storage	0.0240	52	185
Chemical products	0.0237	51	182
Fabricated metal products	0.0184	40	142
Retail trade	0.0177	38	136
Plastics and rubber products	0.0172	37	132
Primary metals	0.0154	33	119
Utilities	0.0100	21	77
Computer systems design and related services	0.0090	19	69
Information and data processing services	0.0089	19	68
Machinery	0.0070	15	54
Computer and electronic products	0.0066	14	51
Electrical equipment, appliances, and components	0.0064	14	50
Paper products	0.0063	14	49
Waste management and remediation services	0.0058	12	44
Publishing industries (includes software)	0.0055	12	42
Construction	0.0052	11	40
Printing and related support activities	0.0040	9	31
Food services and drinking places	0.0036	8	28
Nonmetallic mineral products	0.0028	6	21
Support activities for mining	0.0026	6	20
Mining, except oil and gas	0.0025	5	19
Food and beverage and tobacco products	0.0023	5	18
Wood products	0.0021	5	16
Miscellaneous manufacturing	0.0016	3	12
Farms	0.0015	3	12
Textile mills and textile product mills	0.0015	3	12
Forestry, fishing, and related activities	0.0012	3	9
Other transportation equipment	0.0011	2	9
Furniture and related products	0.0005	1	4
Apparel and leather and allied products	0.0005	1	4
Other (services, government, etc.)	varies	834	2981
Daily Total		2279	8149
Daily Total per Mile		570	2037
Annual Total		831,958	2,974,252

7.4.4 Summary of U.S. 29 Findings

A summary of the values for the U.S. 29 bypass concept demonstration presented in the tables above is given below in Table 25, many of which are also used in the 7.5 Decision Model section.

Table 25. Summary Table of U.S. 29 Measures

Corridor Metrics	Length of Corridor		4 miles
	AADTT		1744 daily trucks
Travel Time Savings	Entire Corridor Length Per Truck		0.71 minutes per truck
	Rate Per Truck		0.18 minutes per truck per mile
	Annual Savings, Entire Corridor		1238 minutes
	Annual Savings Rate Per Mile		310 minutes per mile
Truck Crash Severity 2005-2010 (Fatal:Injury: Property Damage Only ratio of 12:3:1)	Rate per 100 million VMT		981.8 crashes per 100 million VMT
	Rate Difference with Improvement		820 less crashes per 100 million VMT
	Annual Reduction per Mile (Rate*Truck VMT/4)		5.23 crashes reduced per mile
Proposed Economic Metrics	Economic Importance		16.43
	Excess Trucking Cost, \$	Mobility – daily	\$2150 per day
		Mobility – daily per mile	\$538 per day per mile
		Safety – daily	\$7700 per day
		Safety – daily per mile	\$1925 per day per mile
	Economic Hindrance, \$	Mobility – daily per mile	\$570 per day per mile
		Safety – daily per mile	\$2037 per day per mile

7.5 Decision Model

A summary of the key metrics calculated and derived for both the U.S. 460 expressway and U.S. 29 bypass concept demonstrations above are presented in Table 26. Despite having only two corridors to compare, several simple decision models could be employed to rank the corridors for their relative benefits and thus prioritize the improvements. These decision models could also be used to compare a larger number of corridors, if scores were proportionately given to each metric between a range of zero to five, for example.

For this comparison, the first decision model uses equal weightings for all metrics, the second emphasizes safety metrics at a scale of 2:1, and the final emphasizes mobility measures also using a scale of 2:1. The outcome of these decision models are presented in Table 27 below. To avoid double counting, the economic importance metric is not used in any of the decision models.

Table 26. Comparison of Key Metrics for U.S. 460 and U.S. 29 Study Corridors

Metric		Corridor Improvement	
		U.S. 460	U.S. 29
Travel Time Savings	Minutes Saved Per Truck Per Mile	0.26	0.18
	Annual Minutes Saved Per Mile	618	314
Truck Crash Severity 2005-2010 (Fatal:Injury:Property Damage Only ratio of 12:3:1)	Severity Rate per 100 million VMT	201.8	981.8
	Annual Crash Reduction per Mile	0.35	5.23
Proposed Economic Metrics	Economic Importance	3.56	16.43
	Excess Trucking Cost, \$	Mobility – per day per mile	\$1040
		Safety – per day per mile	\$538
	Economic Hindrance, \$	Mobility – per day per mile	\$868
		Safety – per day per mile	\$1925
		\$1103	\$570
		\$920	\$2037

Table 27. Three decision model approaches to prioritize improvements

Metric			Equal Weighting		Weighting Emphasizes Safety		Weighting Emphasizes Mobility	
			U.S. 460	U.S. 29	U.S. 460	U.S. 29	U.S. 460	U.S. 29
Travel Time Savings	Per Truck Per Mile		1	0	1	0	2	0
	Annual Savings Per Mile		1	0	1	0	2	0
Truck Crash Severity 2005-2010 (12:3:1)	Rate per 100 million VMT		0	1	0	2	0	1
	Annual Reduction per Mile		0	1	0	2	0	1
Proposed Economic Metrics	Daily Excess Trucking Cost per mile, \$	Mobility	1	0	1	0	2	0
		Safety	0	1	0	2	0	1
	Daily Economic Hindrance per mile, \$	Mobility	1	0	1	0	2	0
		Safety	0	1	0	2	0	1
Total Score:			4	4	4	8	8	4

As Table 27 shows, of the two corridors being compared, the U.S. 460 corridor improvement provides greater mobility benefits while the U.S. 29 corridor improvement provides greater safety benefits. When all metrics employed here are taken equally, the two corridors have a tied score. However, this outcome is less likely given more corridor improvements to score proportionately for each metric on a scale of zero to five, for example, and an increased number of measures that would come from the Virginia Statewide Performance System to round out the freight module.

Alternatively, instead of presenting the proposed economic metrics as a ranking, because the units are normalized per mile and have a dollar value, the actual dollar value

from these metrics could be summed and used for prioritizing the proposed improvements: the daily mobility and safety excess trucking costs per mile and economic hindrance per mile. This value could be used for a multitude of reasons, including in the event of a tie between several alternatives, as was the case with an equal weighting. In this case, the daily economic benefit derived per mile from improving the U.S. 460 and U.S. 29 corridors totals \$3931 and \$5070, respectively.

7.6 Concept Demonstrations Discussion

The results from these two concept demonstrations show the ability of the developed framework to take publicly available national data as well as other generally accessible state data to prioritize highway infrastructure improvements for freight. Using nationally available freight and economic data in conjunction with state mobility and safety data, a number of freight economic performance measures were developed to assess benefits associated with proposed improvements to the U.S. 460 and U.S. 29 corridors. Once these metrics have been developed, a number of methods are available to compare proposed improvements with one another, particularly if a focus on mobility or safety enhancement is preferred, for example.

The two concept demonstrations presented here illustrate the proposed prioritization framework using a robust, yet restricted dataset. Agencies would have the ability to incorporate additional or fewer commodities for economic analysis, as deemed appropriate given available resources to compile, process, and analyze data. Likewise, while truck travel time and truck crash severity data were incorporated for the concept demonstrations' analyses, depending upon the availability of this data from the state, or the desire to incorporate additional measures, e.g., environmental metrics, additional freight economic measures could be developed for comparative analysis in the framework.

Each of the concept demonstrations are presented in direct comparison to a do-nothing scenario. This assumes that this improvement has already been evaluated at the project level and selected as the preferred alternative. This would not have to be the case for application of the framework, which could also be applied on a project level. For broader applications, e.g., statewide prioritization, this assumption will reduce the complexity of analysis.

Finally, it should be noted that other private economic analysis tools are available that require purchased software or data. While this methodology is developed as an alternative, in order to remove a cost barrier to agencies wishing to consider freight impacts, purchased software or data could confirm the accuracy of this analysis by validating the results. Although not available for this study, further comparison of this proposed framework with other economic analysis tools available for purchase is recommended for future research.

CHAPTER 8: TASK 6 – IMPLEMENTATION, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The results from this research have demonstrated how the framework can prioritize freight highway improvements. This chapter will present a vision for how this framework could be implemented in practice and identify potential funding sources to support the freight highway improvements recommended by the implemented framework. Overarching conclusions and recommendations based on this research and analysis are also presented.

8.1 Implementation

The implementation of a dedicated freight highway asset management system could lead to increased trucking industry support for providing funding for infrastructure projects. Currently, the use of freight performance measures in asset management is relatively rare. The revenue generated from truck-related taxes and fees generally is assigned to general infrastructure improvements. As such, generated highway revenue is combined from all user classes, funding is assigned to various projects without any specific regard for the freight sector that is not only a major user of infrastructure, but also the national economy.

This freight-focused asset management system would enable the public sector to view the highway system from the freight perspective. With the ability to highlight projects that would address freight highway needs, the public sector could reach out to the trucking industry. By showing the benefits and savings the trucking industry could derive from the prioritized infrastructure improvements, there might be increased support for public-private partnerships. Alternatively, a variety of policy or road user fee strategies focused on freight could be justified with this freight module in place to apply funds to prioritized projects that would address freight highway needs.

Under existing revenue generation mechanisms, this freight module could be applied to prioritize freight highway needs within existing funding streams, e.g., funds for safety improvements might be prioritized for select safety improvements that are particularly beneficial to the trucking sector. Alternatively, given the importance of the trucking sector to the national economy, this freight module for asset management could justify a percentage of funding from general highway funds be allocated specifically for freight highway improvements, alongside funds dedicated to transit and safety, for example.

However, given the current state of highway infrastructure, in general, and the continued decline of transportation funds generated from fuel taxes, it may not be desirable to restrict funding within an already strained existing revenue system. An exception to this might be if matching funds could be obtained through public-private partnerships, for example. A better approach might be to implement a new revenue generation mechanism to supplement existing funding sources. This supplemental revenue from the trucking industry could be allocated specifically for freight highway improvements.

Numerous supplemental revenue generating mechanisms might be implemented for trucks, including additional annual trucks fees or taxes or a variety of truck vehicle-miles travelled fee approaches. A number of vehicle-miles travelled road user fee systems have been deployed or tested for a variety of objectives, including replacement of the fuel tax, congestion-based and demand management, environmental, facility-based revenue generation, and supplemental revenue generation. In particular, as shown in Table 28, several Central European countries and New Zealand impose tolls on heavy goods vehicles (HGV), i.e., trucks, in an effort to collect sufficient fees to be proportional with the costs that trucks impose on the highway infrastructure. In these existing systems, the proportional costs for highway wear and tear are measured by the number of axles or maximum laden weight. The motivation behind the implementation of most of these systems relates to increases in truck traffic in conjunction with funding shortfalls compared to the backlog of highway infrastructure needs.

These systems utilize a variety of technologies to serve data collection, communications and enforcement needs. Typically, the deployment requires on-board units and roadside gantries, then uses some combination of global positioning systems (GPS) technology, dedicated short-range communications (DSRC), automatic number plate recognition (ANPR), and/or cellular communications like Global System for Mobile (GSM) Communications.

Table 28. Existing truck-based road user fee deployments and characteristics

Country and Truck-based Road User Fee System	Tolled Roadways		Per-mile Fee Basis				
	Specific	All	Number of Axles	Emissions Class	Roadway Classification	Maximum Laden Weight	Location
Germany, HGV Tolling	X		X	X			
Austria, GO-Maut (HGV Tolling)	X		X				
Czech Republic, Truck Tolling	X		X	X			
Slovak Republic, Truck Tolling	X		X	X	X		
Switzerland, Heavy Vehicle Fee		X		X		X	
New Zealand, EROAD		X				X	X

Notes of interest for each of the various systems include:

- Germany: tolls range from €0.09 to €0.14 per kilometer (US \$0.23 to US \$0.35 per mile) and fund transportation problems; gross revenue in 2009 was about €3.9 billion (US \$5 billion).
- Austria: revenues from the system are earmarked for use on the charged roadway network, which does not receive funding from general revenues.

- Czech Republic: a primary objective of the system is to capture revenues from foreign vehicles that were not viewed as fully contributing to the funding system; the system generated about US \$340 million in 2008.
- Slovak Republic: a relatively newer system than those in neighboring countries, this system started in 2010, and generated an estimated \$11.6 million in the first month of operation.
- Switzerland: with a foundation of freight pricing going back to 1983, the current program was implemented in 2001.
- New Zealand: this high technology deployment is touted as the “world’s first network-wide autonomous Global Navigation Satellite System (GNSS) and cellular tolling system for heavy goods vehicles” (Bradley, 2011).

All of these systems serve as a model for a truck-based road user fee deployment in the United States that could assess and collect supplemental revenue for the purposes of funding prioritized freight highway infrastructure needs. Certainly, other mechanisms could also be employed to generate funding for freight-specific infrastructure needs. Examples of other mechanisms include the dedicated use of fuel taxes or licensing and registration fees that are assessed on trucks. Public private partnerships with the trucking industry might also be a possibility for generating freight-specific funds, although due to the vast number of stakeholders and independent operators, it would likely be overly difficult to be fair and reach consensus.

In conclusion, following the implementation of an asset management system that prioritizes freight highway infrastructure needs, dedicated revenue to fund these needs is required. Supplemental revenue assessed on trucks as a flat fee or based on vehicle-miles traveled are two approaches to accomplish this objective.

8.2 Discussion Points

A number of questions may remain about the proposed framework and how it may be adapted or implemented. A number of these questions will be addressed in this section.

Why are this framework and the proposed performance measures a good approach?

Numerous avenues were explored for developing economic measures to prioritize freight infrastructure needs. Ultimately, however, the Bureau of Economic Analysis’ Regional Input-Output Modeling System and Federal Highway Administration’s Freight Analysis Framework both contain a rich and robust data set that is publically available and can be used to examine any part of the country. The input-output model also has the benefit of being scalable to a national, state, or county-level (or any grouping of states or counties).

Another benefit of the input-output model is the ability of the user to manipulate the data in such a way as to forecast future impacts. The input-output model presents a snapshot in time. However, given the way industrial sectors are presented in the input-output model make and use tables, one could project impacts that could occur due to changing markets, such as a larger hydrogen market given the proliferation of hydrogen-powered vehicles and the need to transport hydrogen to fueling stations, for example.

Overall, the proposed framework gives a valuable approach due to its flexibility for the user to manipulate the framework to meet various agency goals and generate a list of prioritized infrastructure needs. Because many agencies have constrained budgets and resources, the framework is developed around publically available data. Further, it is designed to allow the user to add or remove performance measures in the proposed freight module, as well as measures of excess trucking costs based on available data, and to place emphasis on certain priorities, e.g., safety or mobility, as desired. These features of the developed framework allow it to be user friendly, minimize costs, and more easily interface with existing asset management systems. Because the construction of freight-only highway facilities is relatively rare, the ability to integrate with existing asset management systems is important so that the freight impacts can be included into the highway infrastructure prioritization process.

How does the proposed framework differ from available software?

Other economic analysis tools available to practitioners tend to require purchased software or data. This cost might be a barrier to agencies wanting to begin a new initiative to consider freight impacts. The methodology developed here offers an alternative to a complex software analysis by using existing, easily obtained data sources for the development of the framework, understanding the already limited resources of transportation agencies. While some of the available software programs do use input-output modeling techniques, their proprietary nature does not allow for a side-by-side comparison of how their approach differs from the proposed framework in this research.

Why was the first proposed economic measure not recommended for use?

The metric of economic importance of commodities showed little proportional difference to the basic sum of kilotons carried on the routes or AADTT, as shown in Table 12 above. In other words, despite a potentially laborious process to develop route assignments for commodities to and from given regions, the results are not different from data already given by AADTT in the Freight Analysis Framework. This suggests that the commodities that will most impact the framework will be those that have a particularly high economic importance to the region or are of otherwise distinct regional significance.

This metric attempted to show the relative economic importance of highway links based on sectors most dependent upon the trucking sector. Instead of simply showing the value of the commodities being transported on the route, this measure tried to capture the importance of a route based on the quantity of commodities associated with truck-dependent sectors. Using a disruption to the trucking sector in the inoperability input-output model, and an origin-destination model with route assignments for specific commodities of those truck-dependent sectors, a route on which more commodities of truck-dependent sectors were transported would have a higher value of economic importance.

What measures might be considered for excess trucking costs?

Only truck travel time savings and truck crash severity data were used to calculate excess trucking costs in the concept demonstration of the proposed framework. However, depending upon the availability of this data from the state, or the desire to incorporate additional measures, many additional freight economic measures could, and

should, be developed for comparative analysis in the framework. Examples of these measures might include environmental measures such as the excess cost of carbon emissions or excess trucking costs due to added wear and tear due to poor pavement quality.

Caution should be taken when developing and applying these measures in the proposed framework, however. Some excess costs, such as those of carbon emissions or even truck crashes, as calculated in the concept demonstration, will not directly apply to the measure of economic hindrance unless that cost is being borne by the trucking sector. For example, some of the excess trucking costs due to truck crashes are either societal costs, due to the lost productivity of the deceased individual, or borne by the insurance industry. Likewise, excess costs due to carbon emissions are currently borne by society and would only merit input to the third measure for economic hindrance if the trucking sector were being charged a carbon tax to account for those carbon emissions.

Based on the concept demonstrations, can this framework only be used for the prioritization of new construction programs?

This framework is applicable to asset management programs, as well as new construction programs. Although the concept demonstrations focused on two new construction projects, the framework could be applied to existing roadways also. As an example, an existing roadway with rough pavement might be proposed for resurfacing, which would reduce truck wear and tear, and thus reduce excess trucking costs.

Alternatively, this framework does not have to be applied solely for comparison of an existing and an improved state. Instead, it could be applied to measure the impacts of a do-nothing option by comparing an existing and a degraded state. With tightening budgets, transportation agencies may not have the funding to maintain all roadways to current standards; the proposed framework could be applied to show the excess trucking costs incurred by the degraded infrastructure, or in the event of infrastructure failure, the higher excess trucking costs due to increased travel times and distances of a longer alternate route around the infrastructure failure.

Are there other measures or methods that might be incorporated in the framework?

Many other performance measures exist that might be incorporated in the proposed framework. Further, as seen in the two concept demonstrations, there are also multiple ways to execute the proposed framework. As with many aspects of transportation planning and asset management, numerous approaches exist to solve the same problem. As an example, another way to compare values of excess trucking costs and the economic hindrance would not just be as a rate per mile, but as a rate per truck.

8.3 Conclusions

The freight sector plays an important role in the economy and depends on a reliable highway network, yet the needs of the freight sector are often overlooked by asset management programs that allocate funding for infrastructure maintenance and improvements. As such, this research presents an approach to address the inclusion of

economic metrics to prioritize freight highway infrastructure. A summary of contributions of this research are that it:

1. Expands upon work by Crowther et al. (2004) and Haines et al. (2001, 2004, 2005-a, 2005-b) on the inoperability input-output model by applying concepts from that research to transportation asset management, specifically freight highway infrastructure;
2. Develops new freight-based economic metrics to support the prioritization of highway infrastructure in light of the lack of any universally accepted or comprehensive set of performance measures that currently exist; and
3. Presents an approach that uses publically available data sources and can be integrated with existing asset management systems to minimize burdens to agency stakeholders.

This research offers other contributions that are also important to the fields of freight and transportation asset management by:

1. Advocating for the inclusion of freight considerations to existing highway asset management programs and planning processes due to the critical role trucking has in the economy and to highway systems;
2. Adapting the use of common, general performance measures of mobility and safety (e.g., travel times and crashes, which are also quantified as costs) to focus their application specifically on trucking by using a measure of excess trucking costs as both a direct and indirect economic measure for affecting shipping and industry costs;
3. Presenting freight performance measures that should be considered for inclusion to highway asset management programs to incorporate freight needs; and
4. Advocating for a dedicated funding mechanism to be linked with a freight highway asset management system.

The developed freight highway infrastructure framework, with further refinement, can be used as guidance for planners at state DOTs, MPOs, and even FHWA to consider economic importance of freight corridors and needs of the trucking industry to maintain a strong economy and smooth flow of goods. This tool may be used alongside existing prioritization frameworks and selectively implemented, if preferred. This freight infrastructure prioritization framework could be used fill gaps that currently exist in most asset management strategies by focusing on freight performance and economic importance of selected corridors. Doing so may demonstrate an incremental economic benefit to justify project selection for funding. This incremental benefit to the trucking sector is a real and important part of highway improvements that typically goes

unmeasured currently. The demonstrated framework is one way to give practitioners this additional information to consider for project prioritization.

The concept demonstrations developed here illustrate how the framework can be applied to specific scenarios. In practice, all commodities from the input-output model and Freight Analysis Framework would be applied, but for sake of space and time, a limited number of commodities were selected for demonstration here. Although not used in this research, purchased data is available that could enhance the accuracy of the analysis.

As Table 12 showed above, the metric of economic importance of commodities showed little proportional difference to the basic sum of kilotons carried on the routes or AADTT. In other words, despite a potentially laborious process to develop route assignments for commodities to and from given regions, the results may not differ that much from data already given by AADTT in the Freight Analysis Framework. This suggests that the commodities that will most impact the framework will be those that have a particularly high economic importance to the region or are of otherwise distinct regional significance.

This said, it is believed that using the second and third proposed metrics (excess trucking cost and economic hindrance) together instead of the first metric (economic importance) may be a fuller depiction of the economic situation. In this way, a more common metric, excess trucking costs, which is relatively easy to develop for a variety of issues related to mobility, pavement condition, safety, etc., can be further extrapolated to present a fuller economic impact of the highway's deficiencies.

This is not to say that these metrics are ready for full implementation. A major assumption of this approach is that the metrics selected as economic metrics for the trucking sector can indeed be linked with infrastructure performance. Crowther et al. (2004) validates this assumption by using trucking sector disruptions in the inoperability input-output model as a direct link to highway infrastructure performance in the context of terrorism. Still, the values presented in Table 3 showing the percent disruption and dollar loss for each industry associated with a 100% disruption to the trucking sector reveal some potential concerns. Some of the industrial sectors most impacted by this disruption such as wholesale trade, and warehousing and storage seem to support this assumption that highway infrastructure can be directly linked with the trucking sector. However, the cause of high impacts to other industries like broadcasting and telecommunications, and management of companies and enterprises are less clear. Further, some of the sectors with the greatest disruptions are the motor vehicles, bodies and trailers; petroleum and coal products; and oil and gas extraction industrial sectors, which likely signify the loss of sales of vehicles and fuel to the trucking sector less than it reflects any impact due to infrastructure performance itself. Before widespread implementation of this framework, and specifically the economic metrics presented herein, further examination of this assumption will be necessary.

A second major assumption is made in the development of the third economic metric about economic hindrances due to inefficiencies of excess trucking costs. This metric assumes that all savings incurred by the trucking sector are passed back to other industries. By noting that small fluctuations in shipping costs may be absorbed by industries while larger cost increases are passed onto consumers in the form of higher prices, Emerson (2012) highlights a greater complexity than this assumption allows. In

practice, it is more likely that the greater efficiencies incurred from reduced trucking costs will not be so exclusively direct to industries, but may also be passed along from those industries to consumers in order to maintain competitiveness. In other words, savings due to reduced excess trucking costs are likely to be divided amongst the trucking sector, industries, and consumers.

The metrics developed in this research are based on a complex methodology that still requires further refinement and validation. Due to inherent difficulties with predicting economic outcomes from a single highway improvement due to numerous exogenous factors associated with such diverse and widespread industries, no single validation approach can comprehensively evaluate the economic metrics developed herein without numerous additional assumptions in comparing the findings. Wherever possible, assumptions have been stated to present potential drawbacks of the developed economic metrics. Likewise, logic has been similarly applied and explained to present the potential value in using these economic metrics.

8.4 Recommendations

Numerous recommendations can be drawn from this research. The first and foremost recommendation, as well as a motivation for this research, is an appeal to highway agencies to include freight metrics in asset management programs. Freight plays a significant role in the national, state, and local economies and is highly dependent on the provision of a reliable highway network for success. This research highlights and has developed numerous freight-based performance measures that might be included into asset management programs with further refinement, and develops a framework for including additional economic-based performance measures that can be done using publically available datasets that are robust and applicable nationwide.

As to the methodology and developed economic metrics presented herein, there is a recommendation for future research. In order to verify, validate, and establish any new performance measures, specifically the freight economic metrics developed here, additional case studies need to be developed to demonstrate this framework, which is based on a complex methodology, numerous exogenous factors associated with the economy and trucking sector, and several major assumptions. Further calibration and sensitivity analyses need to be conducted as well. Validating outputs of economic-based measures of expected savings due to an infrastructure improvement, such as those developed here is particularly difficult, given the difficulty in obtaining quality data from all of the stakeholders impacted, but would also be of value. Finally, any well-tested metric will need to be linked with existing state asset management systems, which may require further testing, calibration, and demonstration.

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APPENDIX A – INTRA-STATEWIDE DEMONSTRATION OF PROPOSED ECONOMIC METRIC DEVELOPMENT METHODOLOGY USING 12 COMMODITIES IN VIRGINIA

An application of the methodology depicted in Figure 2 is described here. The tables and figures below demonstrate a model example that uses a sample of data obtained from relevant literature and the FAF. Further refinements have been included in the developed model that was applied to case studies, using literature such as NCHRP Report 606 (Cambridge Systematics, et al., 2008) to improve route assignment and matches between commodity and industrial sector classifications; the following sample demonstration was assembled to provide further initial clarification by exhibiting one strategy to execute the aforementioned methodology for developing economic metrics.

1. *Identify the most transportation-dependent industrial sectors.* First, obtain the input-output (I-O) data from the Bureau of Economic Analysis (BEA) for the study area, which for this example is the entire state of Virginia. The BEA supplies this data for individual or combined county regions, states, groups of states, or the national level.

The BEA supplies “make” (**V**) and “use” (**U**) tables (shown in Tables B-1 and B-2, of Appendix B), which respectively show monetary values of column commodities produced by various row industries, and monetary values of row commodities consumed by various column industries. These tables can be used to generate first an input-output model, then the demand-based inoperability input-output model.

The relationships of commodity transactions between industries can be shown in a Leontif industry-by-industry technical coefficient matrix, **A**. To generate **A**, the BEA “make” (**V**) and “use” (**U**) tables must each be normalized by dividing every element by its column sum. The product of the normalized make (**\hat{V}**) and normalized use (**\hat{U}**) matrices is **A**:

$$\mathbf{A} = \hat{\mathbf{V}}\hat{\mathbf{U}} \quad (\text{A1})$$

Next, the total industry outputs, that is, the “normal” total production vector **$\hat{\mathbf{x}}$** can be generated. This is calculated by multiplying the “make” table (**V**) and a unity vector **Σ** , whose elements are all ones and is also known as a summation vector. This equation is represented by:

$$\hat{\mathbf{x}} = \mathbf{V}\Sigma \quad (\text{A2})$$

The general equation for the I-O model is:

$$\hat{\mathbf{x}} = \mathbf{A}\hat{\mathbf{x}} + \hat{\mathbf{c}} \quad (\text{A3})$$

where: **$\hat{\mathbf{x}}$** is the “normal” total production vector, in millions of dollars,

A is the Leontif coefficient matrix, multipliers,

$\hat{\mathbf{c}}$ is the “normal” final demand vector, in millions of dollars

Knowing **A** and **$\hat{\mathbf{x}}$** , as depicted below in , solve for **$\hat{\mathbf{c}}$** with the general I-O equation, by subtracting the product **$\mathbf{A}\hat{\mathbf{x}}$** from **$\hat{\mathbf{x}}$** :

$$\hat{\mathbf{c}} = \hat{\mathbf{x}} - \mathbf{A}\hat{\mathbf{x}} \quad (\text{A4})$$

<u>x (derived)</u>	<u>A (derived)</u>			<u>c</u>
9221	0.113	0.000	0.000	8179
110434	0.017	0.062	0.051	101947
29492	0.027	0.002	0.062	27243

Figure A-1. Example vectors and Leontif coefficient matrix of the I-O model

A demand-based model, the inoperability I-O model, can be derived using the following transformation, which is also demonstrated below in Figure A-2:

$$\mathbf{A}^* = [\text{diag}(\mathbf{x})]^{-1} \mathbf{A} [\text{diag}(\mathbf{x})] \quad (\text{A5})$$

<u>$\text{diag}(\mathbf{x})^{-1}$</u>			<u>$\text{diag}(\mathbf{x})$</u>			<u>$\mathbf{A}^* = \text{diag}(\mathbf{x})^{-1} \mathbf{A} \text{diag}(\mathbf{x})$</u>		
1E-04	0	0	9221	0	0	0.113	0.000	0.000
0	9E-06	0	0	1E+05	0	0.001	0.062	0.014
0	0	3E-05	0	0	29492	0.009	0.006	0.062

Figure A-2. Deriving the inoperability model, \mathbf{A}^*

The derived inoperability I-O model in equations A6 and A7 shows the interdependence of the sectors upon each other:

$$\mathbf{q} = \mathbf{A}^* \mathbf{q} + \mathbf{c}^* \quad (\text{A6})$$

or, solving equation A6 for \mathbf{q} gives:

$$\mathbf{q} = (\mathbf{I} - \mathbf{A}^*)^{-1} \mathbf{c}^* \quad (\text{A7})$$

where: \mathbf{q} is a demand-based inoperability, representing % disrupted production

\mathbf{I} is an identity matrix,

\mathbf{A}^* is an interdependency matrix (derived from \mathbf{A} above), multipliers,

\mathbf{c}^* is a perturbation vector, a percentage disruption

This is demonstrated below in Figure A-3 using the same example 3x3 matrix as above, as well as a sample perturbation vector, \mathbf{c}^* .

<u>$(\mathbf{I} - \mathbf{A}^*)$</u>			<u>$(\mathbf{I} - \mathbf{A}^*)^{-1}$</u>			<u>\mathbf{c}^* (selected)</u>	<u>$\mathbf{q} = (\mathbf{I} - \mathbf{A}^*)^{-1} \mathbf{c}^*$</u>
0.887	0.000	0.000	1.127	0	0	1/8179=1.2E-4	1.378E-04
0.001	0.938	0.014	-0.002	1.066	-0.016	0	-1.878E-07
0.009	0.006	0.938	-0.010	-0.007	1.066	0	-1.257E-06

Figure A-3. Demonstrating interdependence of sectors

With this equation, knowing \mathbf{A}^* , which is derived from the given \mathbf{A} matrix, a unit disruption will be inserted, specifically for the trucking sector in this study, in the \mathbf{c}^* vector, which represents changes in truck user costs, to determine the percentage impact to the other sectors in \mathbf{q} . The values in \mathbf{q} will be multiplied by the “normal” total production vector, \mathbf{x} to generate the value of the disrupted production. Sector disruptions will be proportional to the value of the original disruption, which is possible since the I-O model is linear; thus, the relative economic impact to a sector is based on an impact to the trucking sector (for example, a \$1 disruption to the trucking sector will disrupt \$.05 of sector A, \$.25 of sector B, etc.). Note, the unit disruption is not intended to represent any specific incident or congestion for any specific point; instead, it is used to show the various industrial sectors’ dependence on the trucking sector for the study area. Thus, for any given incidents or congestion on specific highways in Virginia, it can be known which sectors will be most impacted by a disruption.

However, since the I-O model is linear, these relative values can be multiplied by a specific value representing a trucking disruption event to show indirect impacts for an event.

A larger 12x12 matrix representing 12 industrial sectors is used to demonstrate this and the remaining steps of this methodology; Table A-1 shows a given Leontif coefficient \mathbf{A} matrix and \mathbf{c} vector and the calculated \mathbf{x} from equation 1. Table A-2 shows the results of transforming the \mathbf{A} matrix, establishing a perturbation \mathbf{c}^* vector, and running equation A6.

Table A-1. Example Leontif coefficient (\mathbf{A}) matrix, \mathbf{c} vector, and calculated \mathbf{x} vector

\mathbf{A} (multipliers)												\mathbf{c} (Mil \$)	\mathbf{x} (Mil \$)
Sector	1	2	3	4	5	6	7	8	9	10	11	12	
1	0.113	0.000	0.000	0.000	0.000	0.000	0.000	0.092	0.000	0.000	0.000	0.000	8179
2	0.017	0.062	0.051	0.046	0.021	0.093	0.001	0.012	0.005	0.001	0.003	0.002	101947
3	0.027	0.002	0.062	0.002	0.000	0.001	0.000	0.026	0.001	0.000	0.000	0.001	27243
4	0.011	0.004	0.003	0.157	0.004	0.003	0.001	0.004	0.011	0.011	0.010	0.010	123980
5	0.005	0.004	0.001	0.001	0.125	0.002	0.000	0.004	0.000	0.000	0.000	0.000	26494
6	0.003	0.000	0.005	0.004	0.002	0.061	0.003	0.002	0.002	0.004	0.004	0.003	84463
7	0.001	0.001	0.001	0.013	0.001	0.013	0.124	0.002	0.021	0.009	0.007	0.004	150336
8	0.019	0.009	0.002	0.005	0.003	0.003	0.003	0.000	0.017	0.005	0.031	0.020	158895
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3606
10	0.007	0.007	0.021	0.007	0.015	0.007	0.009	0.012	0.012	0.047	0.032	0.008	244304
11	0.003	0.001	0.003	0.004	0.001	0.003	0.003	0.002	0.002	0.003	0.004	0.003	48363
12	0.004	0.002	0.005	0.005	0.002	0.019	0.004	0.003	0.003	0.004	0.006	0.015	270999

From Santos, 2003

Table A-2. Normal and Reduced Industrial Output by a unit reduction to the 6th industrial sector using Inoperability I-O Model

Industrial Sector	Normal Output \mathbf{x} (Millions \$)	Perturbation Vector \mathbf{c}^* (%)	% Affected \mathbf{q} (%)	Reduced Output $\mathbf{x} - \mathbf{q}$ (Millions \$)
1	26900	0	1.74E-06	0.0005
2	132275	0	8.02E-05	0.1061
3	35584	0	2.92E-06	0.0010
4	157097	0	2.89E-06	0.0045
5	32446	0	7.70E-06	0.0025
6*	94137	1 / 94137	1.13E-03	1.0657
7	180285	0	8.87E-06	0.0160
8	170903	0	2.65E-06	0.0045
9	3684	0	3.29E-06	0.0001
10	268588	0	3.21E-06	0.0086
11	52395	0	7.01E-06	0.0037
12	280740	0	7.60E-06	0.0213

*disrupted sector (trucking sector), with unit reduction to output

2. *Identify freight flows from the transportation-dependent sectors throughout the study area.* Again, the study area for this demonstration is the state of Virginia. The Freight Analysis Framework (FAF) analysis regions for this area are obtained. External regions would typically be strategically aggregated for inclusion during this step (e.g., if Virginia is the study area, all FAF regions in New England might be grouped, since their freight flows would likely be entering the study area on the same highways, in this case I-81 or I-95). For the purpose of this demonstration, however, only intra-state regional flows are considered. The FAF contains Commodity Flow Survey data, and these commodities will be matched to BEA commodities in the input-output model (see Table A-3) using resources such as NCHRP Report 606 (Cambridge Systematics, et al., 2008). Now, the sectors impacted by the transportation disruption in step 1 will be selected from the FAF by mode (truck), regions selected, and commodities selected.

Table A-3. Matched sectors and economic rank given in inoperability I-O example

Example Model Sector	Relative Economic Impact	Assumed Bureau of Economic Analysis Sectors	Assigned Commodity Flow Sectors
6	1.0657	Trucking	Truck Transportation
2	0.1061	Food Manufacturing	Milled Grains AND Other Foodstuffs
12	0.0213	Basic Chemical Manufacturing	Basic Chemicals
		Petroleum and Coal Products	
7	0.0160	Manufacturing	Fuel Oils AND Gasoline
10	0.0086	Agricultural Chemical Production	Fertilizer
4	0.0045	Animal Production	Meat/Seafood
		Pharmaceutical & Medical	
8	0.0045	Manufacturing	Pharmaceuticals
11	0.0037	Apparel Product Manufacturing	Textiles/Leather
5	0.0025	Forestry & Logging	Logs
3	0.0010	Plastics & Rubber Manufacturing	Plastics/Rubber
1	0.0005	Electrical Equipment Manufacturing	Electronics
9	0.0001	Crop Production	Cereal Grains AND Other Ag. Prod.

3. *Create an Origin-Destination Model of the study area to generate a metric of economic importance.* First, nodes will be selected throughout the study area for various points such as population centers, seaports, and industrial areas (see, for example, selected nodes for the model example denoted as red points in Figure A-4). Again, by this step, external stations for origins and destinations outside of the study area would be strategically created for freight flows entering and exiting the area. The regional flows from the FAF (see Table A-4) will be scaled for their relative economic impact and summed (see Table A-5), and then disaggregated amongst the selected nodes (see Tables A-6, A-7). For assistance with this, NCHRP 606 (Cambridge Systematics, et al., 2008) provides guidance for freight productions and attractions using employment and population data for a region. The FAF highway network will be obtained, and routes connecting these nodes will be identified (see Figure A-5). The scaled commodity flows from step two will be assigned to the network using impedances, such as speed, route quality and route length (see Table

A-8); known 2007 AADTT for the network will assist with appropriate route assignment. Summing the resulting flows for each link will give a metric of economic importance (see Figure A-5). Beyond freight tonnage or value of freight, this metric emphasizes corridors used by industrial sectors whose production is most affected by a transportation disruption and whose output is most critical to the region's economy.

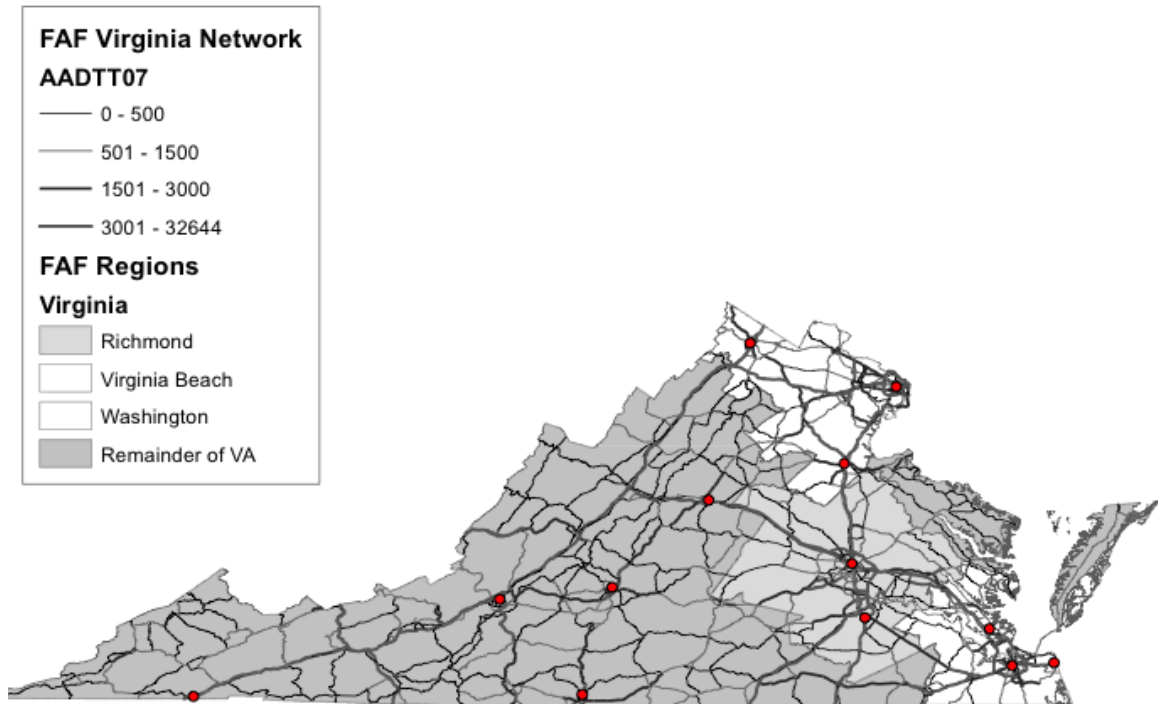


Figure A-4. Freight Analysis Framework – Virginia regions, network and sample nodes

Table A-4. Freight truck flows in kilotons for industrial sectors 1-5, 7-12

Origin	Destination	Total Kton	1	2	3	4	5	7	8	9	10	11	12
Norfolk VA-NC MSA (VA Part)	Remainder of Virginia	199	1	32	2	3	0	0	0	146	14	0	0
Norfolk VA-NC MSA (VA Part)	Richmond VA MSA	1326	2	800	49	19	0	180	10	248	5	9	4
Norfolk VA-NC MSA (VA Part)	Washington DC-MD-VA-WV CSA (VA Part)	113	2	5	2	17	0	36	0	50	2	0	0
Remainder of Virginia	Norfolk VA-NC MSA (VA Part)	608	16	184	2	57	75	157	0	112	2	3	0
Remainder of Virginia	Richmond VA MSA	1949	6	417	9	24	766	523	1	192	4	6	0
Remainder of Virginia	Washington DC-MD-VA-WV CSA (VA Part)	1006	16	221	5	15	4	611	0	129	2	4	0
Richmond VA MSA	Norfolk VA-NC MSA (VA Part)	648	4	267	21	2	55	124	1	111	29	4	30
Richmond VA MSA	Remainder of Virginia	577	5	104	26	13	200	30	2	111	61	3	23
Richmond VA MSA	Washington DC-MD-VA-WV CSA (VA Part)	728	4	112	11	18	1	164	16	388	1	1	13
Washington DC-MD-VA-WV CSA (VA Part)	Norfolk VA-NC MSA (VA Part)	28	3	4	2	0	0	0	0	4	0	16	0
Washington DC-MD-VA-WV CSA (VA Part)	Remainder of Virginia	134	3	64	19	1	0	10	0	29	3	2	3
Washington DC-MD-VA-WV CSA (VA Part)	Richmond VA MSA	509	3	260	14	3	2	80	0	137	0	7	2
Norfolk VA-NC MSA (VA Part)	Norfolk VA-NC MSA (VA Part)	4407	89	538	54	247	234	1978	10	881	300	66	11
Remainder of Virginia	Remainder of Virginia	21866	68	5712	74	747	11817	1604	12	1345	383	84	20
Richmond VA MSA	Richmond VA MSA	8849	64	667	125	80	4917	1792	13	609	217	79	284
Washington DC-MD-VA-WV CSA (VA Part)	Washington DC-MD-VA-WV CSA (VA Part)	6872	112	613	69	133	423	3520	18	1309	483	163	30
	TOTAL:	49820	395	10000	483	1380	18494	10809	83	5800	1508	446	421

Source: FHWA Freight Analysis Framework

Gray rows are intraregional flows, which were removed from analysis for this example

Table A-5. Aggregated FAF O-D Table after scaling

Origin	Destination	Economic Importance
Norfolk VA-NC MSA (VA Part)	Remainder of Virginia	...
Norfolk VA-NC MSA (VA Part)	Richmond VA MSA	...
Norfolk VA-NC MSA (VA Part)	Washington DC-MD-VA-WV CSA (VA Part)	...
Remainder of Virginia	Norfolk VA-NC MSA (VA Part)	...
...

*Note: no intraregional flows for this example

Table A-6. Disaggregated O-D Table by Selected Nodes

Origin	Destination	Economic Importance
Virginia Beach	Bristol	0.08
	Danville	0.21
	Roanoke	0.44
	Lynchburg	0.34
	Charlottesville	0.20
	Richmond	27.16
	Petersburg	4.43
	Alexandria/Arl.	0.36
	Winchester	0.03
	Fredericksburg	0.02
Norfolk/Chesapeake	Bristol	0.09
	Danville	0.22
...

Table A-7. Economic Value of Links between Selected Nodes

Link	Virginia Beach	Norfolk/Chesapeake	Hampton/Newport News	Bristol	Danville	Roanoke	Lynchburg	C-ville	Richmond	Petersburg
Bristol	0.61	0.63	0.45	x	x	x	x	x		
Danville	1.55	1.62	1.16	x	x	x	x	x		
Roanoke	3.23	3.38	2.42	x	x	x	x	x		
Lynchburg	2.52	2.64	1.89	x	x	x	x	x		
C-ville	1.44	1.51	1.08	x	x	x	x	x		
Richmond	36.83	38.46	27.52	3.78	9.70	20.18	15.76	9.01	x	x
Petersburg	6.00	6.27	4.48	0.62	1.58	3.29	2.57	1.47	x	x
Alexandria/Arl	0.51	0.53	0.38	2.31	5.91	12.30	9.61	5.49	33.24	5.42
Winchester	0.04	0.04	0.03	0.17	0.43	0.89	0.70	0.40	2.41	0.39
Fredericksburg	0.03	0.03	0.02	0.15	0.38	0.79	0.62	0.35	2.14	0.35

Table A-8. Example of Link for Route Assignment

Link	Routes	Miles	Speed	AADTT	Iteration 1	Iteration 2	Assignment
Bristol - VA Beach 0.61	US 58	413	50	500	0.06	0.06	0.03
	I-81, US 460	411	55	1500	0.20	0.18	0.11
	I-81, I-64	429	65	5500	0.82	0.76	0.46
					1.08	1.00	

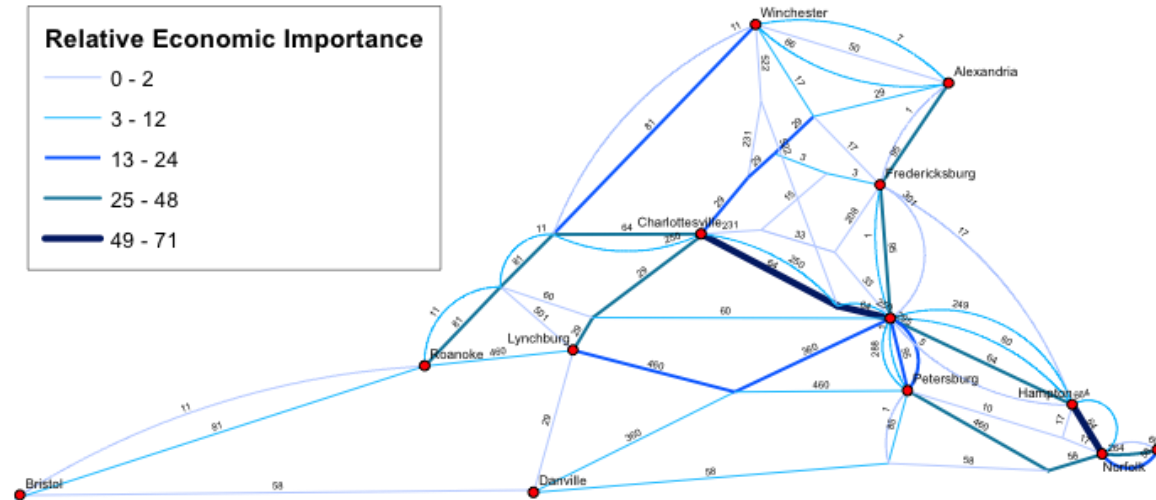


Figure A-5. Relative Economic Importance of Virginia Freight Highways

4. *Identify and prioritize infrastructure needs.* Select an existing asset management system. Obtain data from the National Bridge Inventory Analysis System, Highway Performance Management System, FAF, etc. and apply the performance measures from the asset management system to identify bridges and pavements, safety, and mobility needs along corridors.
 - a. Find the National Bridge Inventory Analysis System “detour length” value to assign to each route in the network. Calculate additional truck user costs associated with 1) detour length associated with a closure or incident on each link for a given period of time and 2) congestion for a given period of time. Texas Transportation Institute’s Urban Mobility Report (Schrang et al., 2010) estimates a trucking value of \$105.67 per hour, including fuel costs. Based on AADTT for each link, the length and capacity of a detour route in the event of a closure, an estimate of excess trucking costs can be calculated for each link (see Figure A-6), which would provide a second metric of economic importance: the higher the value, the greater impact inflicted upon the trucking sector.
 - b. Another measure of economic importance will be developed using the I-O model from step 1, commodity assignments from step 3, and procedure developed by Mahady and Lahr (2008). In the Mahady and Lahr application, the production function of the I-O matrix (**A** matrix) for the trucking sector is adjusted by reducing (or increasing) the trucking sector inputs in relevant industrial sectors for a given route based on the commodity route assignment, and the matrix is renormalized. Using this modified production (**A**) matrix for an I-O model, given calculated excess user costs per truck by sector, a third measure of economic importance can be generated for each link showing indirect economic impacts of closures to specific route links by sector; this value translates to a measure of productivity either increased or decreased due to costs of inefficiencies (congestion or closures) in the transportation network.

Use the direct and indirect economic metrics and that from step 3 to prioritize infrastructure needs that were identified earlier in this step.

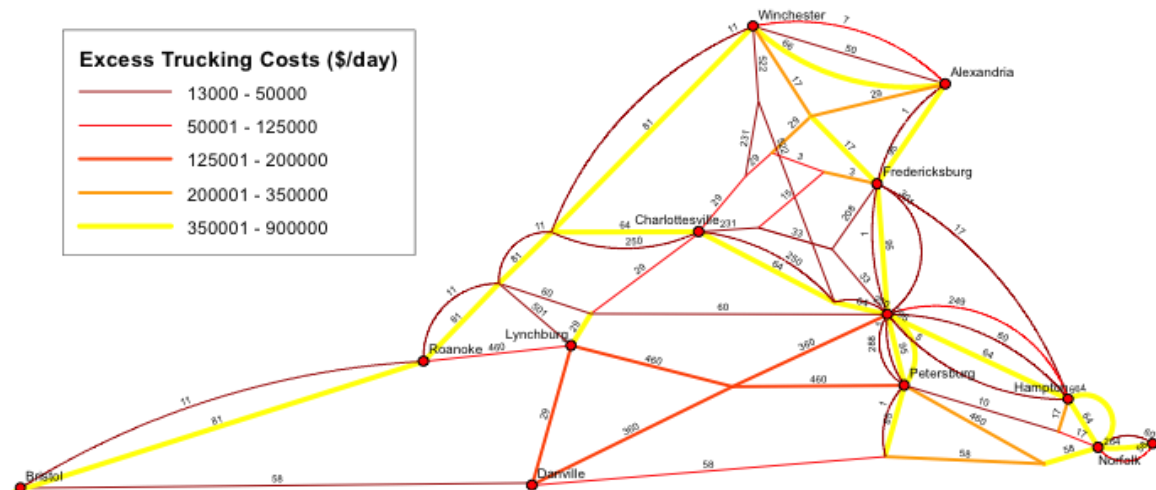


Figure A-6. Estimate of Excess Trucking Costs per day based on AADTT, Detour Length & Relative Capacity of Detour

APPENDIX B – INPUT-OUTPUT DATA TABLES USED IN CONCEPT DEMONSTRATION

TABLE B-1. BEA MAKE TABLE: THE MAKE OF COMMODITIES BY INDUSTRIES, ANNUAL I-O ACCOUNTS, 2007	B-2
TABLE B-2. BEA USE TABLE: THE USE OF COMMODITIES BY INDUSTRIES, ANNUAL I-O ACCOUNTS, 2007	B-5
TABLE B-3. NORMALIZED MAKE TABLE	B-8
TABLE B-4. NORMALIZED USE TABLE	B-11
TABLE B-5. INPUT-OUTPUT MODEL: LEONTIF INDUSTRY-BY-INDUSTRY TECHNICAL COEFFICIENT MATRIX, A	B-14
TABLE B-6. INPUT-OUTPUT MODEL VECTORS AX , X , AND C	B-17
TABLE B-7. INOPERABILITY INPUT-OUTPUT MODEL A* MATRIX	B-18
TABLE B-8. INOPERABILITY INPUT-OUTPUT MODEL RESULTS: PERTURBATION VECTOR, C* ; PERCENT DISRUPTION VECTOR, Q ; AND ASSOCIATED COSTS ASSOCIATED WITH THE GIVEN DISRUPTION, \$	B-21
TABLE B-9. STANDARD CLASSIFICATION OF TRANSPORTED GOODS (SCTG) COMMODITIES MATCHED TO BUREAU OF ECONOMIC ANALYSIS (BEA) INDUSTRIES; SCTG COMMODITIES IN BOLD ARE USED IN CONCEPT DEMONSTRATION, BEA INDUSTRIES WITH <i>ITALICS</i> WERE NOT MATCHED IN FAF DOCUMENTATION	B-22
TABLE B-10. ECONOMIC HINDRANCE BY BEA INDUSTRY DUE TO CALCULATED MOBILITY- AND SAFETY-BASED EXCESS USER COSTS TO THE TRUCKING SECTOR FOR U.S. 460 AND U.S. 29 STUDY CORRIDORS	B-24

Table B-1. BEA Make Table: The Make of Commodities by Industries, Annual I-O Accounts, 2007 (page 1 of 3)

		Commodities (1 of 3)																							
		Farms	Forestry, fishing, and related activities	Oil and gas extraction	Mining, except oil and gas	Support activities for mining	Utilities	Construction	Food and beverage and tobacco products	Textile mills and textile product mills	Apparel and leather and allied products	Wood products	Paper products	Printing and related support activities	Petroleum and coal products	Chemical products	Plastics and rubber products	Nonmetallic mineral products	Primary metals	Fabricated metal products	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Motor vehicles, bodies and trailers, and parts	
Code	indLabel	111CA	113FF	211	212	213	22	23	311FT	313TT	315AL	321	322	323	324	325	326	327	331	332	333	334	335	3361MV	
111CA	Farms	294,718	9,135						50			43													
113FF	Forestry, fishing, and related activities	25	60,316					11	353																
211	Oil and gas extraction			244,792		743		73							27,564	240									
212	Mining, except oil and gas				75,743	146		303							195	2,337		295							
213	Support activities for mining			209	17	126,387														35					
22	Utilities			785			430,570	23,665																	
23	Construction							1,246,452																	
311FT	Food and beverage and tobacco products							76	700,720	5	250					5,295	19								
313TT	Textile mills and textile product mills							7		59,519	888			229	525	26	2,896	453							
315AL	Apparel and leather and allied products							0		1,075	29,044				38			63						4	
321	Wood products							29				97,251						823			248				
322	Paper products							3		106		216	161,202	178			571	1,727			46		157		
323	Printing and related support activities							36		29	507			116	72,633			16			239				
324	Petroleum and coal products							791		201				25		544,959	34,017		123	1,799				2	
325	Chemical products							100	379					67		13,077	606,143	1,950				630	447	8	
326	Plastics and rubber products							26		185		132	941	7			486	201,112			667	763	5	3	
327	Nonmetallic mineral products							21	1	31				100		153	264	692	115,689		25	331	38	1	
331	Primary metals							103						234			636	3	1	233,337	1,625	547		1,683	
332	Fabricated metal products							84		4		97		74			64	1,175	33	5,304	304,623	4,321	237	18	
333	Machinery							14					149				44	170	129	31	4,572	306,882	1,684	883	
334	Computer and electronic products							31									151		5		315	528	368,592	2,680	
335	Electrical equipment, appliances, and components							90		15	146					62	67	83	243	3,132	579	717	964	115,434	
3361MV	Motor vehicles, bodies and trailers, and parts							72	1,550									18			1,174	2,061	559	423	
3364OT	Other transportation equipment							74		6											378	3,160	137	170	
337	Furniture and related products							20		305		753					8	352	130		512	373	23	4	
339	Miscellaneous manufacturing							61		73		340	249	138		5	263	887	463		380	73	1,707		
42	Wholesale trade		879					192	9,277												13	437	339	196	
44RT	Retail trade							1,999	9,187		461			96											
481	Air transportation								163																
482	Rail transportation							7,114																	
483	Water transportation																								
484	Truck transportation																								
485	Transit and ground passenger transportation																								
486	Pipeline transportation						3,493	992																	
487OS	Other transportation and support activities																								
493	Warehousing and storage																								
511	Publishing industries (includes software)							4																	
512	Motion picture and sound recording industries							28																	
513	Broadcasting and telecommunications							11,668																	
514	Information and data processing services																								
521CI	Federal Reserve banks, credit intermediation, and related activities							337																	
523	Securities, commodity contracts, and investments							169																	
524	Insurance carriers and related activities							8																	
525	Funds, trusts, and other financial vehicles																								
531	Real estate							52,306																	
532RL	Rental and leasing services and lessors of intangible assets							33																	
5411	Legal services																								
5412OP	Miscellaneous professional, scientific and technical services							45																	
5415	Computer systems design and related services																								
55	Management of companies and enterprises																								
561	Administrative and support services							108																	
562	Waste management and remediation services							136																	
61	Educational services							475																	
621	Ambulatory health care services																								
622HO	Hospitals and nursing and residential care facilities							1,048																	
624	Social assistance																								
711AS	Performing arts, spectator sports, museums, and related activities							1,250																	
713	Amusements, gambling, and recreation industries							43																	
721	Accommodation							2,000																	
722	Food services and drinking places							48																	
81	Other services, except government							314																	
GFE	Federal government enterprises						14,013																		
GFG	Federal general government		2,377		1,534			22	276					22	17	361			2		13				
GSLE	State and local government enterprises						90,849																		
GSLG	State and local general government		2,850		89		992	17,668	2,235		94		152	798		7									
T007	Total Commodity Output	294,743	75,557	246,354	77,383	127,276	539,939	1,370,568	722,204	63,103	31,390	98,831	163,463	74,508	586,058	653,852	209,543	117,230	243,630	315,737	320,543	374,852	121,311	469,639	

BEA Make Table: The Make of Commodities by Industries, Annual I-O Accounts, 2007 continued (page 2 of 3)

		Commodities (2 of 3)																									
		Other transportation equipment	Furniture and related products	Miscellaneous manufacturing	Wholesale trade	Retail trade	Air transportation	Rail transportation	Water transportation	Truck transportation	Transit and ground passenger transportation	Pipeline transportation	Other transportation and support activities	Warehousing and storage	Publishing industries (includes software)	Motion picture and sound recording industries	Broadcasting and telecommunications	Information and data processing services	Federal Reserve banks, credit intermediation, and related activities	Securities, commodity contracts, and investments	Insurance carriers and related activities	Funds, trusts, and other financial vehicles	Real estate	Rental and leasing services and lessors of intangible assets			
Code	indl. label	3364OT	337	339	42	44RT	481	482	483	484	485	486	487OS	493	511	512	513	514	521CI	523	524	525	531	532RL			
111CA	Farms																										
113FF	Forestry, fishing, and related activities				520																						
211	Oil and gas extraction				12																						
212	Mining, except oil and gas				75																						
213	Support activities for mining				747																						
22	Utilities					98						5,968															
23	Construction																										
311FT	Food and beverage and tobacco products				5,057																						
313TT	Textile mills and textile product mills		3	101	370																						
315AL	Apparel and leather and allied products			51	1,152																						
321	Wood products		179	10	719																						
322	Paper products		1	150	913																						
323	Printing and related support activities				56	1,099																					
324	Petroleum and coal products				690																						
325	Chemical products			30	18,729																						
326	Plastics and rubber products		215	664	1,799																						
327	Nonmetallic mineral products			77	926																						
331	Primary metals		36		374																						
332	Fabricated metal products	138	29	61	3,321																						
333	Machinery	645	137	10	4,113																						
334	Computer and electronic products	5,329		674	3,243																						
335	Electrical equipment, appliances, and components		29	31	1,549																						
3361MV	Motor vehicles, bodies and trailers, and parts	1,204	624		1,473																						
3364OT	Other transportation equipment	212,915		123	690																						
337	Furniture and related products		75,612	521	1,266																						
339	Miscellaneous manufacturing		14	142,109	4,420																						
42	Wholesale trade	6	8	2,956	1,145,310							27	1,178	36										13,943			
44RT	Retail trade			1,378		1,221,340				5,000			2,806	240					2,748		208		31	9,298			
481	Air transportation						150,016																				
482	Rail transportation							63,365																222			
483	Water transportation								35,668				316											20			
484	Truck transportation				250	24				269,638			204	3,451													
485	Transit and ground passenger transportation				14						31,299		111														
486	Pipeline transportation											29,606															
487OS	Other transportation and support activities				469	8	7,516	1,486	588	3,660	72		119,339	155										6			
493	Warehousing and storage				15					583			35	49,936													
511	Publishing industries (includes software)				4,082	745									209,549			601									
512	Motion picture and sound recording industries					99										98,784											
513	Broadcasting and telecommunications				2,804	324										5,165	693,870	4,133						5,589			
514	Information and data processing services					1,054									1,581			180,010									
521CI	Federal Reserve banks, credit intermediation, and related activities					1,777													665,649	19,058	2,588			69,122			
523	Securities, commodity contracts, and investments																	738	4,371	453,506	6,174						
524	Insurance carriers and related activities																			583	657,825		68				
525	Funds, trusts, and other financial vehicles																					113,591					
531	Real estate																				81		2,178,202				
532RL	Rental and leasing services and lessors of intangible assets					1,953					34									9			25	282,617			
5411	Legal services																										
5412OP	Miscellaneous professional, scientific and technical services				496	9,804																					
5415	Computer systems design and related services					3,040												7,753									
55	Management of companies and enterprises														1,602			1,668						246			
561	Administrative and support services				226	2,094																					
562	Waste management and remediation services				69																						
61	Educational services					2,234																					
621	Ambulatory health care services					7,774																		880			
622HO	Hospitals and nursing and residential care facilities					288																		72			
624	Social assistance					873																					
711AS	Performing arts, spectator sports, museums, and related activities					2,076																					
713	Amusements, gambling, and recreation industries					2,152																		86			
721	Accommodation					2,279																	3,149				
722	Food services and drinking places					2,855																					
81	Other services, except government				8	8,708																		585			
GFE	Federal government enterprises					2,081										147					3,550		1,250				
GFG	Federal general government			216											360	8		17					194				
GSLE	State and local government enterprises					3,470		146	69		12,368		9,483						121		282		18,151				
GSLG	State and local general government			133											216			1,967				1,658					
T007	Total Commodity Output	220,237	76,886	149,352	1,206,983	1,277,162	157,531	64,997	36,324	278,881	43,772	35,601	133,472	53,818	213,307	104,104	693,870	196,888	672,889	473,157	670,707	115,443	2,200,875	382,685			

BEA Make Table: The Make of Commodities by Industries, Annual I-O Accounts, 2007 continued (page 3 of 3)

		Commodities (3 of 3)																					Total Industry Output
		Legal services	Miscellaneous professional, scientific and technical services	Computer systems design and related services	Management of companies and enterprises	Administrative and support services	Waste management and remediation services	Educational services	Ambulatory health care services	Hospitals and nursing and residential care facilities	Social assistance	Performing arts, spectator sports, museums, and recreation industries	Accommodation	Food services and drinking places	Other services, except government	Federal government enterprises	Federal general government	State and local government enterprises	State and local general government	Scrap, used and secondhand goods	Inventory valuation adjustment		
Code	indLabel	5411	5412OP	5415	55	561	562	61	621	622HO	624	711AS	713	721	722	81	GFE	GFG	GSLE	GSLG	S002	S004	T008
111CA	Farms												3,064										307,009
113FF	Forestry, fishing, and related activities			6																		-538	60,694
211	Oil and gas extraction			595																		-937	273,081
212	Mining, except oil and gas			60																		-507	78,647
213	Support activities for mining			29																		-163	127,261
22	Utilities			1,242															1,189			-2,573	460,943
23	Construction																					-578	1,245,874
311FT	Food and beverage and tobacco products			912																		-3,438	708,896
313TT	Textile mills and textile product mills			167																	58	-99	65,147
315AL	Apparel and leather and allied products			192																	7	-446	31,176
321	Wood products			82																	163	-270	99,233
322	Paper products			227																	333	-40	165,791
323	Printing and related support activities		26,151	602																	99	355	101,939
324	Petroleum and coal products			108																		-3,691	579,024
325	Chemical products			1,112																		-4,987	637,782
326	Plastics and rubber products			401																	146	-408	207,166
327	Nonmetallic mineral products			105																	14	-614	117,868
331	Primary metals			470																	1,186	-3,819	236,416
332	Fabricated metal products			544																	1,443	-1,936	319,897
333	Machinery			1,182																	1,157	-1,602	320,988
334	Computer and electronic products			5,492																	54	920	388,021
335	Electrical equipment, appliances, and components			391																	39	-424	123,778
3361MV	Motor vehicles, bodies and trailers, and parts			931																	861	-665	477,588
3364OT	Other transportation equipment			1,634																	28	-1,137	218,615
337	Furniture and related products			146																		-219	79,806
339	Miscellaneous manufacturing		3,735	470																	43	-635	154,796
42	Wholesale trade		282	6,423		455		10								53,090						-20,842	1,214,212
44RT	Retail trade		582	2,513		2,582		214	258				638		21,024	97,864						-7,244	1,373,224
481	Air transportation			300																		-81	150,397
482	Rail transportation			35																		-557	70,179
483	Water transportation			71																		-3	36,073
484	Truck transportation		178	390			27										359					-139	274,382
485	Transit and ground passenger transportation		34	74					1							19						-29	31,523
486	Pipeline transportation			123																		-34	34,180
487OS	Other transportation and support activities		390	580				45	7				2			33						-387	133,967
493	Warehousing and storage		64	50												4							50,688
511	Publishing industries (includes software)		68,159	19,390				2,249								64						-1,820	303,023
512	Motion picture and sound recording industries		22	217									38								92		99,279
513	Broadcasting and telecommunications		66,458	5,524												3,138						1,394	800,067
514	Information and data processing services			2,240				198								133						-13	185,202
521CI	Federal Reserve banks, credit intermediation, and related activities			4,307																			762,837
523	Securities, commodity contracts, and investments			2,619																			467,576
524	Insurance carriers and related activities	167		9,493																			668,144
525	Funds, trusts, and other financial vehicles			88																			113,680
531	Real estate			122										497									2,231,208
532RL	Rental and leasing services and lessors of intangible assets			367												1,157						-139	286,057
5411	Legal services	279,473		145																			279,618
5412OP	Miscellaneous professional, scientific and technical services		1,069,835	11,894		1,189																-443	1,100,572
5415	Computer systems design and related services		2,212	199,795				1,588								6,434							216,584
55	Management of companies and enterprises		7,550		440,255																		447,805
561	Administrative and support services		2,829	8,244		595,765										27						-83	609,209
562	Waste management and remediation services		179	84			69,456														4,619		75,110
61	Educational services			4,432				192,909					792	7,431	6,821	194						-22	215,266
621	Ambulatory health care services			574					720,265													-38	729,455
622HO	Hospitals and nursing and residential care facilities			2,341					6,969	673,818						2,311							686,848
624	Social assistance			83						26	136,489					343						-8	137,806
711AS	Performing arts, spectator sports, museums, and related activities		3,366	83								90,737	909			786						-37	99,171
713	Amusements, gambling, and recreation industries		110	46				705				164	208	90,953	383	13,359	514					-147	108,575
721	Accommodation			83									31,959	125,324	35,836							-9	200,621
722	Food services and drinking places			166									1,537	635	510,287						176	-545	515,159
81	Other services, except government		468	644		32		33							5,554	583,505						-39	599,813
GFE	Federal government enterprises														1,672	1	78,198						100,913
GFG	Federal general government		2,246	4,449				191		566		25						856,080					868,975
GSLE	State and local government enterprises								5,390	13,126	84,672	28,073	142,185	2,755	718	8,252	9,765		68,980		1,358,094	3,397	233,338
GSLG	State and local general government		4,739	4,120											16,157	431							1,710,733
T007	Total Commodity Output	279,640	1,259,588	309,208	440,255	605,413	82,609	282,814	755,574	816,594	139,408	92,480	165,029	144,035	614,149	748,709	78,198	856,080	70,169	1,358,094	13,822	-59,620	25,808,901

Table B-2. BEA Use Table: The Use of Commodities by Industries, Annual I-O Accounts, 2007 (page 1 of 3)

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BEA Use Table: The Use of Commodities by Industries, Annual I-O Accounts, 2007 continued (page 2 of 3)

		Industries (2 of 3)																												
		Retail trade	Air transportation	Rail transportation	Water transportation	Truck transportation	Transit and ground passenger transportation	Pipeline transportation	Other transportation and support activities	Warehousing and storage	Publishing industries (includes software)	Motion picture and sound recording industries	Broadcasting and telecommunications	Information and data processing services	Federal Reserve banks, credit intermediation, and related activities	Securities, commodity contracts, and investments	Insurance carriers and related activities	Funds, trusts, and other financial services	Real estate	Rental and leasing services and lessors of intangible assets	Legal services	Miscellaneous professional, scientific and technical services	Computer systems design and related services	Management of companies and enterprises	Administrative and support services	Waste management and remediation services	Educational services	Ambulatory health care services		
ICComCol	comLabel	44RT	481	482	483	484	485	486	487OS	493	511	512	513	514	521CI	523	524	525	531	532RL	5411	5412OP	5415	55	561	562	61	621		
111CA	Farms	414			1			0	3		1		23	1	1				899		0	113	1	5	6,736		99	2		
113FF	Forestry, fishing, and related activities	31			5														1,744		19			52		56				
211	Oil and gas extraction	1						4,955																						
212	Mining, except oil and gas	37		251	13								2		2				1,964	0	469	2	1							
213	Support activities for mining				10																									
22	Utilities	16,387	151	65	66	658	58	488	255	1,056	1,270	781	4,211	852	2,430	3,393	162	139	60,327	1,633	644	6,480	301	7,852	3,412	2,034	1,737	2,808		
23	Construction	5,974	18	9	16	494		884	136	211	829	454	2,730	922	5,017	1,740	300	230	35,799	1,240	678	4,504	232	6,077	1,656	50	3,831	2,379		
311FT	Food and beverage and tobacco products	7,289	166		79			298			55	380									842		2	17		901	22			
313TT	Textile mills and textile product mills	700	4		101	20		48	21		8	137	24	1	252	63	7	0	690	18	6	262	0	17	106	0	40	26		
316AL	Apparel and leather and allied products	199	2	2	40	5	11	2	5	34	10	66	76	10	38	5	5	1	20	248	14	83	4		87	2	25	45		
321	Wood products	2,271	1	722		28		6	68	48	111	122	1,736	145	14	35	2	8	12,946	93	125	676	49	1,011	237	339	384	554		
322	Paper products	5,446	33	64	35	362	37	49	175	137	7,153	165	1,366	469	943	502	136	47	1,893	3,692	809	3,854	248	215	3,263	88	852	2,067		
323	Printing and related support activities	1,519	146	39	7	138	42	19	87	20	12,514	100	2,803	1,264	1,478	420	1,266	84	604	65	264	6,916	246	3,001	4,309	24	700	854		
324	Petroleum and coal products	10,939	32,308	3,287	1,966	24,379	2,340	5,301	7,040	1,234	659	58	1,401	208	907	329	62	30	3,860	1,730	284	1,308	61	602	7,671	8,440	527	1,905		
325	Chemical products	42	49	46		498	49	24	73	14	1,375	187	1,479	341	265	117	91	49	7,118	93	185	10,295	57	887	7,452	905	1,252	17,717		
326	Plastics and rubber products	8,593	21	153	43	2,890	380	13	270	58	430	204	3,358	173	216	120	126	16	4,812	1,290	220	2,946	138	1,967	2,975	171	1,314	7,263		
327	Nonmetallic mineral products	1,407	1	304	5	33	14	9	8	3	58	40	1,840	327	69	65	3	2	12,236	358	62	2,487	25	1,031	216	2	602	1,017		
331	Primary metals	2,067	2	1,806		1		83	58	5	64	6	2,339	28	82	86	32	4	2,069	13	10	307	46	77	39	2	133	49		
332	Fabricated metal products	4,173	716	363	438	2,063	600	888	320	107	2,366	349	8,268	229	125	164	57	7	11,087	887	159	2,885	141	2,553	968	93	1,373	1,672		
333	Machinery	2,076	18	1,060	337	352	62	693	324	14	150	21	354	33	101	120	1	1	3,909	643	26	1,282	201	222	629	51	219	381		
334	Computer and electronic products	2,866	56	764	8	31	14	71	3	5,744	1,247	14,614	14,326	2,652	232	231	15	451	920	118	5,735	5,074	662	2,826	281	569	3,103			
335	Electrical equipment, appliances, and components	1,431	7	531	11	853	176	20	87	13	83	26	7,133	233	91	34	16	7	6,491	120	46	1,288	83	326	643	38	372	270		
336IMV	Motor vehicles, bodies and trailers, and parts	17,832	1	955	7	5,660	975	63	275	113	110	44	136	41	883	86	26		125	1,919	242	823	23	523	1,515	1,362	203	432		
3364OT	Other transportation equipment	1,649	3,634	850	799	13	14		772					2					54	148		259				0	16	71		
337	Furniture and related products	220		23	2			1	0		24	11	182	22	2			0	9,110	11	44	416	10	130	36	0	15	97		
339	Miscellaneous manufacturing	1,464	33	5	13	41	21	6	17	10	73	10	351	438	471	166	70	10	293	189	72	2,010	24	105	832	30	566	12,938		
42	Wholesale trade	10,739	3,775	2,001	829	10,350	1,106	412	1,160	463	8,890	1,656	6,899	1,970	1,395	445	236	65	9,733	1,665	542	6,755	1,162	1,619	7,737	1,546	2,583	7,497		
44RT	Retail trade	4,732	17	9	5	1,610	116	60	74	22	269	71	249	326	264	138	39	1	15,269	995	437	2,047	112	9	6,721	143	131	984		
481	Air transportation	2,343	84	42	29	1,076	31	7	142	12	973	181	847	1,663	3,140	1,764	1,094	193	1,173	1,561	1,410	6,000	470	59	3,370	221	608	1,468		
482	Rail transportation	554	227	130	21	2,100	28	16	94	16	251	15	124	64	114	26	29	8	626	127	39	310	17	70	289	106	65	200		
483	Water transportation	94	97	19	6	167	10	8	24	4	8	1	14	26	6	3	1		123	11	3	36	7	7	81	30	10	35		
484	Truck transportation	3,427	189	320	39	33,863	300	47	240	102	1,036	78	897	235	466	221	43	39	3,556	422	116	1,231	61	321	1,415	843	510	984		
485	Transit and ground passenger transportation	681	10	5	15	36	1,036	1	7	1	145	26	1,408	352	854	231	284	27	1,290	563	425	1,357	78		986	39	305	516		
486	Pipeline transportation	32	107	10	7	76	8	856	23	4	2	0	3	0	3	1	0		3	1	0	2	0	1	21	28	1	5		
487OS	Other transportation and support activities	8,837	11,761	4,489	5,977	11,436	111	59	5,635	213	1,413	369	1,602	1,346	4,547	2,823	950	166	1,461	7,065	1,142	4,712	371	52	1,768	282	420	1,606		
493	Warehousing and storage	8,880	14	1	123	5,764	31	1	251	46	735	5	215	132	3,034	1,008	49	29	71	230	4	899	69	7	1,523	30	63	288		
511	Publishing industries (includes software)	249	10	3	65	47	1	5	35	19	17,098	22	331	810	444	129	28	17	104	247	721	3,182	55	280	621	6	1,354	1,316		
512	Motion picture and sound recording industries	66	7	1	16						170	24,643	20,966	82	13	28	5	37	53	237	11	4,803	12		178		3,256	37		
513	Broadcasting and telecommunications	13,460	1,040	87	46	3,816	186	168	1,840	323	7,323	954	186,247	14,719	4,827	3,067	6,187	126	11,735	4,247	5,405	25,304	3,964	17,735	12,479	868	3,368	10,897		
514	Information and data processing services	10,707	383	20	47	1,035	180	77	1,073	120	5,003	333	3,904	6,765	3,170	7,008	4,362	230	3,346	1,872	2,652	13,431	2,066	12,366	7,862	508	1,361	4,412		
521CI	Federal Reserve banks, credit intermediation, and related activities	27,013	965	784	592	1,962	278	322	567	151	4,965	2,216	18,394	4,374	37,771	42,562	5,935	2,174	73,017	20,631	2,443	13,623	2,006	0	6,775	930	1,217	5,799		
523	Securities, commodity contracts, and investments	3,246	215	184	328	789	92	92	247	54	1,855	389	1,791	2,575	48,363	79,493	10,850	78,444	3,770	2,863	1,099	6,655	407	2	2,168	144	1,967	3,391		
524	Insurance carriers and related activities	3,689	1,169	353	1,480	2,130	158	98	198	56	896	657	9,555	2,340	1,335	1,200	247,462	982	40,655	6,749	326	843	384	4,012	1,465					

BEA Use Table: The Use of Commodities by Industries, Annual I-O Accounts, 2007 continued (page 3 of 3)

		Industries (3 of 3)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
		Social assistance		Performing arts, spectator sports, museums, and related activities		Amusements, gambling, and recreation industries		Accommodation		Food services and drinking places		Other services, except government		Federal government enterprises		Federal general government		State and local government enterprises		State and local general government		Total intermediate use		Personal consumption expenditures		Private fixed investment		Change in private inventories		Exports of goods and services		Imports of goods and services		National defense: Consumption expenditures		National defense: Gross investment		Nondefense: Consumption expenditures		Nondefense: Gross investment		State and local government consumption expenditures, education		State and local government gross investment, education		State and local government consumption expenditures, other		State and local government gross investment, other		Total Final Uses (GDP)		Total Commodity Output																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454

Table B-3. Normalized Make Table (page 1 of 3)

PubInd Code	indLabel	Commodities (1 of 3)																									
		Fams	Forestry, fishing, and related activities	Oil and gas extraction	Mining, except oil and gas	Support activities for mining	Utilities	Construction	Food and beverage and tobacco products	Textile mills and textile product mills	Apparel and leather and allied products	Wood products	Paper products	Printing and related support activities	Petroleum and coal products	Chemical products	Plastics and rubber products	Nonmetallic mineral products	Primary metals	Fabricated metal products	Machinery	Computer and electronic products	Electrical equipment, appliances, and components				
		111CA	113FF	211	212	213	22	23	311FT	313TT	315AL	321	322	323	324	325	326	327	331	332	333	334	335				
111CA	Farms	0.9999	0.1209	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
113FF	Forestry, fishing, and related activities	0.0001	0.7983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
211	Oil and gas extraction	0.0000	0.0000	0.9937	0.0000	0.0058	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0470	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
212	Mining, except oil and gas	0.0000	0.0000	0.0000	0.9788	0.0011	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0036	0.0000	0.0025	0.0000	0.0000	0.0000	0.0000				
213	Support activities for mining	0.0000	0.0000	0.0000	0.0002	0.9930	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000				
22	Utilities	0.0000	0.0000	0.0032	0.0000	0.0173	0.7974	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
23	Construction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
311FT	Food and beverage and tobacco products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.9703	0.0001	0.0080	0.0000	0.0000	0.0000	0.0000	0.0000	0.0081	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000				
313TT	Textile mills and textile product mills	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9432	0.0283	0.0000	0.0014	0.0070	0.0000	0.0000	0.0044	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000				
315AL	Apparel and leather and allied products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0170	0.9253	0.0000	0.0000	0.0005	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
321	Wood products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9840	0.0000	0.0000	0.0000	0.0000	0.0000	0.0039	0.0000	0.0000	0.0008	0.0000	0.0000				
322	Paper products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017	0.0000	0.0022	0.9862	0.0024	0.0000	0.0009	0.0082	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000				
323	Printing and related support activities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0162	0.0000	0.0007	0.9748	0.0000	0.0000	0.0001	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000				
324	Petroleum and coal products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0032	0.0000	0.0000	0.0002	0.0000	0.9299	0.0520	0.0000	0.0010	0.0074	0.0000	0.0000	0.0000	0.0000				
325	Chemical products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0005	0.0000	0.0000	0.0000	0.0004	0.0000	0.0223	0.9270	0.0093	0.0000	0.0000	0.0000	0.0020	0.0012	0.0000				
326	Plastics and rubber products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0029	0.0000	0.0013	0.0058	0.0001	0.0000	0.0007	0.9598	0.0002	0.0000	0.0021	0.0024	0.0000	0.0000				
327	Nonmetallic mineral products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0003	0.0004	0.0033	0.9869	0.0000	0.0001	0.0010	0.0001	0.0000	0.0001				
331	Primary metals	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0014	0.0000	0.0010	0.0000	0.0000	0.9578	0.0051	0.0017	0.0000	0.0139	0.0000				
332	Fabricated metal products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0010	0.0000	0.0010	0.0000	0.0001	0.0056	0.0003	0.0218	0.9648	0.0135	0.0006	0.0001				
333	Machinery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0001	0.0008	0.0011	0.0001	0.0145	0.9574	0.0045	0.0073				
334	Computer and electronic products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0010	0.0016	0.9833	0.0221				
335	Electrical equipment, appliances, and components	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0047	0.0000	0.0000	0.0000	0.0001	0.0001	0.0004	0.0021	0.0129	0.0018	0.0022	0.0026	0.9516				
3361MV	Motor vehicles, bodies and trailers, and parts	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0246	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0037	0.0064	0.0015	0.0035				
3364OT	Other transportation equipment	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0099	0.0004	0.0014				
337	Furniture and related products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0048	0.0000	0.0076	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017	0.0011	0.0000	0.0016	0.0012	0.0001				
339	Miscellaneous manufacturing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0000	0.0034	0.0015	0.0019	0.0000	0.0004	0.0042	0.0039	0.0000	0.0012	0.0002	0.0046	0.0000				
42	Wholesale trade	0.0000	0.0116	0.0000	0.0000	0.0000	0.0000	0.0001	0.0128	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.0009	0.0000				
44RT	Retail trade	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.0127	0.0000	0.0147	0.0000	0.0000	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
481	Air transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
482	Rail transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0052	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
483	Water transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
484	Truck transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
485	Transit and ground passenger transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
486	Pipeline transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0065	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
487OS	Other transportation and support activities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
493	Warehousing and storage	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
511	Publishing industries (includes software)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
512	Motion picture and sound recording industries	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
513	Broadcasting and telecommunications	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0085	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
514	Information and data processing services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
521CI	Federal Reserve banks, credit intermediation, related activities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
523	Securities, commodity contracts, and investments	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
524	Insurance carriers and related activities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
525	Funds, trusts, and other financial vehicles	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
531	Real estate	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0382	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
532RL	Rental and leasing services and lessors of intangible assets	0.0000	0.0000	0.																							

Normalized Make Table continued (page 2 of 3)

[illegible]

Normalized Make Table continued (page 3 of 3)

PubInd Code	indLabel	Commodities (3 of 3)																										
		Funds, trusts, and other financial vehicles	Real estate	Rental and leasing services and lessors of intangible assets	Legal services	Miscellaneous professional, scientific and technical services	Computer systems design and related services	Management of companies and enterprises	Administrative and support services	Waste management and remediation services	Educational services	Ambulatory health care services	Hospitals and nursing and residential care facilities	Social assistance	Performing arts, spectator sports, museums, and related industries	Accommodation	Food services and drinking places	Other services, except government	Federal government enterprises	Federal general government	State and local government enterprises	State and local government	State and local government	State and local government	State and local government	State and local government	State and local government	
		525	531	532RL	5411	5412OP	5415	55	561	562	61	621	622HO	624	711AS	713	721	722	81	GFE	GFG	GSLE	GSLE	GSLE	GSLE	GSLE	GSLE	GSLE
111CA	Farms	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0186	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
113FF	Forestry, fishing, and related activities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
211	Oil and gas extraction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
212	Mining, except oil and gas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
213	Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
22	Utilities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0169	0.0000	0.0000	0.0000	0.0000	
23	Construction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
311FT	Food and beverage and tobacco products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
313TT	Textile mills and textile product mills	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
315AL	Apparel and leather and allied products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
321	Wood products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0118	
322	Paper products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0241	
323	Printing and related support activities	0.0000	0.0000	0.0000	0.0000	0.0208	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0072	
324	Petroleum and coal products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
325	Chemical products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
326	Plastics and rubber products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0106	
327	Nonmetallic mineral products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	
331	Primary metals	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
332	Fabricated metal products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1044	
333	Machinery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0038	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0837	
334	Computer and electronic products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0178	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0039	
335	Electrical equipment, appliances, and components	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
3361MV	Motor vehicles, bodies and trailers, and parts	0.0000	0.0000	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
3364OT	Other transportation equipment	0.0000	0.0000	0.0000	0.0000	0.0000	0.0053	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
337	Furniture and related products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
339	Miscellaneous manufacturing	0.0000	0.0000	0.0000	0.0000	0.0030	0.0015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0031	
42	Wholesale trade	0.0000	0.0000	0.0364	0.0000	0.0002	0.0208	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0709	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
44RT	Retail trade	0.0000	0.0000	0.0243	0.0000	0.0005	0.0081	0.0000	0.0043	0.0000	0.0008	0.0003	0.0000	0.0000	0.0000	0.0039	0.0000	0.0342	0.1307	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
481	Air transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
482	Rail transportation	0.0000	0.0000	0.0006	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
483	Water transportation	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
484	Truck transportation	0.0000	0.0000	0.0000	0.0000	0.0001	0.0013	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
485																												

Table B-4. Normalized Use Table (page 1 of 3)

Pub Com Code	comLabel	Industries (1 of 3)																																					
		Farms	Forestry, fishing, and related activities	Oil and gas extraction	Mining, except oil and gas	Support activities for mining	Utilities	Construction	Food and beverage and tobacco products	Textile mills and textile product mills	Apparel and leather and allied products	Wood products	Paper products	Printing and related support activities	Petroleum and coal products	Chemical products	Plastics and rubber products	Nonmetallic mineral products	Primary metals	Fabricated metal products	Machinery	Computer and electronic products	Electrical equipment, appliances, and components																
111CA	Farms	0.1236	0.0098	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.2297	0.0282	0.0000	0.0000	0.0000	0.0000	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
113FF	Forestry, fishing, and related activities	0.0581	0.3859	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0055	0.0001	0.0006	0.1888	0.0419	0.0001	0.0000	0.0003	0.0097	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
211	Oil and gas extraction	0.0000	0.0001	0.1649	0.0129	0.0008	0.2085	0.0000	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.6071	0.0144	0.0003	0.0005	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
212	Mining, except oil and gas	0.0015	0.0000	0.0000	0.0893	0.0011	0.0335	0.0069	0.0006	0.0005	0.0000	0.0000	0.0003	0.0000	0.0022	0.0057	0.0001	0.0735	0.0484	0.0006	0.0003	0.0004	0.0017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
213	Support activities for mining	0.0000	0.0000	0.0254	0.0151	0.0029	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
22	Utilities	0.0167	0.0015	0.0058	0.0171	0.0051	0.0006	0.0032	0.0137	0.0158	0.0053	0.0098	0.0243	0.0098	0.0125	0.0123	0.0146	0.0288	0.0191	0.0106	0.0053	0.0055	0.0040	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
23	Construction	0.0032	0.0023	0.0000	0.0000	0.0009	0.0103	0.0011	0.0021	0.0020	0.0008	0.0013	0.0023	0.0019	0.0005	0.0020	0.0020	0.0025	0.0016	0.0024	0.0022	0.0020	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
311FT	Food and beverage and tobacco products	0.0628	0.0079	0.0000	0.0000	0.0000	0.0000	0.0000	0.1299	0.0005	0.0183	0.0002	0.0053	0.0004	0.0003	0.0031	0.0005	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
313TT	Textile mills and textile product mills	0.0008	0.0013	0.0000	0.0001	0.0000	0.0000	0.0000	0.0015	0.0002	0.1824	0.1380	0.0006	0.0092	0.0006	0.0000	0.0001	0.0139	0.0010	0.0000	0.0003	0.0013	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
315AL	Apparel and leather and allied products	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0795	0.0001	0.0006	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
321	Wood products	0.0015	0.0003	0.0000	0.0004	0.0005	0.0009	0.0312	0.0009	0.0010	0.0050	0.2077	0.0167	0.0003	0.0001	0.0005	0.0011	0.0027	0.0011	0.0010	0.0015	0.0004	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
322	Paper products	0.0018	0.0001	0.0005	0.0007	0.0009	0.0003	0.0021	0.0244	0.0068	0.0024	0.0038	0.1946	0.1668	0.0012	0.0081	0.0180	0.0134	0.0011	0.0041	0.0038	0.0031	0.0087	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
323	Printing and related support activities	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0005	0.0021	0.0031	0.0000	0.0005	0.0317	0.0000	0.0013	0.0001	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
324	Petroleum and coal products	0.0332	0.0087	0.0072	0.0479	0.0655	0.0127	0.0245	0.0030	0.0024	0.0012	0.0050	0.0159	0.0037	0.1011	0.0371	0.0074	0.0055	0.0100	0.0041	0.0030	0.0006	0.0029	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
325	Chemical products	0.0594	0.0183	0.0177	0.0005	0.0197	0.0007	0.0066	0.0005	0.2022	0.0092	0.0142	0.0521	0.0320	0.0171	0.2462	0.2967	0.0251	0.0067	0.0156	0.0006	0.0115	0.0042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
326	Plastics and rubber products	0.0034	0.0009	0.0018	0.0078	0.0031	0.0166	0.0188	0.0232	0.0061	0.0059	0.0069	0.0182	0.0080	0.0011	0.0185	0.0612	0.0074	0.0011	0.0044	0.0187	0.0088	0.0204	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
327	Nonmetallic mineral products	0.0017	0.0000	0.0014	0.0020	0.0119	0.0023	0.0452	0.0055	0.0020	0.0000	0.0000	0.0009	0.0001	0.0017	0.0019	0.0052	0.0993	0.0103	0.0029	0.0035	0.0006	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
331	Primary metals	0.0017	0.0000	0.0085	0.0090	0.0264	0.0017	0.0073	0.0000	0.0001	0.0000	0.0002	0.0024	0.0009	0.0001	0.0006	0.0076	0.0092	0.3131	0.2150	0.1162	0.0191	0.1341	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
332	Fabricated metal products	0.0031	0.0008	0.0073	0.0097	0.0256	0.0035	0.0530	0.0168	0.0056	0.0049	0.0224	0.0112	0.0059	0.0043	0.0092	0.0132	0.0122	0.0142	0.0963	0.0874	0.0301	0.0341	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
333	Machinery	0.0120	0.0020	0.0063	0.0391	0.0244	0.0012	0.0193	0.0016	0.0031	0.0007	0.0024	0.0040	0.0118	0.0002	0.0034	0.0077	0.0012	0.0071	0.0092	0.0770	0.0074	0.0084	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
334	Computer and electronic products	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
335	Electrical equipment, appliances, and components	0.0015	0.0001	0.0001	0.0004	0.0019	0.0042	0.0187	0.0013	0.0012	0.0010	0.0084	0.0015	0.0010	0.0013	0.0013	0.0053	0.0015	0.0088	0.0035	0.0357	0.0142	0.0571	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3361MV	Motor vehicles, bodies and trailers, and parts	0.0013	0.0008	0.0014	0.0025	0.0031	0.0002	0.0032	0.0003	0.0001	0.0002	0.0014	0.0002	0.0003	0.0002	0.0002	0.0001	0.0006	0.0001	0.0006	0.0099	0.0008	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3364OT	Other transportation equipment	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
337	Furniture and related products	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0098	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000																						

Normalized Use Table continued (page 2 of 3)

Pub Com Code	comLabel	Industries (2 of 3)																										
		Motor vehicles, bodies and trailers, and parts	Other transportation equipment	Furniture and related products	Miscellaneous manufacturing	Wholesale trade	Retail trade	Air transportation	Rail transportation	Water transportation	Truck transportation	Transit and ground passenger transportation	Pipeline transportation	Other transportation and support activities	Warehousing and storage	Publishing industries (includes software)	Motion picture and sound recording industries	Broadcasting and telecommunications	Information and data processing services	Federal Reserve banks, credit intermediation, and related activities	Securities, commodity contracts, and investments	Insurance carriers and related activities	Funds, trusts, and other financial vehicles					
111CA	Farms	0.0000	0.0000	0.0000	0.0002	0.0025	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
113FF	Forestry, fishing, and related activities	0.0000	0.0000	0.0003	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
211	Oil and gas extraction	0.0001	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
212	Mining, except oil and gas	0.0045	0.0001	0.0001	0.0014	0.0001	0.0000	0.0000	0.0036	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
213	Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
22	Utilities	0.0038	0.0041	0.0082	0.0056	0.0066	0.0119	0.0010	0.0009	0.0018	0.0024	0.0018	0.0143	0.0019	0.0208	0.0042	0.0079	0.0053	0.0046	0.0032	0.0073	0.0002	0.0012	0.0000	0.0000	0.0000	0.0000	
23	Construction	0.0007	0.0017	0.0022	0.0036	0.0027	0.0044	0.0001	0.0001	0.0005	0.0018	0.0000	0.0259	0.0010	0.0042	0.0027	0.0046	0.0034	0.0050	0.0066	0.0037	0.0004	0.0020	0.0000	0.0000	0.0000	0.0000	
311FT	Food and beverage and tobacco products	0.0000	0.0001	0.0011	0.0021	0.0039	0.0053	0.0011	0.0000	0.0022	0.0000	0.0000	0.0000	0.0022	0.0000	0.0002	0.0038	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
313TT	Textile mills and textile product mills	0.0104	0.0033	0.0375	0.0201	0.0066	0.0005	0.0000	0.0000	0.0028	0.0001	0.0000	0.0014	0.0002	0.0000	0.0000	0.0014	0.0000	0.0000	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
315AL	Apparel and leather and allied products	0.0021	0.0002	0.0001	0.0016	0.0018	0.0001	0.0000	0.0000	0.0014	0.0000	0.0004	0.0000	0.0000	0.0007	0.0000	0.0007	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
321	Wood products	0.0016	0.0014	0.0894	0.103	0.0032	0.0017	0.0000	0.0103	0.0000	0.0001	0.0000	0.0002	0.0005	0.0010	0.0004	0.0012	0.0022	0.0008	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	
322	Paper products	0.0025	0.0009	0.0138	0.199	0.0031	0.0040	0.0002	0.0009	0.0010	0.0013	0.0012	0.0014	0.0013	0.0027	0.0236	0.0017	0.0017	0.0025	0.0012	0.0011	0.0002	0.0004	0.0000	0.0000	0.0000	0.0000	
323	Printing and related support activities	0.0001	0.0002	0.0021	0.0002	0.0043	0.0012	0.0010	0.0005	0.0002	0.0005	0.0013	0.0005	0.0007	0.0004	0.0413	0.0010	0.0035	0.0068	0.0019	0.0009	0.0019	0.0007	0.0000	0.0000	0.0000	0.0000	
324	Petroleum and coal products	0.0016	0.0042	0.0020	0.0017	0.0061	0.0080	0.2148	0.0468	0.0545	0.0888	0.0742	0.1551	0.0526	0.0243	0.0022	0.0006	0.0018	0.0011	0.0012	0.0007	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	
325	Chemical products	0.0141	0.0140	0.108	0.396	0.0033	0.0015	0.0003	0.0007	0.0013	0.0018	0.0015	0.0007	0.0005	0.0003	0.0045	0.0019	0.0018	0.0016	0.0003	0.0002	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000	
326	Plastics and rubber products	0.0280	0.0128	0.0527	0.304	0.0076	0.0063	0.0001	0.0022	0.0012	0.0105	0.0120	0.0004	0.0020	0.0011	0.0014	0.0021	0.0042	0.0009	0.0003	0.0003	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	
327	Nonmetallic mineral products	0.0076	0.0033	0.0031	0.0041	0.0008	0.0000	0.0010	0.0000	0.0043	0.0001	0.0001	0.0005	0.0003	0.0001	0.0001	0.0002	0.0004	0.0023	0.0018	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
331	Primary metals	0.0834	0.0494	0.0411	0.0508	0.029	0.0015	0.0000	0.0257	0.0000	0.0000	0.0000	0.0024	0.0004	0.0001	0.0002	0.0001	0.0029	0.0001	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
332	Fabricated metal products	0.0532	0.0746	0.0335	0.323	0.0035	0.0030	0.0046	0.0052	0.0122	0.0075	0.0159	0.0260	0.0024	0.0021	0.0078	0.0035	0.0103	0.0012	0.0002	0.0003	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	
333	Machinery	0.0402	0.0252	0.0008	0.0087	0.0039	0.0015	0.0001	0.0151	0.0093	0.0013	0.0020	0.0203	0.0024	0.0003	0.0005	0.0002	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
334	Computer and electronic products	0.0205	0.0578	0.0048	0.130	0.0067	0.0021	0.0004	0.0109	0.0002	0.0001	0.0004	0.0004	0.0005	0.0001	0.190	0.0126	0.0183	0.0774	0.0035	0.0005	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	
335	Electrical equipment, appliances, and components	0.0084	0.0082	0.0009	0.0034	0.0014	0.010	0.0000	0.0076	0.0003	0.0031	0.0056	0.0006	0.0006	0.0003	0.0003	0.0003	0.0089	0.0013	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
3361MV	Motor vehicles, bodies and trailers, and parts	0.2881	0.0049	0.0004	0.0002	0.0020	0.0130	0.0000	0.0138	0.0000	0.0038	0.0002	0.0206	0.0309	0.0018	0.0021	0.0022	0.0004	0.0004	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
3364OT	Other transportation equipment	0.0003	0.1312	0.0000	0.0000	0.0003	0.0012	0.0242	0.0121	0.0221	0.0000	0.0004	0.0000	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
337	Furniture and related products	0.0001	0.0003	0.0143	0.0008	0.0001	0.0002	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
339	Miscellaneous manufacturing	0.0010	0.0009	0.0002	0.0458	0.0018	0.0011	0.0002	0.0001	0.0004	0.0001	0.0007	0.0002	0.0001	0.0002	0.0002	0.0001	0.0004	0.0024	0.0006	0.0004	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	
42	Wholesale trade	0.0639	0.0376	0.0662	0.0555	0.353	0.0078	0.0251	0.0285	0.0230	0.0377	0.0351	0.0121	0.0087	0.0091	0.0293	0.0167	0.0086	0.0106	0.0018	0.0010	0.0004	0.0006	0.0000	0.0000	0.0000	0.0000	
44RT	Retail trade	0.0054	0.0002	0.0173	0.0023	0.0026	0.0034	0.0001	0.0001	0.0014	0.0059	0.0037	0.0018	0.0005	0.0004	0.0009	0.0007	0.0003	0.0018	0.0003	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	
481	Air transportation	0.0032	0.0030	0.0020	0.0016	0.0022	0.0017	0.0006	0.0006	0.0008	0.0039	0.0010	0.0002	0.0011	0.0002	0.0032	0.0018	0.0011	0.0101	0.0041	0.0038	0.0016	0.0017	0.0000	0.0000	0.0000	0.0000	
482	Rail transportation	0.0036	0.0009	0.0028	0.0019	0.0003	0.0004	0.0015	0.0019	0.0008	0.0077	0.0009	0.0005	0.0007	0.0003	0.0008	0.0001	0.0002	0.0003	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
483	Water transportation	0.0001	0.0000	0.0003	0.0002	0.0000	0.0001	0.0006	0.0003	0.0002	0.0000	0.0000	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
484	Truck transportation	0.0119	0.0049	0.0180	0.108	0.0016	0.0025	0.0013	0.0048	0.0011	0.1235	0.0095	0.0014	0.0018	0.0020	0.0034	0.0008	0.0011	0.0013	0.0006	0.0005	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	
485	Transit and ground passenger transportation	0.0002	0.0002	0.0001	0.0002	0.0004	0.0005	0.0001	0.0001	0.0004	0.0001	0.0329	0.0000	0.0001	0.0000	0.0005	0.0003	0.0018	0.0019	0.0011	0.0005	0.0004	0.0002	0.0000	0.0000	0.0000	0.0000	
486	Pipeline transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0001	0.0002	0.0003	0.0002	0.0250	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.							

Normalized Use Table continued (page 3 of 3)

Pub Com Code	comLabel	Industries (3 of 3)																											
		Real estate	Rental and leasing services and lessors of intangible assets	Legal services	Miscellaneous professional, scientific and technical services	Computer systems design and related services	Management of companies and enterprises	Administrative and support services	Waste management and remediation services	Educational services	Ambulatory health care services	Hospitals and nursing and residential care facilities	Social assistance	Performing arts, spectator sports, museums, and related activities	Amusements, gambling, and recreation industries	Accommodation	Food services and drinking places	Other services, except government	Federal government enterprises	Federal general government	State and local government enterprises	State and local general government							
		531	532RL	5411	5412OP	5415	55	561	562	61	621	622HO	624	711AS	713	721	722	81	GFE	GFG	GSLE	GSLG							
111CA	Farms	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0005	0.0008	0.0011	0.0025	0.0018	0.0123	0.0002	0.0002	0.0000	0.0002	0.0012							
113FF	Forestry, fishing, and related activities	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0003	0.0000	0.0002	0.0000	0.0001	0.0005	0.0012	0.0091	0.0007	0.0002	0.0000	0.0001							
211	Oil and gas extraction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0000	0.0486	0.0000							
212	Mining, except oil and gas	0.0009	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0153	0.0007							
213	Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
22	Utilities	0.0270	0.0057	0.0023	0.0059	0.0014	0.0175	0.0056	0.0271	0.0081	0.0038	0.0118	0.0080	0.0053	0.0192	0.0244	0.0237	0.0132	0.0032	0.0062	0.0386	0.0241							
23	Construction	0.0160	0.0043	0.0024	0.0041	0.0011	0.0136	0.0027	0.0007	0.0178	0.0033	0.0057	0.0069	0.0038	0.0115	0.0141	0.0079	0.0079	0.0522	0.0170	0.0602	0.0213							
311FT	Food and beverage and tobacco products	0.0000	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000	0.0042	0.0000	0.0112	0.0215	0.0017	0.0176	0.0272	0.1595	0.0027	0.0057	0.0005	0.0031	0.0110							
3131T	Textile mills and textile product mills	0.0003	0.0001	0.0000	0.0002	0.0000	0.0000	0.0002	0.0000	0.0002	0.0000	0.0015	0.0009	0.0013	0.0010	0.0031	0.0004	0.0011	0.0000	0.0015	0.0110	0.0008							
315AL	Apparel and leather and allied products	0.0000	0.0009	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0002	0.0008	0.0002	0.0002	0.0000	0.0007	0.0003	0.0003	0.0000	0.0011	0.0000							
321	Wood products	0.0058	0.0003	0.0004	0.0006	0.0002	0.0023	0.0004	0.0045	0.0018	0.0008	0.0010	0.0038	0.0014	0.0016	0.0030	0.0013	0.0018	0.0000	0.0000	0.0039	0.0014							
322	Paper products	0.0008	0.0129	0.0029	0.0035	0.0011	0.0005	0.0054	0.0012	0.0040	0.0028	0.0048	0.0064	0.0016	0.0019	0.0031	0.0065	0.0032	0.0035	0.0011	0.0017	0.0040							
323	Printing and related support activities	0.0002	0.0002	0.0009	0.0063	0.0011	0.0067	0.0071	0.0003	0.0033	0.0012	0.0033	0.0094	0.0014	0.0006	0.0008	0.0004	0.0129	0.0041	0.0021	0.0012	0.0033							
324	Petroleum and coal products	0.0017	0.0060	0.0010	0.0012	0.0004	0.0013	0.0126	0.0124	0.0024	0.0026	0.0019	0.0150	0.0009	0.0027	0.0035	0.0032	0.0053	0.0464	0.0151	0.0565	0.0406							
325	Chemical products	0.0032	0.0028	0.0007	0.0094	0.0003	0.0020	0.0122	0.0121	0.0058	0.0243	0.0352	0.0064	0.0012	0.0029	0.0040	0.0018	0.0158	0.0020	0.0064	0.0159	0.0147							
326	Plastics and rubber products	0.0022	0.0045	0.0008	0.0027	0.0006	0.0044	0.0049	0.0023	0.0061	0.0100	0.0172	0.0108	0.0014	0.0023	0.0060	0.0102	0.0088	0.0003	0.0014	0.0093	0.0040							
327	Nonmetallic mineral products	0.0055	0.0013	0.0002	0.0023	0.0001	0.0023	0.0004	0.0000	0.0028	0.0014	0.0019	0.0008	0.0013	0.0011	0.0038	0.0022	0.0026	0.0000	0.0004	0.0131	0.0019							
331	Primary metals	0.0009	0.0000	0.0000	0.0003	0.0002	0.0002	0.0001	0.0000	0.0006	0.0001	0.0002	0.0009	0.0001	0.0029	0.0006	0.0001	0.0016	0.0000	0.0007	0.0022	0.0005							
332	Fabricated metal products	0.0050	0.0031	0.0006	0.0026	0.0007	0.0057	0.0016	0.0012	0.0064	0.0022	0.0022	0.0038	0.0022	0.0030	0.0047	0.0018	0.0088	0.0040	0.0065	0.0258	0.0027							
333	Machinery	0.0018	0.0022	0.0001	0.0012	0.0009	0.0005	0.0010	0.0007	0.0010	0.0005	0.0006	0.0002	0.0008	0.0011	0.0007	0.0010	0.0141	0.0046	0.0016	0.0106	0.0031							
334	Computer and electronic products	0.0002	0.0032	0.0004	0.0052	0.0234	0.0015	0.0046	0.0037	0.0026	0.0043	0.0040	0.0011	0.0004	0.0002	0.0003	0.0001	0.0095	0.0000	0.0243	0.0045	0.0025							
335	Electrical equipment, appliances, and components	0.0025	0.0005	0.0002	0.0012	0.0004	0.0007	0.0009	0.0005	0.0017	0.0004	0.0011	0.0006	0.0007	0.0013	0.0018	0.0006	0.0076	0.0009	0.0014	0.0086	0.0015							
3361MV	Motor vehicles, bodies and trailers, and parts	0.0001	0.0067	0.0009	0.0007	0.0001	0.0012	0.0025	0.0181	0.0009	0.0009	0.0030	0.0006	0.0005	0.0010	0.0007	0.0262	0.0072	0.0015	0.0015	0.0045	0.0000							
3364OT	Other transportation equipment	0.0000	0.0005	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0015	0.0004	0.0006							
337	Furniture and related products	0.0041	0.0000	0.0002	0.0004	0.0000	0.0003	0.0001	0.0000	0.0001	0.0001	0.0003	0.0002	0.0002	0.0007	0.0005	0.0002	0.0002	0.0003	0.0000	0.0015	0.0002							
339	Miscellaneous manufacturing	0.0001	0.0007	0.0003	0.0018	0.0001	0.0002	0.0014	0.0004	0.0026	0.0177	0.0135	0.0259	0.0031	0.0035	0.0024	0.0019	0.0061	0.0000	0.0039	0.0035	0.0051							
42	Wholesale trade	0.0042	0.0058	0.0019	0.0061	0.0054	0.0036	0.0127	0.0206	0.0120	0.0103	0.0138	0.0223	0.0032	0.0073	0.0113	0.0314	0.0225	0.0094	0.0075	0.0224	0.0146							
44RT	Retail trade	0.0068	0.0035	0.0016	0.0019	0.0005	0.0000	0.0110	0.0019	0.0006	0.0013	0.0020	0.0012	0.0010	0.0017	0.0031	0.0047	0.0154	0.0003	0.0000	0.0000	0.0000							
481	Air transportation	0.0005	0.0055	0.0050	0.0055	0.0022	0.0001	0.0055	0.0029	0.0028	0.0020	0.0058	0.0018	0.0010	0.0010	0.0016	0.0023	0.0024	0.0105	0.0063	0.0013	0.0015							
482	Rail transportation	0.0003	0.0004	0.0001	0.0003	0.0001	0.0002	0.0005	0.0014	0.0003	0.0003	0.0005	0.0005	0.0001	0.0003	0.0004	0.0013	0.0006	0.0031	0.0012	0.0084	0.0010							
483	Water transportation	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0011	0.0007	0.0002							
484	Truck transportation	0.0016	0.0015	0.0004	0.0011	0.0003	0.0007	0.0023	0.0112	0.0024	0.0014	0.0025	0.0046	0.0013	0.0019	0.0029	0.0078	0.0047	0.0253	0.0071	0.0082	0.0043							
485	Transit and ground passenger transportation	0.0006	0.0020	0.0015	0.0012	0.0004	0.0000	0.0016	0.0005	0.0014	0.0007	0.0020	0.0002	0.0011	0.0004	0.0030	0.0004	0.0015	0.0002	0.0000	0.0004	0.0035							
486	Pipeline transportation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0099	0.0001							
487OS	Other transportation and support activities	0.0007	0.0247	0.0041	0.0043	0.0017	0.0001	0.0029	0.0038	0.0019	0.0022	0.0025	0.0015	0.0018	0.0031	0.0025	0.0026	0.0023	0.0051	0.0001	0.0046	0.0011							
493	Warehousing and storage	0.0000	0.0008	0.0000	0.0008	0.0003	0.0000	0.0025	0.0004	0.0003	0.0004	0.0007	0.0015	0.0005	0.0015	0.0020	0.0001	0.0007	0.0000	0.0001	0.0009	0.0008							
511	Publishing industries (includes software)	0.0000	0.0009	0.0026	0.0029	0.0003	0.0006	0.0009	0.0001	0.0063	0.0018	0.0013	0.0067	0.0008	0.0008	0.0011	0.0003	0.0069	0.0011	0.0005	0.0003	0.0034							
512	Motion picture and sound recording industries	0.0000	0.0008	0.0000	0.0044	0.0001	0.0000	0.0003	0.0000	0.0000	0.0015	0.0001	0.0007	0.0054	0.0185	0.0005	0.0040	0.0068	0.0009	0.0035	0.0012	0.0002							
513	Broadcasting and telecommunications	0.0053	0.0148	0.0193	0.0030	0.0183	0.0396	0.0209	0.0116	0.0156	0.0149	0.0201	0.0139	0.0061	0.0114	0.0184	0.0137	0.0160	0.0063	0.0014	0.0078	0.0030							
514	Information and data processing services	0.0015	0.0065	0.0095	0.0122	0.0095	0.0276	0.0129	0.0068	0.0063	0.0060	0.0042	0.0060	0.0086	0.0051	0.0075	0.0045	0.0052	0.0034	0.0167	0.0081	0.0024							
521CI	Federal Reserve banks, credit intermediation, related activities	0.0327	0.0721	0.0087	0.0124	0.0093	0.0000	0.0011	0.0124	0.0005	0.0079	0.0079	0.0098	0.0151	0.0118	0.0224	0.0236	0.0085	0.0031	0.0008	0.0045	0.0001							
523	Securities, commodity contracts, and investments	0.0017	0.0100	0.0039	0.0060	0.0019	0.0000	0.0036	0.0019	0.0091	0.0006	0.0261	0.0012	0.0034	0.0032	0.0060	0.0035	0.0046	0.0021	0.0000	0.0083	0.0001							
524	Insurance carriers and related activities	0.0182	0.0236	0.0012	0.0008	0.0018	0.0090	0.0024	0.0058	0.0009	0.0028	0.0044	0.0018	0.0023	0.0011	0.0063	0.0024	0.0013	0.0043	0.0114	0.0033	0.0000							
525	Funds, trusts, and other financial vehicles	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
531	Real estate	0.0428	0.0341	0.0679	0.0498	0.0134	0.0578	0.0279	0.0031	0.1197	0.0463	0.0828	0.0607	0.0312	0.0682	0.0347	0.0615	0.0830	0.0172	0.0066	0.0285	0.0196							
532RL	Rental and leasing services and lessors of intangible assets	0.0010	0.0247	0.0035	0.0048	0.0095	0.0022	0.0075	0.0010	0.0085	0.0044	0.0085	0.0066	0.0077	0.0034	0.0130	0.0105	0.0161	0.0103	0.0024	0.0116	0.0050							
5411	Legal services	0.0090	0.0046	0.0354	0.0042	0.0022	0.0375	0.0110	0.0038	0.0035	0.0154	0.0119	0.0023	0.0046	0.0042	0.0047	0.0020	0.0059	0.0030	0.0025	0.0055	0.0063							
5412OP	Miscellaneous professional, scientific and technical services	0.0210	0.0838	0.0427	0.1055																								

Table B-5. Input-Output Model: Leontif industry-by-industry technical coefficient matrix, **A** (page 1 of 3)

		Industry (1 of 3)																					
		Farms	Forestry, fishing, and related activities	Oil and gas extraction	Mining, except oil and gas	Support activities for mining	Utilities	Construction	Food and beverage and tobacco products	Textile mills and textile product mills	Apparel and leather and allied products	Wood products	Paper products	Printing and related support activities	Petroleum and coal products	Chemical products	Plastics and rubber products	Nonmetallic mineral products	Primary metals	Fabricated metal products	Machinery	Computer and electronic products	Electrical equipment, appliances, and components
A	indLabel																						
	Farms	0.1304	0.0565	0.0000	0.0000	0.0001	0.0001	0.0014	0.2304	0.0282	0.0001	0.0205	0.0051	0.0000	0.0000	0.0026	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	
	Forestry, fishing, and related activities	0.0448	0.3081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0045	0.0001	0.0005	0.1348	0.0335	0.0001	0.0000	0.0003	0.0078	0.0000	0.0001	0.0000	0.0000	
	Oil and gas extraction	0.0016	0.0005	0.1644	0.0152	0.0039	0.2078	0.0012	0.0002	0.0003	0.0001	0.0004	0.0010	0.0003	0.6080	0.0162	0.0007	0.0007	0.0006	0.0003	0.0002	0.0001	
	Mining, except oil and gas	0.0017	0.0001	0.0001	0.0875	0.0012	0.0328	0.0069	0.0007	0.0012	0.0001	0.0001	0.0054	0.0001	0.0023	0.0064	0.0012	0.0723	0.0474	0.0006	0.0003	0.0004	
	Support activities for mining	0.0000	0.0000	0.0254	0.0150	0.0029	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	
	Utilities	0.0134	0.0012	0.0063	0.0141	0.0042	0.0083	0.0026	0.0110	0.0127	0.0043	0.0078	0.0194	0.0079	0.0140	0.0102	0.0117	0.0230	0.0152	0.0085	0.0043	0.0045	
	Construction	0.0030	0.0021	0.0000	0.0000	0.0009	0.0094	0.0010	0.0019	0.0019	0.0007	0.0012	0.0021	0.0017	0.0005	0.0018	0.0018	0.0023	0.0014	0.0022	0.0020	0.0019	
	Food and beverage and tobacco products	0.0616	0.0079	0.0002	0.0002	0.0003	0.0000	0.0002	0.1264	0.0025	0.0187	0.0006	0.0059	0.0010	0.0006	0.0053	0.0031	0.0005	0.0004	0.0004	0.0004	0.0005	
	Textile mills and textile product mills	0.0010	0.0013	0.0001	0.0002	0.0001	0.0000	0.0015	0.0003	0.1733	0.1325	0.0007	0.0094	0.0071	0.0001	0.0012	0.0146	0.0011	0.0004	0.0004	0.0014	0.0002	
	Apparel and leather and allied products	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0119	0.0760	0.0001	0.0008	0.0100	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	
	Wood products	0.0015	0.0003	0.0000	0.0004	0.0005	0.0009	0.0309	0.0010	0.0011	0.0050	0.2045	0.0170	0.0003	0.0002	0.0006	0.0014	0.0028	0.0022	0.0011	0.0017	0.0005	
	Paper products	0.0019	0.0002	0.0005	0.0008	0.0010	0.0004	0.0023	0.0243	0.0073	0.0027	0.0043	0.1930	0.1647	0.0013	0.0084	0.0187	0.0134	0.0032	0.0042	0.0040	0.0033	
	Printing and related support activities	0.0003	0.0002	0.0004	0.0003	0.0008	0.0003	0.0014	0.0035	0.0030	0.0049	0.0006	0.0014	0.0320	0.0005	0.0022	0.0009	0.0007	0.0010	0.0009	0.0009	0.0015	
	Petroleum and coal products	0.0340	0.0090	0.0077	0.0451	0.0621	0.0119	0.0233	0.0033	0.0134	0.0020	0.0054	0.0176	0.0052	0.0949	0.0474	0.0225	0.0066	0.0120	0.0062	0.0042	0.0013	
	Chemical products	0.0565	0.0175	0.0167	0.0095	0.0202	0.0011	0.0093	0.0093	0.1887	0.0096	0.0145	0.0501	0.0308	0.0188	0.2301	0.2767	0.0240	0.0076	0.0155	0.0094	0.0123	
	Plastics and rubber products	0.0034	0.0010	0.0018	0.0076	0.0031	0.0015	0.0183	0.0226	0.0067	0.0062	0.0071	0.0191	0.0088	0.0011	0.0161	0.0592	0.0073	0.0021	0.0046	0.0184	0.0087	
	Nonmetallic mineral products	0.0018	0.0000	0.0014	0.0020	0.0119	0.0023	0.0447	0.0056	0.0023	0.0002	0.0001	0.0012	0.0003	0.0017	0.0021	0.0055	0.0981	0.0104	0.0030	0.0037	0.0009	
	Primary metals	0.0017	0.0000	0.0082	0.0088	0.0255	0.0018	0.0076	0.0002	0.0007	0.0001	0.0005	0.0056	0.0012	0.0002	0.0010	0.0080	0.0092	0.3074	0.2067	0.1124	0.0187	
	Fabricated metal products	0.0033	0.0009	0.0074	0.0101	0.0257	0.0034	0.0518	0.0185	0.0061	0.0049	0.0221	0.0147	0.0062	0.0043	0.0093	0.0138	0.0123	0.0298	0.0981	0.0882	0.0300	
	Machinery	0.0117	0.0020	0.0062	0.0377	0.0239	0.0013	0.0196	0.0021	0.0038	0.0010	0.0030	0.0072	0.0118	0.0004	0.0036	0.0082	0.0018	0.0145	0.0106	0.0756	0.0087	
	Computer and electronic products	0.0002	0.0001	0.0002	0.0002	0.0032	0.0007	0.0038	0.0016	0.0058	0.0032	0.0048	0.0057	0.0080	0.0008	0.0040	0.0075	0.0045	0.0043	0.0055	0.0124	0.1703	
	Electrical equipment, appliances, and components	0.0016	0.0001	0.0002	0.0006	0.0024	0.0041	0.0182	0.0014	0.0014	0.0015	0.0082	0.0117	0.0011	0.0013	0.0014	0.0053	0.0018	0.0128	0.0064	0.0359	0.0144	
	Motor vehicles, bodies and trailers, and parts	0.0014	0.0008	0.0015	0.0028	0.0034	0.0002	0.0038	0.0005	0.0050	0.0037	0.0018	0.0026	0.0007	0.0003	0.0003	0.0008	0.0011	0.0057	0.0012	0.0109	0.0014	
	Other transportation equipment	0.0001	0.0001	0.0001	0.0005	0.0003	0.0000	0.0004	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0000	0.0001	0.0001	0.0001	0.0003	0.0003	0.0001	0.0003	
	Furniture and related products	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001	0.0101	0.0002	0.0010	0.0008	0.0129	0.0004	0.0002	0.0001	0.0002	0.0003	0.0003	0.0002	0.0004	0.0004	0.0009	
	Miscellaneous manufacturing	0.0004	0.0002	0.0004	0.0003	0.0006	0.0001	0.0016	0.0009	0.0009	0.0083	0.0015	0.0010	0.0010	0.0003	0.0016	0.0021	0.0014	0.0009	0.0011	0.0027	0.0028	
	Wholesale trade	0.0406	0.0213	0.0093	0.0210	0.0239	0.0051	0.0285	0.0665	0.0687	0.0610	0.0766	0.0739	0.0556	0.0426	0.0517	0.0519	0.0298	0.0698	0.0493	0.0644	0.0772	
	Retail trade	0.0024	0.0010	0.0027	0.0023	0.0025	0.0006	0.0625	0.0077	0.0040	0.0034	0.0030	0.0056	0.0035	0.0018	0.0051	0.0047	0.0053	0.0029	0.0026	0.0022	0.0031	
	Air transportation	0.0005	0.0003	0.0001	0.0004	0.0006	0.0002	0.0009	0.0025	0.0016	0.0021	0.0012	0.0018	0.0025	0.0008	0.0011	0.0018	0.0012	0.0012	0.0015	0.0020	0.0028	
	Rail transportation	0.0054	0.0013	0.0004	0.0209	0.0018	0.0161	0.0017	0.0049	0.0068	0.0007	0.0073	0.0096	0.0051	0.0012	0.0031	0.0055	0.0089	0.0141	0.0023	0.0015	0.0004	
	Water transportation	0.0003	0.0002	0.0002	0.0015	0.0010	0.0009	0.0004	0.0004	0.0007	0.0000	0.0006	0.0007	0.0001	0.0006	0.0005	0.0003	0.0034	0.0015	0.0001	0.0001	0.0002	
	Truck transportation	0.0105	0.0036	0.0013	0.0177	0.0084	0.0042	0.0104	0.0172	0.0299	0.0130	0.0354	0.0483	0.0214	0.0028	0.0160	0.0199	0.0775	0.0475	0.0081	0.0075	0.0029	
	Transit and ground passenger transportation	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	
	Pipeline transportation	0.0002	0.0000	0.0004	0.0024	0.0003	0.0348	0.0001	0.0001	0.0001	0.0000	0.0001	0.0002	0.0001	0.0104	0.0016	0.0001	0.0002	0.0001	0.0001	0.0000	0.0000	
	Other transportation and support activities	0.0003	0.0007	0.0004	0.0013	0.0008	0.0010	0.0020	0.0027	0.0027	0.0009	0.0017	0.0019	0.0017	0.0009	0.0010	0.0015	0.0026	0.0018	0.0014	0.0013	0.0013	
	Warehousing and storage	0.0066	0.0001	0.0010	0.0022	0.0075	0.0000	0.0001	0.0054	0.0020	0.0034	0.0015	0.0013	0.0037	0.0013	0.0052	0.0019	0.0022	0.0009	0.0018	0.0024	0.0049	
	Publishing industries (includes software)	0.0007	0.0005	0.0015	0.0011	0.0021	0.0006	0.0036	0.0029	0.0017	0.0015	0.0018	0.0018	0.0032	0.0013	0.0027	0.0020	0.0017	0.0012	0.0021	0.0024	0.0279	
	Motion picture and sound recording industries	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0006	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004	0.0001	0.0000	0.0000	0.0001	0.0001	0.0002	
	Broadcasting and telecommunications	0.0034	0.0008	0.0025	0.0017	0.0060	0.0012	0.0121	0.0062	0.0040	0.0032	0.0041	0.0036	0.0062	0.0018	0.0045	0.0052	0.0048	0.0022	0.0056	0.0117	0.0108	
	Information and data processing services	0.0006	0.0004	0.0005	0.0007	0.0029	0.0007	0.0022	0.0037	0.0030	0.0018	0.0021	0.0021	0.0036	0.0005	0.0031	0.0023	0.0024	0.0014	0.0027	0.0045	0.0060	
	Federal Reserve banks, credit intermediation, related activities	0.0089	0.0045	0.0166	0.0085	0.0133	0.0076	0.0113	0.0130	0.0076	0.0064	0.0071	0.0081	0.0101	0.0054	0.0081	0.0094	0.0092	0.0053	0.0085	0.0093	0.0121	
	Securities, commodity contracts, and investments	0.0003	0.00.																				

Input-Output Model: Leontif industry-by-industry technical coefficient matrix, A (page 2 of 3)

A	indLabel	Industry (2 of 3)																												
		Motor vehicles, bodies and trailers, and parts	Other transportation equipment	Furniture and related products	Miscellaneous manufacturing	Wholesale trade	Retail trade	Air transportation	Rail transportation	Water transportation	Truck transportation	Transit and ground passenger transportation	Pipeline transportation	Other transportation and support activities	Warehousing and storage	Publishing industries (includes software)	Motion picture and sound recording industries	Broadcasting and telecommunications	Information and data processing services	Federal reserve banks, credit intermediation, and related activities	Securities, commodity contracts, and investments	Insurance carriers and related activities	Funds, trusts, and other financial vehicles							
	Farms	0.0000	0.0000	0.0001	0.0004	0.0025	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
	Forestry, fishing, and related activities	0.0000	0.0000	0.0003	0.0009	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
	Oil and gas extraction	0.0002	0.0003	0.0003	0.0002	0.0003	0.0004	0.0101	0.0022	0.0026	0.0042	0.0035	0.1514	0.0025	0.0011	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000							
	Mining, except oil and gas	0.0044	0.0002	0.0001	0.0015	0.0001	0.0001	0.0000	0.0001	0.0035	0.0004	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
	Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
	Utilities	0.0030	0.0033	0.0066	0.0045	0.0053	0.0096	0.0009	0.0008	0.0015	0.0020	0.0016	0.0166	0.0016	0.0167	0.0035	0.0064	0.0043	0.0038	0.0027	0.0059	0.0002	0.0010							
	Construction	0.0006	0.0016	0.0020	0.0033	0.0025	0.0040	0.0001	0.0001	0.0004	0.0016	0.0000	0.0235	0.0009	0.0038	0.0025	0.0042	0.0031	0.0045	0.0060	0.0034	0.0004	0.0018							
	Food and beverage and tobacco products	0.0004	0.0004	0.0014	0.0027	0.0040	0.0052	0.0012	0.0002	0.0022	0.0002	0.0002	0.0000	0.0022	0.0000	0.0004	0.0038	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000						
	Textile mills and textile product mills	0.0100	0.0033	0.0356	0.0193	0.0007	0.0005	0.0001	0.0000	0.0027	0.0001	0.0001	0.0014	0.0002	0.0000	0.0004	0.0013	0.0001	0.0001	0.0003	0.0001	0.0000	0.0000	0.0000						
	Apparel and leather and allied products	0.0022	0.0003	0.0008	0.0019	0.0017	0.0002	0.0000	0.0001	0.0013	0.0001	0.0004	0.0001	0.0001	0.0006	0.0001	0.0007	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000						
	Wood products	0.0018	0.0015	0.0083	0.0104	0.0032	0.0017	0.0000	0.0102	0.0000	0.0002	0.0001	0.0002	0.0005	0.0010	0.0004	0.0012	0.0022	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000						
	Paper products	0.0028	0.0011	0.0144	0.0203	0.0032	0.0040	0.0002	0.0010	0.0010	0.0014	0.0013	0.0015	0.0013	0.0027	0.0234	0.0017	0.0018	0.0026	0.0012	0.0011	0.0002	0.0004	0.0010						
	Printing and related support activities	0.0010	0.0011	0.0031	0.0013	0.0051	0.0021	0.0011	0.0010	0.0020	0.0009	0.0021	0.0024	0.0010	0.0007	0.0420	0.0027	0.0053	0.0087	0.0031	0.0016	0.0021	0.0013	0.0000						
	Petroleum and coal products	0.0029	0.0050	0.0028	0.0042	0.0059	0.0075	0.1998	0.0438	0.0508	0.0827	0.0691	0.1443	0.0489	0.0227	0.0023	0.0007	0.0018	0.0012	0.0011	0.0007	0.0001	0.0003	0.0000						
	Chemical products	0.0145	0.0139	0.0116	0.0383	0.0038	0.0018	0.0055	0.0023	0.0028	0.0444	0.0038	0.0044	0.0019	0.0010	0.0048	0.0021	0.0020	0.0021	0.0004	0.0003	0.0002	0.0004	0.0000						
	Plastics and rubber products	0.0273	0.0126	0.0511	0.0298	0.0074	0.0061	0.0002	0.0022	0.0012	0.102	0.0117	0.0005	0.0020	0.0011	0.0016	0.0020	0.0041	0.0010	0.0003	0.0003	0.0002	0.0001	0.0000						
	Nonmetallic mineral products	0.0077	0.0035	0.0034	0.0044	0.0009	0.0010	0.0001	0.0043	0.0002	0.0002	0.0006	0.0004	0.0001	0.0001	0.0002	0.0004	0.0023	0.0018	0.0001	0.0001	0.0000	0.0000	0.0000						
	Primary metals	0.0805	0.0479	0.0396	0.0496	0.0028	0.0015	0.0001	0.0248	0.0001	0.0001	0.0002	0.0025	0.0004	0.0001	0.0003	0.0001	0.0030	0.0002	0.0001	0.0002	0.0001	0.0000	0.0000						
	Fabricated metal products	0.0544	0.0739	0.0338	0.0335	0.0036	0.0031	0.0047	0.0059	0.0119	0.0075	0.0155	0.0255	0.0024	0.0021	0.0077	0.0035	0.0101	0.0013	0.0002	0.0003	0.0001	0.0001	0.0000						
	Machinery	0.0403	0.0261	0.0016	0.0098	0.0040	0.0016	0.0047	0.0093	0.0016	0.0024	0.0199	0.0024	0.0003	0.0009	0.0004	0.0008	0.0006	0.0002	0.0003	0.0000	0.0000	0.0000	0.0000						
	Computer and electronic products	0.0206	0.0605	0.0050	0.0134	0.0068	0.0022	0.0011	0.0116	0.0008	0.0004	0.0008	0.0010	0.0008	0.0001	0.0191	0.0124	0.0182	0.0764	0.0035	0.0006	0.0004	0.0002	0.0000						
	Electrical equipment, appliances, and components	0.0098	0.0088	0.0016	0.0041	0.0015	0.0011	0.0001	0.0077	0.0004	0.0031	0.0055	0.0008	0.0007	0.0003	0.0004	0.0003	0.0086	0.0014	0.0001	0.0001	0.0000	0.0001	0.0000						
	Motor vehicles, bodies and trailers, and parts	0.2876	0.0063	0.0016	0.0014	0.0021	0.0130	0.0002	0.0140	0.0005	0.0206	0.0309	0.0022	0.0021	0.0022	0.0005	0.0005	0.0003	0.0004	0.0012	0.0002	0.0001	0.0000	0.0000						
	Other transportation equipment	0.0011	0.1273	0.0001	0.0002	0.0004	0.0012	0.0234	0.0120	0.0215	0.0002	0.0006	0.0004	0.0056	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000						
	Furniture and related products	0.0005	0.0005	0.0151	0.0013	0.0002	0.0002	0.0000	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	0.0002	0.0003	0.0002	0.0000	0.0000	0.0000	0.0000						
	Miscellaneous manufacturing	0.0016	0.0015	0.0012	0.0443	0.0020	0.0012	0.0003	0.0004	0.0007	0.0004	0.0009	0.0005	0.0002	0.0003	0.0008	0.0005	0.0009	0.0030	0.0008	0.0005	0.0001	0.0002	0.0000						
	Wholesale trade	0.0630	0.0363	0.0635	0.0638	0.0346	0.0084	0.0249	0.0309	0.0245	0.0383	0.0347	0.0130	0.0092	0.0094	0.0295	0.0167	0.0103	0.0131	0.0026	0.0018	0.0007	0.0009	0.0000						
	Retail trade	0.0091	0.0011	0.0180	0.0040	0.0045	0.0051	0.0030	0.0040	0.0069	0.0117	0.0057	0.0038	0.0023	0.0017	0.0030	0.0021	0.0036	0.0064	0.0021	0.0017	0.0007	0.0007	0.0000						
	Air transportation	0.0030	0.0029	0.0019	0.0016	0.0021	0.0016	0.0005	0.0006	0.0008	0.0037	0.0009	0.0002	0.0010	0.0002	0.0031	0.0017	0.0010	0.0096	0.0039	0.0036	0.0016	0.0016	0.0000						
	Rail transportation	0.0035	0.0009	0.0027	0.0019	0.0004	0.0004	0.0015	0.0018	0.0006	0.0075	0.0009	0.0006	0.0007	0.0003	0.0008	0.0002	0.0002	0.0004	0.0002	0.0001	0.0000	0.0001	0.0000						
	Water transportation	0.0001	0.0000	0.0003	0.0002	0.0001	0.0001	0.0008	0.0004	0.0006	0.0007	0.0003	0.0002	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000						
	Truck transportation	0.0117	0.0050	0.0175	0.0106	0.0017	0.0029	0.0014	0.0045	0.0015	0.1208	0.0093	0.0014	0.0019	0.0020	0.0035	0.0008	0.0011	0.0013	0.0009	0.0006	0.0001	0.0004	0.0000						
	Transit and ground passenger transportation	0.0001	0.0001	0.0001	0.0001	0.0003	0.0004	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.0000	0.0004	0.0002	0.0013	0.0014	0.0008	0.0004	0.0003	0.0002	0.0000						
	Pipeline transportation	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0006	0.0001	0.0002	0.0003	0.0002	0.0209	0.0002	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
	Other transportation and support activities	0.0011	0.0010	0.0016	0.0012	0.0089	0.0059	0.0700	0.0574	0.1483	0.0394	0.0344	0.0177	0.0377	0.0038	0.0045	0.0035	0.0019	0.0017	0.0056	0.0056	0.0014	0.0014	0.0000						
	Warehousing and storage	0.0032	0.0047	0.0016	0.0027	0.0028	0.0060	0.0001	0.0000	0.0032	0.0198	0.0009	0.0000	0.0018	0.0009	0.0023	0.0001	0.0003	0.0007	0.0037	0.0020	0.0001	0.0002	0.0000						
	Publishing industries (includes software)	0.0023	0.0026	0.0027	0.0027	0.0027	0.0028	0.0009	0.0025	0.0064	0.0019	0.0025	0.0065	0.0016	0.0013	0.0611	0.0048	0.0056	0.0107	0.0038	0.0026	0.0009	0.0017	0.0000						
	Motion picture and sound recording industries	0.0001	0.0000	0.0005	0.0003	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0001	0.0000	0.0005	0.2355	0.0249	0.0004	0.0000	0.0001	0.0000	0.0003	0.0000						
	Broadcasting and telecommunications	0.0057	0.0049	0.0066	0.0091	0.0149	0.0126	0.0075	0.0038	0.0060	0.0156	0.0084	0.0103	0.0150																

Input-Output Model: Leontif industry-by-industry technical coefficient matrix, A (page 3 of 3)

		Industry (3 of 3)																						
		Real estate	Rental and leasing services and lessors of intangible assets	Legal services	Miscellaneous professional, scientific and technical services	Computer systems design and related services	Management of companies and enterprises	Administrative and support services	Waste management and remediation services	Educational services	Ambulatory health care services	Hospitals and nursing and residential care facilities	Social assistance	Performing arts, spectator sports, museums, and related activities	Amusements, gambling, and recreation industries	Accommodation	Food services and drinking places	Other services, except government	Federal government enterprises	Federal general government	State and local government enterprises	State and local general government		
A	indLabel																							
	Farms	0.0005	0.0000	0.0000	0.0001	0.0000	0.0000	0.0111	0.0000	0.0005	0.0000	0.0000	0.0008	0.0011	0.0025	0.0019	0.0134	0.0003	0.0002	0.0000	0.0002	0.0012		
	Forestry, fishing, and related activities	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0000	0.0001	0.0000	0.0001	0.0004	0.0010	0.0074	0.0006	0.0002	0.0000	0.0000	0.0001		
	Oil and gas extraction	0.0001	0.0003	0.0001	0.0001	0.0000	0.0000	0.0001	0.0006	0.0053	0.0001	0.0001	0.0001	0.0007	0.0000	0.0001	0.0002	0.0002	0.0003	0.0031	0.0008	0.0510		
	Mining, except oil and gas	0.0009	0.0000	0.0000	0.0005	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0002	0.0151			
	Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
	Utilities	0.0218	0.0047	0.0019	0.0048	0.0011	0.0143	0.0045	0.0217	0.0068	0.0031	0.0095	0.0065	0.0043	0.0155	0.0198	0.0191	0.0107	0.0035	0.0054	0.0338			
	Construction	0.0146	0.0039	0.0022	0.0037	0.0010	0.0123	0.0025	0.0006	0.0162	0.0030	0.0052	0.0063	0.0034	0.0105	0.0128	0.0072	0.0072	0.0474	0.0154	0.0547			
	Food and beverage and tobacco products	0.0000	0.0001	0.0000	0.0009	0.0000	0.0001	0.0002	0.0002	0.0042	0.0003	0.0112	0.0210	0.0017	0.0171	0.0265	0.1549	0.0029	0.0056	0.0007	0.0032			
	Textile mills and textile product mills	0.0003	0.0001	0.0000	0.0003	0.0000	0.0001	0.0003	0.0001	0.0003	0.0002	0.0016	0.0010	0.0013	0.0010	0.0029	0.0004	0.0012	0.0001	0.0015	0.0010			
	Apparel and leather and allied products	0.0000	0.0008	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0001	0.0005	0.0003	0.0008	0.0002	0.0003	0.0001	0.0007	0.0003	0.0003	0.0001			
	Wood products	0.0057	0.0003	0.0004	0.0006	0.0002	0.0022	0.0004	0.0045	0.0018	0.0008	0.0010	0.0038	0.0014	0.0016	0.0030	0.0013	0.0018	0.0000	0.0001	0.0039			
	Paper products	0.0009	0.0127	0.0029	0.0035	0.0012	0.0005	0.0054	0.0012	0.0040	0.0029	0.0049	0.0065	0.0016	0.0019	0.0031	0.0065	0.0034	0.0035	0.0013	0.0018			
	Printing and related support activities	0.0007	0.0020	0.0018	0.0083	0.0015	0.0087	0.0079	0.0007	0.0038	0.0016	0.0038	0.0096	0.0021	0.0016	0.0016	0.0011	0.0134	0.0045	0.0045	0.0033			
	Petroleum and coal products	0.0018	0.0058	0.0010	0.0016	0.0004	0.0014	0.0124	0.1051	0.0026	0.0037	0.0036	0.0143	0.0009	0.0027	0.0035	0.0031	0.0058	0.0433	0.0144	0.0535			
	Chemical products	0.0031	0.0029	0.0007	0.0089	0.0004	0.0020	0.0119	0.0140	0.0057	0.0228	0.0330	0.0067	0.0012	0.0029	0.0041	0.0025	0.0152	0.0031	0.0066	0.0165			
	Plastics and rubber products	0.0021	0.0044	0.0008	0.0026	0.0006	0.0043	0.0048	0.0022	0.0059	0.0097	0.0166	0.0105	0.0014	0.0023	0.0059	0.0099	0.0086	0.0003	0.0015	0.0091			
	Nonmetallic mineral products	0.0054	0.0013	0.0002	0.0023	0.0001	0.0023	0.0004	0.0001	0.0028	0.0014	0.0019	0.0009	0.0013	0.0012	0.0038	0.0022	0.0026	0.0000	0.0004	0.0130			
	Primary metals	0.0010	-0.0001	0.0000	0.0003	0.0002	0.0002	0.0001	0.0001	0.0007	0.0001	0.0002	0.0009	0.0001	0.0028	0.0006	0.0002	0.0019	0.0001	0.0012	0.0024			
	Fabricated metal products	0.0049	0.0029	0.0006	0.0026	0.0007	0.0056	0.0016	0.0013	0.0063	0.0022	0.0023	0.0038	0.0022	0.0030	0.0046	0.0019	0.0090	0.0040	0.0070	0.0252			
	Machinery	0.0018	0.0021	0.0001	0.0012	0.0010	0.0006	0.0011	0.0008	0.0012	0.0006	0.0008	0.0004	0.0008	0.0012	0.0008	0.0011	0.0140	0.0045	0.0025	0.0108			
	Computer and electronic products	0.0003	0.0033	0.0005	0.0053	0.0232	0.0016	0.0047	0.0038	0.0027	0.0044	0.0041	0.0013	0.0005	0.0003	0.0004	0.0003	0.0097	0.0002	0.0255	0.0049			
	Electrical equipment, appliances, and components	0.0024	0.0005	0.0002	0.0011	0.0004	0.0007	0.0009	0.0006	0.0017	0.0004	0.0011	0.0006	0.0007	0.0013	0.0018	0.0007	0.0074	0.0009	0.0015	0.0083			
	Motor vehicles, bodies and trailers, and parts	0.0001	0.0066	0.0009	0.0008	0.0002	0.0012	0.0025	0.0181	0.0010	0.0006	0.0010	0.0031	0.0007	0.0006	0.0011	0.0008	0.0263	0.0073	0.0022	0.0018			
	Other transportation equipment	0.0001	0.0006	0.0000	0.0003	0.0000	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0007	0.0000	0.0001	0.0016	0.0005	0.0393	0.0007			
	Furniture and related products	0.0041	0.0001	0.0002	0.0004	0.0001	0.0003	0.0001	0.0001	0.0001	0.0002	0.0004	0.0003	0.0003	0.0008	0.0005	0.0002	0.0003	0.0003	0.0001	0.0017			
	Miscellaneous manufacturing	0.0003	0.0010	0.0004	0.0022	0.0003	0.0006	0.0016	0.0006	0.0027	0.0171	0.0131	0.0249	0.0030	0.0035	0.0025	0.0021	0.0062	0.0001	0.0043	0.0039			
	Wholesale trade	0.0051	0.0091	0.0023	0.0071	0.0060	0.0058	0.0132	0.0267	0.0125	0.0108	0.0146	0.0226	0.0040	0.0088	0.0128	0.0331	0.0229	0.0096	0.0084	0.0224			
	Retail trade	0.0088	0.0095	0.0025	0.0041	0.0019	0.0033	0.0127	0.0152	0.0026	0.0029	0.0047	0.0032	0.0024	0.0045	0.0061	0.0087	0.0174	0.0020	0.0015	0.0020			
	Air transportation	0.0005	0.0052	0.0048	0.0052	0.0021	0.0001	0.0053	0.0028	0.0027	0.0019	0.0055	0.0017	0.0010	0.0010	0.0016	0.0022	0.0023	0.0100	0.0061	0.0012			
	Rail transportation	0.0004	0.0005	0.0001	0.0003	0.0001	0.0002	0.0005	0.0014	0.0004	0.0003	0.0005	0.0006	0.0001	0.0003	0.0005	0.0013	0.0007	0.0033	0.0013	0.0085			
	Water transportation	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0011	0.0007			
	Truck transportation	0.0016	0.0016	0.0004	0.0012	0.0003	0.0007	0.0024	0.0110	0.0023	0.0014	0.0025	0.0046	0.0013	0.0020	0.0030	0.0075	0.0046	0.0245	0.0070	0.0080			
	Transit and ground passenger transportation	0.0004	0.0014	0.0011	0.0009	0.0003	0.0000	0.0012	0.0004	0.0010	0.0005	0.0015	0.0002	0.0008	0.0003	0.0021	0.0003	0.0011	0.0001	0.0000	0.0003			
	Pipeline transportation	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0005	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0003	0.0001	0.0086			
	Other transportation and support activities	0.0006	0.0224	0.0039	0.0042	0.0017	0.0002	0.0029	0.0037	0.0019	0.0021	0.0026	0.0015	0.0017	0.0029	0.0024	0.0026	0.0023	0.0055	0.0006	0.0045			
	Warehousing and storage	0.0000	0.0008	0.0000	0.0008	0.0003	0.0000	0.0023	0.0004	0.0003	0.0004	0.0006	0.0014	0.0005	0.0014	0.0019	0.0001	0.0006	0.0001	0.0012	0.0009			
	Publishing industries (includes software)	0.0012	0.0059	0.0050	0.0091	0.0018	0.0068	0.0037	0.0011	0.0081	0.0032	0.0029	0.0078	0.0027	0.0033	0.0035	0.0023	0.0091	0.0023	0.0087	0.0063			
	Motion picture and sound recording industries	0.0000	0.0008	0.0000	0.0041	0.0001	0.0000	0.0003	0.0000	0.0144	0.0001	0.0006	0.0051	0.0176	0.0005	0.0038	0.0064	0.0009	0.0003	0.0015	0.0011			
	Broadcasting and telecommunications	0.0066	0.0201	0.0219	0.0294	0.0199	0.0462	0.0235	0.0131	0.0185	0.0164	0.0218	0.0156	0.0092	0.0143	0.0213	0.0163	0.0187	0.0079	0.0206	0.0141			
	Information and data processing services	0.0014	0.0061	0.0087	0.0112	0.0088	0.0253	0.0118	0.0062	0.0059	0.0056	0.0039	0.0046	0.0060	0.0047	0.0069	0.0041	0.0085	0.0031	0.0155	0.0056			
	Federal Reserve banks, credit intermediation, related activities	0.0327	0.0764	0.0095	0.0144	0.0110	0.0038	0.0128	0.0132	0.0075	0.0093	0.0081	0.0106	0.0174	0.0236	0.0254	0.0255	0.0098	0.0037	0.0166	0.0059			
	Securities, commodity contracts, and investments	0.0020	0.0104	0.0039	0.0060	0.0020	0.0003	0.0036	0.0020	0.0088	0.0046	0.0251	0.0070	0.0034	0.0033	0.0060	0.0036	0.0045	0.0021	0.0004	0.0081			
	Insurance carriers and related activities	0.0179	0.0234	0.0012	0.0010	0.0019	0.0091	0.0091	0.0025	0.0057	0.0009	0.0021	0.0054	0.0018	0.0022	0.0011	0.0063	0.0024	0.0013	0.0043	0.0121			
	Funds, trusts, and other financial vehicles	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
	Real estate	0.0430	0.0340	0.0673	0.0445	0.0133	0.0577	0.0278	0.0031	0.1192	0.0460	0.0821	0.0603	0.0130	0.0680	0.0349	0.0612	0.0825	0.0190	0.0072	0.0285			
	Rental and leasing services and lessors of intangible assets	0.0007	0.0183	0.0026	0.0073	0.0070	0.0150	0.0063	0.0034	0.0063	0.0049	0.0057	0.0025	0.0096	0.0042	0.0119	0.0081	0.0047	0.0018	0.0013	0.0037			
	Legal services	0.0090	0.0046	0.0034	0.0092	0.0022	0.0375	0.0110	0.0038	0.0035	0.0154	0.0179	0.0023	0.0046	0.0078	0.0046	0.0020	0.0059	0.0030	0.0025	0.0055			
	Miscellaneous professional, scientific and technical services	0.0180	0.0719	0.0368	0.0905	0.0179	0.0883	0.0401	0.0143	0.0264	0.0184	0.0222	0.0175	0.0286	0.0390	0.0355	0.0284	0.0351	0.0162	0.0098	0.0853			
	Computer systems design and related services	0.0006	0.0055	0.0016	0.0052	0.0036	0.0064	0.0025	0.0017	0.0016	0.0020	0.0016	0.0006	0.0006	0.0008	0.0009	0.0007	0.0013	0.0019	0.0200	0.0051			
	Management of companies and enterprises	0.0007	0.0166	0.0009	0.0066	0.0037	0.0006	0.0239	0.0017	0.0048	0.0114	0.0134	0.0267	0.0065	0.0187	0.0223	0.0003	0.0114	0.0001	0.0008	0.0025			

Table B-6. Input-Output Model vectors **Ax**, **x**, and **c**

indLabel	Ax	x	c
Farms	10248825	19758371	9509546
Forestry, fishing, and related activities	10710954	19512594	8801640
Oil and gas extraction	25217916	19725380	-5492537
Mining, except oil and gas	5894184	19530516	13636332
Support activities for mining	899311	19578786	18679475
Utilities	10793383	19914878	9121495
Construction	7178338	20697814	13519476
Food and beverage and tobacco products	10441151	20163696	9722545
Textile mills and textile product mills	8581864	19516607	10934744
Apparel and leather and allied products	2285347	19482983	17197636
Wood products	8593162	19550865	10957703
Paper products	12426968	19617192	7190224
Printing and related support activities	4697614	19552945	14855332
Petroleum and coal products	28765143	20034077	-8731066
Chemical products	26945537	20094131	-6851406
Plastics and rubber products	10416172	19658935	9242763
Nonmetallic mineral products	5831068	19569844	13738776
Primary metals	22150456	19691597	-2458859
Fabricated metal products	17678561	19773194	2094633
Machinery	8946361	19773951	10827590
Computer and electronic products	12381492	19838462	7456971
Electrical equipment, appliances, and components	5342792	19575563	14232771
Motor vehicles, bodies and trailers, and parts	10341951	19929614	9587663
Other transportation equipment	4820621	19671114	14850493
Furniture and related products	1186954	19531386	18344432
Miscellaneous manufacturing	3758014	19606792	15848778
Wholesale trade	36735813	20686416	-16049397
Retail trade	7051699	20831829	13780130
Air transportation	2782341	19601839	16819498
Rail transportation	3320142	19522097	16201955
Water transportation	433906	19487437	19053530
Truck transportation	13886723	19725882	5839159
Transit and ground passenger transportation	970794	19482914	18512119
Pipeline transportation	1797903	19485575	17687672
Other transportation and support activities	10112529	19585716	9473186
Warehousing and storage	2582988	19502049	16919061
Publishing industries (includes software)	5890591	19756204	13865614
Motion picture and sound recording industries	6350569	19550549	13199980
Broadcasting and telecommunications	20744613	20250034	-494579
Information and data processing services	6916475	19636577	12720102
Federal Reserve banks, credit intermediation, and related activities	19874532	20214199	339667
Securities, commodity contracts, and investments	22674187	19918938	-2755249
Insurance carriers and related activities	13735051	20119505	6384455
Funds, trusts, and other financial vehicles	459475	19565041	19105566
Real estate	30507410	21682569	-8824841
Rental and leasing services and lessors of intangible assets	9547895	19737557	10189662
Legal services	7427421	19730980	12303559
Miscellaneous professional, scientific and technical services	44859962	20552377	-24307585
Computer systems design and related services	3894746	19667946	15773200
Management of companies and enterprises	21408348	19899166	-1509182
Administrative and support services	24742630	20060653	-4681977
Waste management and remediation services	4847740	19526471	14678731
Educational services	1572819	19666650	18093831
Ambulatory health care services	423073	20180854	19757781
Hospitals and nursing and residential care facilities	158783	20138209	19979426
Social assistance	108566	19589175	19480609
Performing arts, spectator sports, museums, and related activities	4663349	19550569	14887220
Amusements, gambling, and recreation industries	476042	19560084	19084042
Accommodation	2403180	19651992	17248812
Food services and drinking places	4376862	19967066	15590204
Other services, except government	10405740	20051214	9645473
Federal government enterprises	3302342	19552275	16249933
Federal general government	744144	20320337	19576193
State and local government enterprises	4553602	19684700	15131098
State and local general government	3689097	21162095	17472998

Table B-7. Inoperability Input-Output Model A* matrix (page 1 of 3)

		Industry (1 of 3)																							
		Farms	Forestry, fishing, and related activities	Oil and gas extraction	Mining, except oil and gas	Support activities for mining	Utilities	Construction	Food and beverage and tobacco products	Textile mills and textile product mills	Apparel and leather and allied products	Wood products	Paper products	Printing and related support activities	Petroleum and coal products	Chemical products	Plastics and rubber products	Nonmetallic mineral products	Primary metals	Fabricated metal products	Machinery	Computer and electronic products	Electrical equipment, appliances, and components		
A*	indLabel																								
	Farms	0.1304	0.0558	0.0000	0.0000	0.0001	0.0001	0.0015	0.2351	0.0278	0.0001	0.0203	0.0050	0.0000	0.0000	0.0027	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000			
	Forestry, fishing, and related activities	0.0454	0.3081	0.0000	0.0000	0.0000	0.0000	0.0000	0.0046	0.0001	0.0005	0.1351	0.0337	0.0001	0.0000	0.0003	0.0078	0.0000	0.0001	0.0000	0.0000	0.0000			
	Oil and gas extraction	0.0016	0.0005	0.1644	0.0150	0.0039	0.2098	0.0012	0.0003	0.0003	0.0001	0.0004	0.0001	0.0003	0.6175	0.1655	0.0007	0.0006	0.0003	0.0002	0.0001	0.0002			
	Mining, except oil and gas	0.0018	0.0001	0.0001	0.0875	0.0012	0.0335	0.0073	0.0007	0.0012	0.0001	0.0001	0.0054	0.0001	0.0023	0.0668	0.0012	0.0725	0.0478	0.0006	0.0003	0.0004			
	Support activities for mining	0.0000	0.0000	0.0256	0.0150	0.0029	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
	Utilities	0.0133	0.0012	0.0062	0.0138	0.0041	0.0083	0.0027	0.0112	0.0124	0.0042	0.0077	0.0191	0.0077	0.0141	0.0103	0.0115	0.0226	0.0151	0.0085	0.0043	0.0045			
	Construction	0.0028	0.0020	0.0000	0.0000	0.0008	0.0090	0.0010	0.0019	0.0018	0.0007	0.0011	0.0020	0.0016	0.0005	0.0017	0.0017	0.0022	0.0014	0.0021	0.0019	0.0018			
	Food and beverage and tobacco products	0.0604	0.0076	0.0002	0.0002	0.0003	0.0000	0.0002	0.1264	0.0024	0.0181	0.0006	0.0057	0.0010	0.0006	0.0053	0.0030	0.0005	0.0004	0.0003	0.0004	0.0005			
	Textile mills and textile product mills	0.0010	0.0013	0.0001	0.0002	0.0001	0.0000	0.0016	0.0004	0.1733	0.1323	0.0007	0.0095	0.0072	0.0001	0.0013	0.0148	0.0011	0.0004	0.0004	0.0014	0.0002			
	Apparel and leather and allied products	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0120	0.0760	0.0001	0.0008	0.0100	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001			
	Wood products	0.0016	0.0003	0.0000	0.0004	0.0005	0.0009	0.0327	0.0010	0.0011	0.0050	0.2045	0.170	0.0003	0.0002	0.0006	0.014	0.0028	0.0022	0.0011	0.0017	0.0006			
	Paper products	0.0019	0.0002	0.0005	0.0008	0.0010	0.0004	0.0024	0.0250	0.0072	0.0027	0.0043	0.1930	0.1641	0.0013	0.0068	0.187	0.0133	0.0032	0.0043	0.0040	0.0034			
	Printing and related support activities	0.0003	0.0002	0.0004	0.0003	0.0008	0.0003	0.0015	0.0036	0.0030	0.0049	0.0006	0.014	0.0320	0.0005	0.0023	0.0009	0.0007	0.0011	0.0009	0.0009	0.0015			
	Petroleum and coal products	0.0335	0.0088	0.0075	0.0439	0.0607	0.0118	0.0241	0.0033	0.0131	0.0020	0.0053	0.0172	0.0051	0.0949	0.0475	0.0221	0.0664	0.0118	0.0062	0.0041	0.0013			
	Chemical products	0.0555	0.0170	0.0164	0.0092	0.0197	0.0010	0.0095	0.0094	0.1832	0.0093	0.0141	0.0489	0.0300	0.0188	0.2301	0.2707	0.0233	0.0075	0.0152	0.0093	0.0121			
	Plastics and rubber products	0.0034	0.0010	0.0018	0.0076	0.0031	0.0015	0.0193	0.0232	0.0067	0.0062	0.0071	0.0191	0.0088	0.0012	0.0165	0.0592	0.0073	0.0021	0.0046	0.0186	0.0088			
	Nonmetallic mineral products	0.0018	0.0000	0.0014	0.0020	0.0119	0.0024	0.0473	0.0057	0.0023	0.0002	0.0080	0.0021	0.0003	0.0018	0.0022	0.0056	0.0981	0.0104	0.0030	0.0037	0.0009			
	Primary metals	0.0017	0.0000	0.0082	0.0087	0.0254	0.0018	0.0080	0.0002	0.0007	0.0001	0.0005	0.0056	0.0012	0.0002	0.0010	0.0079	0.0091	0.3074	0.2076	0.1129	0.188			
	Fabricated metal products	0.0033	0.0009	0.0074	0.0100	0.0255	0.0034	0.0542	0.189	0.0061	0.0049	0.0219	0.0146	0.0061	0.0033	0.0094	0.0137	0.0122	0.0296	0.0981	0.0882	0.301			
	Machinery	0.0117	0.0019	0.0062	0.0372	0.0237	0.0013	0.0205	0.0022	0.0037	0.0010	0.0030	0.0072	0.0116	0.0004	0.0037	0.0081	0.0018	0.144	0.106	0.756	0.0087			
	Computer and electronic products	0.0002	0.0001	0.0002	0.0002	0.0031	0.0007	0.0039	0.0016	0.0057	0.0032	0.0048	0.0056	0.0079	0.0008	0.0040	0.0074	0.0045	0.0042	0.0055	0.0124	0.1703			
	Electrical equipment, appliances, and components	0.0016	0.0001	0.0002	0.0006	0.0024	0.0042	0.0193	0.0014	0.0014	0.0015	0.0081	0.0017	0.0011	0.0014	0.0015	0.0054	0.0018	0.0019	0.0064	0.0363	0.146			
	Motor vehicles, bodies and trailers, and parts	0.0014	0.0008	0.0015	0.0028	0.0033	0.0002	0.0039	0.0005	0.0049	0.0036	0.0017	0.0026	0.0006	0.0003	0.0003	0.0008	0.0010	0.0056	0.0012	0.0109	0.0014			
	Other transportation equipment	0.0001	0.0001	0.0001	0.0005	0.0003	0.0000	0.0005	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0000	0.0001	0.0001	0.0001	0.0003	0.0003	0.0011	0.0003			
	Furniture and related products	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001	0.0107	0.0002	0.0010	0.0008	0.0129	0.0004	0.0002	0.0001	0.0002	0.0003	0.0003	0.0002	0.0004	0.0004	0.0009			
	Miscellaneous manufacturing	0.0004	0.0002	0.0004	0.0003	0.0006	0.0001	0.0017	0.0009	0.0009	0.0082	0.0015	0.0010	0.0010	0.0003	0.0016	0.0021	0.0014	0.0010	0.0011	0.0027	0.0028			
	Wholesale trade	0.0388	0.0201	0.0089	0.198	0.0226	0.0049	0.0885	0.0648	0.0575	0.0724	0.0701	0.0525	0.0413	0.0502	0.0493	0.0282	0.0664	0.0471	0.0616	0.0741	0.0625			
	Retail trade	0.0023	0.0009	0.0026	0.0021	0.0023	0.0006	0.0621	0.0075	0.0038	0.0031	0.0028	0.0053	0.0032	0.0018	0.0049	0.0044	0.0050	0.0027	0.0024	0.0021	0.0029			
	Air transportation	0.0005	0.0003	0.0001	0.0004	0.0006	0.0002	0.0009	0.0025	0.0016	0.0021	0.0012	0.0018	0.0025	0.0008	0.0011	0.0018	0.0012	0.0012	0.0015	0.0020	0.0028			
	Rail transportation	0.0055	0.0013	0.0004	0.0209	0.0018	0.0164	0.0018	0.0051	0.0068	0.0007	0.0073	0.0096	0.0051	0.0012	0.0032	0.0055	0.0089	0.0142	0.0023	0.0015	0.0004			
	Water transportation	0.0003	0.0002	0.0002	0.0015	0.0010	0.0009	0.0004	0.0004	0.0007	0.0000	0.0006	0.0007	0.0001	0.0006	0.0005	0.0003	0.0034	0.0015	0.0002	0.0001	0.0000			
	Truck transportation	0.0105	0.0036	0.0013	0.0175	0.0083	0.0043	0.0110	0.0176	0.0296	0.0129	0.0351	0.0480	0.0212	0.0029	0.0163	0.0198	0.0768	0.0474	0.0081	0.0075	0.0029			
	Transit and ground passenger transportation	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0002	0.0001			
	Pipeline transportation	0.0002	0.0000	0.0055	0.0024	0.0003	0.0355	0.0001	0.0001	0.0001	0.0000	0.0001	0.0002	0.0001	0.0107	0.0016	0.0001	0.0002	0.0001	0.0001	0.0000	0.0000			
	Other transportation and support activities	0.0003	0.0007	0.0004	0.0013	0.0008	0.0010	0.0022	0.0028	0.0027	0.0009	0.0017	0.0019	0.0017	0.0009	0.0011	0.0015	0.0026	0.0018	0.0015	0.0014	0.0013			
	Warehousing and storage	0.0067	0.0001	0.0010	0.0022	0.0075	0.0000	0.0001	0.0056	0.0020	0.0034	0.0015	0.0013	0.0037	0.0013	0.0053	0.0019	0.0022	0.0009	0.0018	0.0024	0.0050			
	Publishing industries (includes software)	0.0007	0.0005	0.0015	0.0011	0.0021	0.0006	0.0038	0.0030	0.0017	0.0015	0.0017	0.0018	0.0032	0.0013	0.0027	0.0020	0.0017	0.0012	0.0021	0.0024	0.0280			
	Motion picture and sound recording industries	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0007	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0004	0.0001	0.0000	0.0000	0.0001	0.0002	0.0001			
	Broadcasting and telecommunications	0.0033	0.0008	0.0025	0.0016	0.0058	0.0011	0.0124	0.0061	0.0039	0.0031	0.0039	0.0035	0.0079	0.0018	0.0045	0.0050	0.0047	0.0021	0.0054	0.0114	0.106			
	Information and data processing services	0.0006	0.0004	0.0005	0.0007	0.0029	0.0007	0.0024	0.0038	0.0030	0.0018	0.0021	0.0021	0.0036	0.0005	0.0032	0.0023	0.0024	0.0014	0.0027	0.0045	0.0060			
	Federal Reserve banks, credit intermediation, related activities	0.0087	0.0044	0.162	0.0083	0.0129	0.0075	0.0115	0.0129	0.0073	0.0062	0.0068	0.0079	0.0098	0.0054	0.0081	0.0092	0.0089	0.0051	0.0083	0.0091	0.0119			
	Securities, commodity contracts, and investments	0.0003	0.0007	0.0018	0.0067	0.0084	0.0010	0.0050	0.0036	0.0018	0.0014	0.0020	0.0018	0.0020	0.0020	0.0015	0.0024	0.0027	0.0016	0.0027	0.0029	0.0044			
	Insurance carriers and related activities	0.0095	0.0014	0.0029	0.0032	0.0056	0.0022	0.0014	0.0019	0.0019	0.0012	0.0018	0.0041	0.0033	0.0048	0.0026	0.0025	0.0039	0.0018	0.0026	0.0029	0.0050			
	Real estate	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
	Rental and leasing services and lessors of intangible assets	0.0020	0.0018	0.0517	0.0104	0.0125	0.0008	0.0104	0.0099	0.0027	0.0024	0.0025	0.0021	0.0063	0.0022	0.0083	0.0034	0.0036	0.0014	0.0040	0.0039	0.0098			
	Legal services	0.0009	0.0011	0.0032	0.0017	0.0103	0.0033	0.0033	0.0023	0.0009	0.0009	0.0013	0.0007	0.0021	0.0020	0.0035	0.0018	0.0013	0.0008	0.0024	0.0028	0.0065			
	Miscellaneous professional, scientific and technical services	0.0069	0.0066	0.0135	0.0097	0.0277	0.0073	0.0546	0.0379	0.0217	0.0186	0.0205	0.0185	0.0313	0.0164	0.0363	0.0262	0.0227	0.0129	0.0247	0.0274	0.0499			
	Computer systems design and related services	0.0001	0.0001	0.0066	0.0012	0.0016	0.0005	0.0009	0.0025	0.0004	0.0003	0.0003	0.0005	0.0019	0.0011	0.0007	0.0005	0.0004	0.0004	0.0028	0.0033	0.0092			
	Management of companies and enterprises	0.0001	0.0013	0.0168	0.0221	0.0003	0.0003	0.0024	0.0568	0.0221	0.0221	0.0													

Inoperability Input-Output Model A* matrix (page 2 of 3)

A*	indLabel	Industry (2 of 3)																					
		Motor vehicles, bodies and trailers, and parts	Other transportation equipment	Furniture and related products	Miscellaneous manufacturing	Wholesale trade	Retail trade	Air transportation	Rail transportation	Water transportation	Truck transportation	Transit and ground passenger transportation	Pipeline transportation	Other transportation and support activities	Warehousing and storage	Publishing industries (includes software)	Motion picture and sound recording industries	Broadcasting and telecommunications	Information and data processing services	Federal Reserve banks, credit intermediation, and related activities	Securities, commodity contracts, and investments	Insurance carriers and related activities	Funds, trusts, and other financial vehicles
Farms	0.0000	0.0000	0.0001	0.0004	0.0026	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Forestry, fishing, and related activities	0.0000	0.0000	0.0003	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Oil and gas extraction	0.0002	0.0003	0.0003	0.0002	0.0003	0.0004	0.0100	0.0022	0.0025	0.0042	0.0035	0.1496	0.0025	0.0011	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
Mining, except oil and gas	0.0045	0.0002	0.0001	0.0015	0.0000	0.0001	0.0035	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Utilities	0.0030	0.0033	0.0065	0.0045	0.0055	0.0101	0.0009	0.0008	0.0015	0.0020	0.0015	0.0162	0.0016	0.0164	0.0035	0.0063	0.0044	0.0038	0.0027	0.0059	0.0002	0.0010	0.0010
Construction	0.0006	0.0015	0.0019	0.0031	0.0025	0.0040	0.0001	0.0001	0.0004	0.0016	0.0000	0.0221	0.0009	0.0036	0.0024	0.0039	0.0030	0.0043	0.0058	0.0033	0.0004	0.0017	0.0017
Food and beverage and tobacco products	0.0004	0.0004	0.0014	0.0026	0.0041	0.0054	0.0012	0.0002	0.0022	0.0002	0.0002	0.0001	0.0021	0.0000	0.0004	0.0037	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
Textile mills and textile product mills	0.0102	0.0033	0.0356	0.0194	0.0007	0.0006	0.0001	0.0000	0.0027	0.0001	0.0001	0.0014	0.0002	0.0000	0.0004	0.0014	0.0001	0.0001	0.0003	0.0001	0.0000	0.0000	0.0000
Apparel and leather and allied products	0.0022	0.0003	0.0008	0.0019	0.0018	0.0002	0.0000	0.0001	0.0013	0.0001	0.0004	0.0001	0.0001	0.0006	0.0001	0.0007	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
Wood products	0.0018	0.0015	0.0882	0.0105	0.0034	0.0018	0.0000	0.0101	0.0000	0.0002	0.0001	0.0002	0.0005	0.0009	0.0004	0.0012	0.0022	0.0008	0.0000	0.0001	0.0000	0.0000	0.0001
Paper products	0.0029	0.0011	0.0143	0.0202	0.0034	0.0042	0.0002	0.0010	0.0010	0.0010	0.0013	0.0015	0.0013	0.0027	0.0236	0.0017	0.0018	0.0026	0.0013	0.0011	0.0002	0.0004	0.0004
Printing and related support activities	0.0010	0.0011	0.0031	0.0013	0.0054	0.0023	0.0011	0.0010	0.0020	0.0010	0.0021	0.0024	0.0010	0.0007	0.0424	0.0027	0.0055	0.0088	0.0032	0.0016	0.0021	0.0013	0.0013
Petroleum and coal products	0.0029	0.0050	0.0028	0.0041	0.0060	0.0078	0.1955	0.0427	0.0494	0.0815	0.0672	0.1404	0.0478	0.0221	0.0023	0.0006	0.0018	0.0011	0.0011	0.0007	0.0001	0.0000	0.0003
Chemical products	0.0144	0.0136	0.1112	0.0374	0.0039	0.0019	0.0053	0.0022	0.0027	0.0043	0.0036	0.0043	0.0018	0.0009	0.0048	0.0020	0.0020	0.0020	0.0004	0.0003	0.0002	0.0004	0.0004
Plastics and rubber products	0.0277	0.0126	0.0508	0.2988	0.0078	0.0064	0.0002	0.0022	0.0012	0.0102	0.0116	0.0005	0.0020	0.0011	0.0016	0.0020	0.0042	0.0010	0.0003	0.0003	0.0002	0.0001	0.0001
Nonmetallic mineral products	0.0079	0.0035	0.0034	0.0044	0.0009	0.0011	0.0001	0.0043	0.0002	0.0002	0.0006	0.0004	0.0001	0.0001	0.0002	0.0004	0.0024	0.0018	0.0001	0.0001	0.0000	0.0000	0.0000
Primary metals	0.0815	0.0479	0.3992	0.4930	0.0030	0.0016	0.0001	0.0246	0.0001	0.0001	0.0002	0.0025	0.0004	0.0001	0.0003	0.0001	0.0031	0.0002	0.0001	0.0002	0.0001	0.0000	0.0000
Fabricated metal products	0.0548	0.0735	0.0334	0.3332	0.0038	0.0032	0.0046	0.0058	0.0118	0.0074	0.0153	0.0251	0.0024	0.0020	0.0077	0.0034	0.0103	0.0013	0.0002	0.0003	0.0001	0.0001	0.0001
Machinery	0.0406	0.0260	0.0016	0.0097	0.0042	0.0017	0.0004	0.0147	0.0091	0.0016	0.0023	0.0197	0.0024	0.0003	0.0009	0.0004	0.0008	0.0006	0.0002	0.0003	0.0000	0.0000	0.0000
Computer and electronic products	0.0207	0.0600	0.0049	0.1332	0.0070	0.0023	0.0011	0.0114	0.0008	0.0004	0.0008	0.0010	0.0008	0.0001	0.0190	0.0123	0.0186	0.0756	0.0035	0.0006	0.0004	0.0001	0.0001
Electrical equipment, appliances, and components	0.0100	0.0089	0.0016	0.0041	0.0016	0.0011	0.0001	0.0077	0.0004	0.0003	0.0008	0.0007	0.0003	0.0004	0.0003	0.0009	0.0014	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001
Motor vehicles, bodies and trailers, and parts	0.2876	0.0062	0.0016	0.0014	0.0022	0.0136	0.0002	0.0137	0.0005	0.0204	0.0302	0.0022	0.0021	0.0022	0.0005	0.0005	0.0003	0.0004	0.0012	0.0002	0.0001	0.0000	0.0000
Other transportation equipment	0.0011	0.1273	0.0001	0.0002	0.0004	0.0013	0.0233	0.0119	0.0213	0.0002	0.0005	0.0004	0.0056	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
Furniture and related products	0.0005	0.0005	0.0151	0.0013	0.0002	0.0002	0.0000	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	0.0002	0.0003	0.0002	0.0000	0.0000	0.0000	0.0000
Miscellaneous manufacturing	0.0017	0.0015	0.0012	0.0443	0.0021	0.0013	0.0003	0.0004	0.0007	0.0004	0.0009	0.0005	0.0002	0.0003	0.0008	0.0005	0.0009	0.0030	0.0008	0.0005	0.0002	0.0000	0.0000
Wholesale trade	0.0066	0.0345	0.0600	0.0605	0.0346	0.0084	0.0235	0.0292	0.0231	0.0365	0.0327	0.0123	0.0087	0.0089	0.0282	0.0157	0.0101	0.0124	0.0025	0.0017	0.0007	0.0008	0.0008
Retail trade	0.0087	0.0010	0.0169	0.0037	0.0044	0.0051	0.0029	0.0037	0.0064	0.0111	0.0053	0.0036	0.0022	0.0016	0.0028	0.0020	0.0035	0.0060	0.0020	0.0016	0.0007	0.0007	0.0007
Air transportation	0.0031	0.0029	0.0019	0.0016	0.0022	0.0017	0.0005	0.0006	0.0008	0.0038	0.0009	0.0002	0.0010	0.0002	0.0031	0.0017	0.0010	0.0096	0.0040	0.0037	0.0016	0.0016	0.0016
Rail transportation	0.0036	0.0008	0.0027	0.0019	0.0004	0.0004	0.0015	0.0018	0.0006	0.0076	0.0009	0.0006	0.0007	0.0003	0.0008	0.0002	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000
Water transportation	0.0001	0.0000	0.0003	0.0002	0.0001	0.0001	0.0008	0.0004	0.0006	0.0007	0.0003	0.0002	0.0003	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
Truck transportation	0.0118	0.0050	0.0174	0.0106	0.0018	0.0030	0.0013	0.0045	0.0015	0.1208	0.0092	0.0014	0.0019	0.0020	0.0035	0.0008	0.0012	0.0013	0.0009	0.0006	0.0001	0.0004	0.0004
Transit and ground passenger transportation	0.0001	0.0001	0.0001	0.0001	0.0003	0.0004	0.0001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0004	0.0002	0.0013	0.0014	0.0008	0.0004	0.0003
Pipeline transportation	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0006	0.0001	0.0002	0.0003	0.0002	0.0209	0.0002	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
Other transportation and support activities	0.0011	0.0010	0.0016	0.0012	0.0094	0.0063	0.0701	0.0572	0.1475	0.0396	0.0034	0.0017	0.0377	0.0038	0.0045	0.0035	0.0020	0.0071	0.0058	0.0057	0.0014	0.0014	0.0014
Warehousing and storage	0.0033	0.0047	0.0016	0.0028	0.0030	0.0064	0.0001	0.0000	0.0032	0.0200	0.0009	0.0000	0.0018	0.0009	0.0023	0.0001	0.0003	0.0007	0.0038	0.0020	0.0001	0.0002	0.0002
Publishing industries (includes software)	0.0023	0.0026	0.0026	0.0027	0.0028	0.0030	0.0009	0.0025	0.0063	0.0018	0.0025	0.0064	0.0015	0.0013	0.0611	0.0047	0.0057	0.0106	0.0038	0.0026	0.0009	0.0016	0.0016
Motion picture and sound recording industries	0.0001	0.0000	0.0005	0.0003	0.0000	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0001	0.0000	0.0006	0.2355	0.0258	0.0004	0.0000	0.0001	0.0000	0.0003	0.0003
Broadcasting and telecommunications	0.0057	0.0047	0.0064	0.0088	0.0152	0.0130	0.0073	0.0037	0.0058	0.0152	0.0081	0.0099	0.0146	0.0072	0.0287	0.0256	0.2394	0.0836	0.0096	0.0089	0.0100	0.0026	0.0026
Information and data processing services	0.0025	0.0035	0.0036	0.0039	0.0058	0.0076	0.0024	0.0004	0.0012	0.0035	0.0052	0.0023	0.0073	0.0022	0.0185	0.0031	0.0046	0.0335	0.0039	0.0140	0.0062	0.0019	0.0019
Federal Reserve banks, credit intermediation, related activities	0.0085	0.0065	0.0094	0.0097	0.0188	0.0212	0.0067	0.0234	0.0185	0.0103	0.0106	0.0098	0.0053	0.0039	0.0200	0.0229	0.0259	0.0285	0.0531	0.0982	0.0116	0.0456	0.0456
Securities, commodity contracts, and investments	0.0029	0.0027	0.0029	0.0028	0.0034	0.0026	0.0015	0.0027	0.0090	0.0029	0.0029	0.0028	0.0018	0.0010	0.0062	0.0039	0.0025	0.0137	0.0620	0.1637	0.0193	0.6499	0.6499
Insurance carriers and related activities	0.0054	0.0029	0.0020	0.0031	0.0041	0.0028	0.0076	0.0054	0.0392	0.0077	0.0049	0.0009	0.0005	0.0016	0.0011	0.0035	0.0064	0.0119	0.0126	0.0019	0.0029	0.3634	0.0091
Funds, trusts, and other financial vehicles	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.1663	0.0000	0.0000
Real estate	0.0011	0.0024	0.0091	0.0063	0.0222	0.0497	0.0050																

Inoperability Input-Output Model A* matrix (page 3 of 3)

A*	indLabel	Industry (3 of 3)																					
		Real estate	Rental and leasing services and lessors of intangible assets	Legal services	Miscellaneous professional, scientific and technical services	Computer systems design and related services	Management of companies and enterprises	Administrative and support services	Waste management and remediation services	Educational services	Ambulatory health care services	Hospitals and nursing and residential care facilities	Social assistance	Performing arts, spectator sports, museums, and related activities	Amusements, gambling, and recreation industries	Accommodation	Food services and drinking places	Other services, except government	Federal government enterprises	Federal general government	State and local government enterprises	State and local general government	
Farms	0.0005	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0113	0.0000	0.0005	0.0000	0.0006	0.0008	0.0011	0.0025	0.0019	0.0136	0.0003	0.0002	0.0000	0.0002	0.0012	
Forestry, fishing, and related activities	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0000	0.0001	0.0000	0.0001	0.0004	0.0010	0.0075	0.0006	0.0002	0.0000	0.0000	0.0001	
Oil and gas extraction	0.0001	0.0003	0.0001	0.0001	0.0000	0.0001	0.0006	0.0052	0.0001	0.0001	0.0001	0.0001	0.0007	0.0000	0.0001	0.0002	0.0002	0.0003	0.0031	0.0008	0.0525	0.0020	
Mining, except oil and gas	0.0010	0.0000	0.0000	0.0005	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0002	0.0157	0.0008	
Support activities for mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	
Utilities	0.0238	0.0047	0.0019	0.0050	0.0011	0.0143	0.0046	0.0213	0.0067	0.0032	0.0096	0.0064	0.0043	0.0152	0.0195	0.0192	0.0108	0.0035	0.0055	0.0345	0.0200		
Construction	0.0153	0.0038	0.0021	0.0037	0.0009	0.0119	0.0024	0.0006	0.0154	0.0029	0.0050	0.0059	0.0032	0.0099	0.0122	0.0069	0.0070	0.0448	0.0152	0.0537	0.0190		
Food and beverage and tobacco products	0.0001	0.0001	0.0000	0.0009	0.0000	0.0001	0.0002	0.0002	0.0001	0.0003	0.0002	0.0017	0.0010	0.0013	0.0010	0.0030	0.0005	0.0013	0.0001	0.0016	0.0011	0.0010	
Textile mills and textile product mills	0.0004	0.0001	0.0000	0.0003	0.0000	0.0001	0.0003	0.0001	0.0003	0.0002	0.0017	0.0010	0.0013	0.0010	0.0030	0.0005	0.0013	0.0001	0.0016	0.0011	0.0010		
Apparel and leather and allied products	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0001	0.0001	0.0005	0.0003	0.0008	0.0002	0.0003	0.0001	0.0008	0.0003	0.0003	0.0001	0.0011		
Wood products	0.0064	0.0003	0.0005	0.0007	0.0002	0.0023	0.0004	0.0045	0.0018	0.0008	0.0011	0.0038	0.0014	0.0016	0.0030	0.0014	0.0019	0.0000	0.0001	0.0040	0.0015		
Paper products	0.0010	0.0128	0.0029	0.0037	0.0012	0.0006	0.0055	0.0012	0.0004	0.0030	0.0051	0.0065	0.0016	0.0019	0.0031	0.0066	0.0035	0.0035	0.0013	0.0019	0.0042		
Printing and related support activities	0.0007	0.0020	0.0018	0.0088	0.0016	0.0088	0.0081	0.0007	0.0039	0.0017	0.0039	0.0096	0.0021	0.0016	0.0016	0.0012	0.0138	0.0045	0.0047	0.0034	0.0040		
Petroleum and coal products	0.0019	0.0057	0.0010	0.0016	0.0004	0.0124	0.0125	0.0028	0.0037	0.0036	0.0140	0.0009	0.0026	0.0034	0.0031	0.0058	0.0423	0.0146	0.0543	0.0391			
Chemical products	0.0033	0.0028	0.0007	0.0091	0.0004	0.0020	0.0119	0.0136	0.0056	0.0229	0.0331	0.0065	0.0011	0.0028	0.0040	0.0024	0.0152	0.0030	0.0066	0.0167	0.0150		
Plastics and rubber products	0.0023	0.0044	0.0008	0.0028	0.0006	0.0043	0.0049	0.0022	0.0059	0.0100	0.0170	0.0105	0.0014	0.0023	0.0059	0.0101	0.0088	0.0003	0.0015	0.0094	0.0040		
Nonmetallic mineral products	0.0060	0.0013	0.0002	0.0024	0.0001	0.0023	0.0004	0.0001	0.0028	0.0015	0.0020	0.0009	0.0013	0.0012	0.0038	0.0023	0.0027	0.0000	0.0004	0.0135	0.0020		
Primary metals	0.0011	-0.0001	0.0000	0.0003	0.0002	0.0002	0.0001	0.0001	0.0007	0.0001	0.0002	0.0009	0.0001	0.0028	0.0006	0.0002	0.0019	0.0001	0.0013	0.0025	0.0007		
Fabricated metal products	0.0053	0.0029	0.0006	0.0027	0.0007	0.0056	0.0017	0.0013	0.0062	0.0022	0.0023	0.0038	0.0021	0.0030	0.0046	0.0019	0.0091	0.0039	0.0072	0.0259	0.0030		
Machinery	0.0020	0.0021	0.0001	0.0013	0.0010	0.0006	0.0011	0.0008	0.0011	0.0006	0.0008	0.0004	0.0008	0.0012	0.0008	0.0011	0.0141	0.0044	0.0026	0.0111	0.0033		
Computer and electronic products	0.0003	0.0033	0.0005	0.0055	0.0230	0.0017	0.0047	0.0037	0.0027	0.0044	0.0042	0.0013	0.0005	0.0003	0.0004	0.0003	0.0098	0.0002	0.0261	0.0050	0.0027		
Electrical equipment, appliances, and components	0.0026	0.0005	0.0002	0.0012	0.0004	0.0007	0.0009	0.0006	0.0007	0.0004	0.0011	0.0006	0.0007	0.0013	0.0018	0.0007	0.0076	0.0009	0.0016	0.0087	0.0016		
Motor vehicles, bodies and trailers, and parts	0.0002	0.0065	0.0009	0.0008	0.0002	0.0012	0.0025	0.0177	0.0010	0.0006	0.0010	0.0030	0.0007	0.0006	0.0011	0.0008	0.0265	0.0071	0.0023	0.0018	0.0048		
Other transportation equipment	0.0001	0.0006	0.0000	0.0003	0.0000	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0007	0.0000	0.0001	0.0017	0.0005	0.0406	0.0008	0.0001		
Furniture and related products	0.0045	0.0001	0.0002	0.0004	0.0001	0.0003	0.0001	0.0001	0.0001	0.0002	0.0004	0.0003	0.0003	0.0008	0.0005	0.0002	0.0003	0.0003	0.0001	0.0017	0.0002		
Miscellaneous manufacturing	0.0003	0.0010	0.0004	0.0023	0.0003	0.0006	0.0016	0.0006	0.0027	0.0176	0.0135	0.0249	0.0030	0.0035	0.0025	0.0021	0.0063	0.0001	0.0044	0.0040	0.0052		
Wholesale trade	0.0053	0.0087	0.0022	0.0071	0.0057	0.0056	0.0128	0.0252	0.0119	0.0106	0.0142	0.0214	0.0038	0.0083	0.0122	0.0319	0.0222	0.0091	0.0082	0.0220	0.0155		
Retail trade	0.0092	0.0090	0.0023	0.0041	0.0018	0.0032	0.0122	0.0142	0.0025	0.0028	0.0045	0.0031	0.0023	0.0042	0.0057	0.0083	0.0168	0.0019	0.0015	0.0019	0.0032		
Air transportation	0.0006	0.0052	0.0048	0.0055	0.0021	0.0001	0.0054	0.0028	0.0027	0.0020	0.0056	0.0017	0.0010	0.0010	0.0016	0.0022	0.0023	0.0100	0.0063	0.0013	0.0015		
Rail transportation	0.0004	0.0005	0.0002	0.0003	0.0001	0.0002	0.0005	0.0014	0.0004	0.0003	0.0005	0.0006	0.0001	0.0003	0.0005	0.0013	0.0007	0.0033	0.0013	0.0088	0.0012		
Water transportation	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0000	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0003	0.0012	0.0008	0.0002		
Truck transportation	0.0017	0.0016	0.0004	0.0012	0.0003	0.0003	0.0017	0.0025	0.0109	0.0023	0.0014	0.0025	0.0045	0.0013	0.0020	0.0029	0.0076	0.0047	0.0243	0.0072	0.0083	0.0044	
Transit and ground passenger transportation	0.0005	0.0015	0.0011	0.0009	0.0003	0.0001	0.0012	0.0004	0.0010	0.0005	0.0015	0.0007	0.0008	0.0003	0.0022	0.0003	0.0011	0.0001	0.0000	0.0003	0.0026		
Pipeline transportation	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0002	0.0002	0.0001	0.0003	0.0001	0.0089	0.0003		
Other transportation and support activities	0.0007	0.0226	0.0040	0.0044	0.0017	0.0002	0.0030	0.0037	0.0019	0.0022	0.0027	0.0015	0.0017	0.0029	0.0024	0.0026	0.0023	0.0054	0.0007	0.0047	0.0012		
Warehousing and storage	0.0000	0.0008	0.0000	0.0008	0.0003	0.0000	0.0024	0.0004	0.0003	0.0004	0.0006	0.0014	0.0005	0.0014	0.0019	0.0001	0.0007	0.0001	0.0013	0.0009	0.0008		
Publishing industries (includes software)	0.0014	0.0059	0.0050	0.0094	0.0018	0.0069	0.0037	0.0111	0.0081	0.0032	0.0029	0.0078	0.0027	0.0033	0.0035	0.0023	0.0093	0.0023	0.0089	0.0064	0.0053		
Motion picture and sound recording industries	0.0000	0.0008	0.0000	0.0044	0.0001	0.0000	0.0003	0.0000	0.0001	0.0044	0.0001	0.0007	0.0051	0.0176	0.0005	0.0038	0.0066	0.0009	0.0003	0.0015	0.0012	0.0002	
Broadcasting and telecommunications	0.0071	0.0196	0.0213	0.0298	0.0193	0.0454	0.0233	0.0126	0.0180	0.0163	0.0217	0.0151	0.0089	0.0138	0.0207	0.0161	0.0185	0.0077	0.0206	0.0141	0.0153		
Information and data processing services	0.0015	0.0061	0.0087	0.0118	0.0088	0.0257	0.0121	0.0062	0.0059	0.0057	0.0040	0.0046	0.0060	0.0047	0.0069	0.0042	0.0086	0.0031	0.0161	0.0058	0.0087		
Federal Reserve banks, credit intermediation, related activities	0.0351	0.0746	0.0092	0.0146	0.0107	0.0038	0.0127	0.0127	0.0073	0.0093	0.0081	0.0103	0.0169	0.0228	0.0247	0.0252	0.0097	0.0036	0.0016	0.0059	0.0042		
Securities, commodity contracts, and investments	0.0022	0.0103	0.0039	0.0062	0.0019	0.0003	0.0036	0.0020	0.0087	0.0046	0.0254	0.0069	0.0033	0.0032	0.0059	0.0036	0.0045	0.0020	0.0004	0.0083	0.0090		
Insurance carriers and related activities	0.0193	0.0229	0.0012	0.0010	0.0019	0.0090	0.0025	0.0055	0.0009	0.0021	0.0054	0.0017	0.0022	0.0011	0.0061	0.0024	0.0013	0.0042	0.0122	0.0036	0.0016		
Funds, trusts, and other financial vehicles	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
Real estate	0.0430	0.0309	0.0813	0.0422	0.0121	0.0530	0.0257	0.0028	0.1081	0.0428	0.0763	0.0545	0.0280	0.0613	0.0316	0.0563	0.0763	0.0172	0.0068	0.0287	0.0189		
Rental and leasing services and lessors of intangible assets	0.0008	0.0183	0.0026	0.0076	0.0070	0.0151	0.0065	0.0034	0.0063	0.0050	0.0058	0.0025	0.0095	0.0077	0.0119	0.0082	0.0047	0.0018	0.0013	0.0038	0.0058		
Legal services	0.0099	0.0046	0.0354	0.0096	0.0022	0.0378	0.0112	0.0037	0.0035	0.0158	0.0182	0.0023	0.0045	0.0042	0.0046	0.0021	0.0060	0.0029	0.0026	0.0056	0.0065		
Miscellaneous professional, scientific and technical services	0.0190	0.0691	0.0353	0.0905	0.0172	0.0854																	

Table B-8. Inoperability Input-Output Model Results: Perturbation Vector, \mathbf{c}^* ; Percent Disruption Vector, \mathbf{q} ; and associated costs associated with the given disruption, \$

IndLabel	\mathbf{c}^*	\mathbf{q} (% disruption, ratio)	\$ loss, ratio
Farms	0	7.7676E-11	0.0015
Forestry, fishing, and related activities	0	6.0592E-11	0.0012
Oil and gas extraction	0	4.8269E-09	0.0952
Mining, except oil and gas	0	1.2547E-10	0.0025
Support activities for mining	0	1.3108E-10	0.0026
Utilities	0	5.0173E-10	0.0100
Construction	0	2.5237E-10	0.0052
Food and beverage and tobacco products	0	1.1544E-10	0.0023
Textile mills and textile product mills	0	7.6744E-11	0.0015
Apparel and leather and allied products	0	2.4134E-11	0.0005
Wood products	0	1.0873E-10	0.0021
Paper products	0	3.2190E-10	0.0063
Printing and related support activities	0	2.0499E-10	0.0040
Petroleum and coal products	0	5.8366E-09	0.1169
Chemical products	0	1.1795E-09	0.0237
Plastics and rubber products	0	8.7295E-10	0.0172
Nonmetallic mineral products	0	1.4184E-10	0.0028
Primary metals	0	7.8366E-10	0.0154
Fabricated metal products	0	9.3231E-10	0.0184
Machinery	0	3.5353E-10	0.0070
Computer and electronic products	0	3.3492E-10	0.0066
Electrical equipment, appliances, and components	0	3.2915E-10	0.0064
Motor vehicles, bodies and trailers, and parts	0	1.8253E-09	0.0364
Other transportation equipment	0	5.7354E-11	0.0011
Furniture and related products	0	2.4891E-11	0.0005
Miscellaneous manufacturing	0	8.0285E-11	0.0016
Wholesale trade	0	3.1940E-09	0.0661
Retail trade	0	8.4846E-10	0.0177
Air transportation	0	3.0462E-10	0.0060
Rail transportation	0	5.1107E-10	0.0100
Water transportation	0	5.3159E-11	0.0010
Truck transportation	-5.1E-08	5.7932E-08	1.1428
Transit and ground passenger transportation	0	2.5775E-11	0.0005
Pipeline transportation	0	1.3278E-10	0.0026
Other transportation and support activities	0	2.5878E-09	0.0507
Warehousing and storage	0	1.2315E-09	0.0240
Publishing industries (includes software)	0	2.7812E-10	0.0055
Motion picture and sound recording industries	0	8.9740E-11	0.0018
Broadcasting and telecommunications	0	1.8548E-09	0.0376
Information and data processing services	0	4.5234E-10	0.0089
Federal Reserve banks, credit intermediation, and related activities	0	1.3439E-09	0.0272
Securities, commodity contracts, and investments	0	4.9904E-10	0.0099
Insurance carriers and related activities	0	1.0524E-09	0.0212
Funds, trusts, and other financial vehicles	0	2.1962E-11	0.0004
Real estate	0	1.5596E-09	0.0338
Rental and leasing services and lessors of intangible assets	0	1.2898E-09	0.0255
Legal services	0	4.5934E-10	0.0091
Miscellaneous professional, scientific and technical services	0	2.4985E-09	0.0513
Computer systems design and related services	0	4.5574E-10	0.0090
Management of companies and enterprises	0	1.6992E-09	0.0338
Administrative and support services	0	1.1303E-09	0.0227
Waste management and remediation services	0	2.9571E-10	0.0058
Educational services	0	5.9179E-11	0.0012
Ambulatory health care services	0	3.4692E-11	0.0007
Hospitals and nursing and residential care facilities	0	7.1117E-12	0.0001
Social assistance	0	1.3836E-12	0.0000
Performing arts, spectator sports, museums, and related activities	0	1.0221E-10	0.0020
Amusements, gambling, and recreation industries	0	1.9676E-11	0.0004
Accommodation	0	1.1741E-10	0.0023
Food services and drinking places	0	1.8197E-10	0.0036
Other services, except government	0	1.1374E-09	0.0228
Federal government enterprises	0	1.5874E-10	0.0031
Federal general government	0	2.0238E-11	0.0004
State and local government enterprises	0	3.4433E-10	0.0068
State and local general government	0	1.4460E-10	0.0031

Table B-9. Standard Classification of Transported Goods (SCTG) Commodities matched to Bureau of Economic Analysis (BEA) Industries; SCTG Commodities in **bold** are used in Concept Demonstration, BEA industries with *italics* were not matched in FAF documentation (Southworth, et al., 2011) (page 1 of 2)

SCTG Commodity	BEA Industry Labels	q (% disruption, ratio)	\$ loss, ratio
1 Live animals/fish	<i>Farms</i>	7.77E-11	0.00153
1 Live animals/fish	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
1 Live animals/fish	<i>Forestry, fishing, and related activities</i>	6.06E-11	0.00118
2 Cereal grains	<i>Farms</i>	7.77E-11	0.00153
2 Cereal grains	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
3 Other agricultural products	<i>Farms</i>	7.77E-11	0.00153
3 Other agricultural products	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
4 Animal feed	<i>Farms</i>	7.77E-11	0.00153
4 Animal feed	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
5 Meat/seafood	<i>Farms</i>	7.77E-11	0.00153
5 Meat/seafood	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
6 Milled grain prods.	<i>Farms</i>	7.77E-11	0.00153
6 Milled grain prods.	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
7 Other foodstuffs	<i>Farms</i>	7.77E-11	0.00153
7 Other foodstuffs	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
8 Alcoholic beverages	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
9 Tobacco prods.	<i>Food and beverage and tobacco products</i>	1.15E-10	0.00233
10 Building stone	Mining, except oil and gas	1.25E-10	0.00245
10 Building stone	<i>Support activities for mining</i>	1.31E-10	0.00257
11 Natural sands	Mining, except oil and gas	1.25E-10	0.00245
11 Natural sands	<i>Support activities for mining</i>	1.31E-10	0.00257
12 Gravel	Mining, except oil and gas	1.25E-10	0.00245
12 Gravel	<i>Support activities for mining</i>	1.31E-10	0.00257
13 Nonmetallic minerals	Mining, except oil and gas	1.25E-10	0.00245
13 Nonmetallic minerals	<i>Support activities for mining</i>	1.31E-10	0.00257
14 Metallic ores	Mining, except oil and gas	1.25E-10	0.00245
14 Metallic ores	<i>Support activities for mining</i>	1.31E-10	0.00257
15 Coal	Mining, except oil and gas	1.25E-10	0.00245
15 Coal	Petroleum and coal products	5.84E-09	0.11693
15 Coal	<i>Support activities for mining</i>	1.31E-10	0.00257
16 Crude petroleum	<i>Oil and gas extraction</i>	4.83E-09	0.09521
16 Crude petroleum	Petroleum and coal products	5.84E-09	0.11693
17 Gasoline	<i>Oil and gas extraction</i>	4.83E-09	0.09521
17 Gasoline	Petroleum and coal products	5.84E-09	0.11693
18 Fuel oils	<i>Oil and gas extraction</i>	4.83E-09	0.09521
18 Fuel oils	Petroleum and coal products	5.84E-09	0.11693
19 Coal-n.e.c.	Motor vehicles, bodies and trailers, and parts	1.83E-09	0.03638
19 Coal-n.e.c.	<i>Oil and gas extraction</i>	4.83E-09	0.09521
19 Coal-n.e.c.	<i>Other transportation equipment</i>	5.74E-11	0.00113
19 Coal-n.e.c.	Petroleum and coal products	5.84E-09	0.11693
20 Basic chemicals	Chemical products	1.18E-09	0.02370
21 Pharmaceuticals	Chemical products	1.18E-09	0.02370
22 Fertilizers	Chemical products	1.18E-09	0.02370
23 Chemical prods.	Chemical products	1.18E-09	0.02370
24 Plastics/rubber	Chemical products	1.18E-09	0.02370
24 Plastics/rubber	Motor vehicles, bodies and trailers, and parts	1.83E-09	0.03638
24 Plastics/rubber	<i>Other transportation equipment</i>	5.74E-11	0.00113
24 Plastics/rubber	Plastics and rubber products	8.73E-10	0.01716
25 Logs	<i>Forestry, fishing, and related activities</i>	6.06E-11	0.00118
25 Logs	Wood products	1.09E-10	0.00213
26 Wood products	Furniture and related products	2.49E-11	0.00049
26 Wood products	Wood products	1.09E-10	0.00213
27 Newsprint/paper	Paper products	3.22E-10	0.00631
27 Newsprint/paper	<i>Publishing industries (includes software)</i>	2.78E-10	0.00549
27 Newsprint/paper	Wood products	1.09E-10	0.00213
28 Paper articles	Paper products	3.22E-10	0.00631
28 Paper articles	Wood products	1.09E-10	0.00213
29 Printed products	Printing and related support activities	2.05E-10	0.00401
29 Printed products	<i>Publishing industries (includes software)</i>	2.78E-10	0.00549
30 Textiles/leather	Apparel and leather and allied products	2.41E-11	0.00047
30 Textiles/leather	Furniture and related products	2.49E-11	0.00049
30 Textiles/leather	Textile mills and textile product mills	7.67E-11	0.00150
31 Nonmetal mineral products	Nonmetallic mineral products	1.42E-10	0.00278

Standard Classification of Transported Goods (SCTG) Commodities matched to Bureau of Economic Analysis (BEA) Industries; SCTG Commodities in **bold** are used in Concept Demonstration, BEA industries with *italics* were not matched in FAF documentation (Southworth, et al., 2011) (page 2 of 2)

<i>SCTG Commodity</i>	<i>BEA Industry Labels</i>	<i>q (% disruption, ratio)</i>	<i>\$ loss, ratio</i>
32 Base metals	Fabricated metal products	9.32E-10	0.01843
32 Base metals	Primary metals	7.84E-10	0.01543
33 Articles-base metal	Fabricated metal products	9.32E-10	0.01843
33 Articles-base metal	Primary metals	7.84E-10	0.01543
34 Machinery	Electrical equipment, appliances, and components	3.29E-10	0.00644
34 Machinery	Machinery	3.54E-10	0.00699
35 Electronics	Computer and electronic products	3.35E-10	0.00664
35 Electronics	Electrical equipment, appliances, and components	3.29E-10	0.00644
35 Electronics	Machinery	3.54E-10	0.00699
35 Electronics	<i>Motion picture and sound recording industries</i>	8.97E-11	0.00175
35 Electronics	Motor vehicles, bodies and trailers, and parts	1.83E-09	0.03638
35 Electronics	<i>Other transportation equipment</i>	5.74E-11	0.00113
35 Electronics	<i>Publishing industries (includes software)</i>	2.78E-10	0.00549
36 Motorized vehicles	Motor vehicles, bodies and trailers, and parts	1.83E-09	0.03638
36 Motorized vehicles	<i>Other transportation equipment</i>	5.74E-11	0.00113
37 Transport equipment	Motor vehicles, bodies and trailers, and parts	1.83E-09	0.03638
37 Transport equipment	<i>Other transportation equipment</i>	5.74E-11	0.00113
38 Precision instruments	Computer and electronic products	3.35E-10	0.00664
38 Precision instruments	Electrical equipment, appliances, and components	3.29E-10	0.00644
38 Precision instruments	Fabricated metal products	9.32E-10	0.01843
38 Precision instruments	Machinery	3.54E-10	0.00699
39 Furniture	Furniture and related products	2.49E-11	0.00049
39 Furniture	Wood products	1.09E-10	0.00213
40 Misc. mfg. products.	<i>Miscellaneous manufacturing</i>	8.03E-11	0.00157
41 Waste/scrap	<i>Waste management and remediation services</i>	2.96E-10	0.00577
(assume within county)	Construction	2.52E-10	0.00522
(assumed within county)	Retail trade	8.48E-10	0.01767
<i>Multiple commodities</i>	<i>Warehousing and storage</i>	1.23E-09	0.02402
<i>Multiple commodities</i>	<i>Wholesale trade</i>	3.19E-09	0.06607
(Service Industry)	Accommodation	1.17E-10	0.00231
(Service Industry)	Administrative and support services	1.13E-09	0.02267
(Service Industry)	Air transportation	3.05E-10	0.00597
(Service Industry)	Ambulatory health care services	3.47E-11	0.00070
(Service Industry)	Amusements, gambling, and recreation industries	1.97E-11	0.00038
(Service Industry)	Broadcasting and telecommunications	1.85E-09	0.03756
(Service Industry)	Computer systems design and related services	4.56E-10	0.00896
(Service Industry)	Educational services	5.92E-11	0.00116
(Service Industry)	Federal general government	2.02E-11	0.00041
(Service Industry)	Federal government enterprises	1.59E-10	0.00310
(Service Industry)	Federal Reserve banks, credit intermediation, and related activities	1.34E-09	0.02716
(Service Industry)	Food services and drinking places	1.82E-10	0.00363
(Service Industry)	Funds, trusts, and other financial vehicles	2.20E-11	0.00043
(Service Industry)	Hospitals and nursing and residential care facilities	7.11E-12	0.00014
(Service Industry)	Information and data processing services	4.52E-10	0.00888
(Service Industry)	Insurance carriers and related activities	1.05E-09	0.02117
(Service Industry)	Legal services	4.59E-10	0.00906
(Service Industry)	Management of companies and enterprises	1.70E-09	0.03381
(Service Industry)	Miscellaneous professional, scientific and technical services	2.50E-09	0.05135
(Service Industry)	Other services, except government	1.14E-09	0.02281
(Service Industry)	Other transportation and support activities	2.59E-09	0.05068
(Service Industry)	Performing arts, spectator sports, museums, and related activities	1.02E-10	0.00200
(Service Industry)	Pipeline transportation	1.33E-10	0.00259
(Service Industry)	Rail transportation	5.11E-10	0.00998
(Service Industry)	Real estate	1.56E-09	0.03382
(Service Industry)	Rental and leasing services and lessors of intangible assets	1.29E-09	0.02546
(Service Industry)	Securities, commodity contracts, and investments	4.99E-10	0.00994
(Service Industry)	Social assistance	1.38E-12	0.00003
(Service Industry)	State and local general government	1.45E-10	0.00306
(Service Industry)	State and local government enterprises	3.44E-10	0.00678
(Service Industry)	Transit and ground passenger transportation	2.58E-11	0.00050
(Service Industry)	Truck transportation	5.79E-08	1.14275
(Service Industry)	Utilities	5.02E-10	0.00999
(Service Industry)	Water transportation	5.32E-11	0.00104

Table B-10. Economic Hindrance by BEA Industry due to Calculated Mobility- and Safety-based Excess User Costs to the Trucking Sector for U.S. 460 and U.S. 29 Study Corridors (page 1 of 2)

BEA Industry Labels (Input-Output Model)	BEA \$ loss, ratio	U.S. 460 Economic Hindrance, \$		U.S. 29 Economic Hindrance, \$	
		Mobility	Safety	Mobility	Safety
Truck transportation	1.1428	7423	6195	307	1097
Petroleum and coal products	0.1169	6080	5075	251	899
Oil and gas extraction	0.0952	4951	4132	205	732
Wholesale trade	0.0661	3436	2867	142	508
<i>Miscellaneous professional, scientific and technical services</i>	0.0513	2670	2228	110	395
<i>Other transportation and support activities</i>	0.0507	2636	2200	109	390
<i>Broadcasting and telecommunications</i>	0.0376	1953	1630	81	289
Motor vehicles, bodies and trailers, and parts	0.0364	1892	1579	78	280
<i>Real estate</i>	0.0338	1758	1468	73	260
<i>Management of companies and enterprises</i>	0.0338	1758	1467	73	260
<i>Federal Reserve banks, credit intermediation, and related activities</i>	0.0272	1413	1179	58	209
<i>Rental and leasing services and lessors of intangible assets</i>	0.0255	1324	1105	55	196
Warehousing and storage	0.0240	1249	1042	52	185
Chemical products	0.0237	1232	1029	51	182
<i>Other services, except government</i>	0.0228	1186	990	49	175
<i>Administrative and support services</i>	0.0227	1179	984	49	174
<i>Insurance carriers and related activities</i>	0.0212	1101	919	46	163
Fabricated metal products	0.0184	959	800	40	142
Retail trade	0.0177	919	767	38	136
Plastics and rubber products	0.0172	892	745	37	132
Primary metals	0.0154	802	670	33	119
<i>Utilities</i>	0.0100	520	434	21	77
<i>Rail transportation</i>	0.0100	519	433	21	77
<i>Securities, commodity contracts, and investments</i>	0.0099	517	431	21	76
<i>Legal services</i>	0.0091	471	393	19	70
Computer systems design and related services	0.0090	466	389	19	69
Information and data processing services	0.0089	462	385	19	68
Machinery	0.0070	364	303	15	54
<i>State and local government enterprises</i>	0.0068	352	294	15	52
Computer and electronic products	0.0066	346	288	14	51
Electrical equipment, appliances, and components	0.0064	335	280	14	50
Paper products	0.0063	328	274	14	49
<i>Air transportation</i>	0.0060	310	259	13	46
Waste management and remediation services	0.0058	300	251	12	44
Publishing industries (includes software)	0.0055	286	238	12	42
Construction	0.0052	272	227	11	40

BEA Industry Labels (Input-Output Model)	BEA \$ loss, ratio	U.S. 460 Economic Hindrane, \$		U.S. 29 Economic Hindrane, \$	
		Mobility	Safety	Mobility	Safety
Printing and related support activities	0.0040	208	174	9	31
Food services and drinking places	0.0036	189	158	8	28
<i>Federal government enterprises</i>	0.0031	161	135	7	24
<i>State and local general government</i>	0.0031	159	133	7	24
Nonmetallic mineral products	0.0028	144	120	6	21
<i>Pipeline transportation</i>	0.0026	135	112	6	20
Support activities for mining	0.0026	133	111	6	20
Mining, except oil and gas	0.0025	127	106	5	19
Food and beverage and tobacco products	0.0023	121	101	5	18
<i>Accommodation</i>	0.0023	120	100	5	18
Wood products	0.0021	111	92	5	16
<i>Performing arts, spectator sports, museums, and related activities</i>	0.0020	104	87	4	15
<i>Motion picture and sound recording industries</i>	0.0018	91	76	4	13
Miscellaneous manufacturing	0.0016	82	68	3	12
Farms	0.0015	80	67	3	12
Textile mills and textile product mills	0.0015	78	65	3	12
Forestry, fishing, and related activities	0.0012	61	51	3	9
<i>Educational services</i>	0.0012	61	51	3	9
Other transportation equipment	0.0011	59	49	2	9
<i>Water transportation</i>	0.0010	54	45	2	8
<i>Ambulatory health care services</i>	0.0007	36	30	2	5
<i>Transit and ground passenger transportation</i>	0.0005	26	22	1	4
Furniture and related products	0.0005	25	21	1	4
Apparel and leather and allied products	0.0005	24	20	1	4
<i>Funds, trusts, and other financial vehicles</i>	0.0004	22	19	1	3
<i>Federal general government</i>	0.0004	21	18	1	3
<i>Amusements, gambling, and recreation industries</i>	0.0004	20	17	1	3
<i>Hospitals and nursing and residential care facilities</i>	0.0001	7	6	0	1
<i>Social assistance</i>	0.0000	1	1	0	0
Total:		55125	46005	2279	8149

APPENDIX C – CRASH DATA USED IN CONCEPT DEMONSTRATIONS

TABLE C-1. U.S. 460 RAW TRUCK CRASH DATA FOR CONCEPT DEMONSTRATION STUDY AREA	C-2
TABLE C-2. U.S. 29 RAW TRUCK CRASH DATA FOR CONCEPT DEMONSTRATION STUDY AREA	C-6
TABLE C-3. U.S. 460 FAF SEGMENTS AND AADTT FOR CONCEPT S DEMONSTRATION STUDY AREA	C-8

Table C-1. U.S. 460 Raw Truck Crash Data for Concept Demonstration Study Area (page 1 of 4)

CrashDocument _CRASHDATE	FATAL COUNT	INJURY COUNT	ROUTE MILE POST	LATITUDE	LONGITUDE	VEHICLE TYPE
12-Oct-09	0	0	324.09	37.184165	-77.319056	04
03-Nov-06	0	0	324.12	0	0	04
05-Jul-06	0	0	324.201	0	0	05
07-Aug-09	0	1	324.24	37.183896	-77.318637	23
06-Oct-09	0	0	324.39	37.183715	-77.318355	23
08-Apr-09	0	0	324.39	37.182903	-77.317094	23
06-Jul-09	0	0	324.39	37.174785	-77.30448	23
01-Nov-10	1	1	324.39	37.174785	-77.30448	04
15-Jul-06	0	2	325.12	0	0	04
15-Jul-06	0	2	325.12	0	0	04
27-Mar-07	0	0	325.22	0	0	04
27-Mar-07	0	0	325.22	0	0	05
06-May-08	0	0	325.9	0	0	04
02-Jun-05	0	0	326.05	0	0	05
13-Jun-08	0	1	326.1	0	0	25
26-Feb-06	0	0	326.3	0	0	05
18-May-06	0	0	326.3	0	0	05
13-Jul-06	0	1	326.3	0	0	05
07-Feb-07	1	0	326.3	0	0	05
06-Feb-07	0	0	326.3	0	0	05
06-Feb-07	0	0	326.3	0	0	05
01-Dec-10	1	3	326.47	37.165306	-77.289761	23
14-Jan-09	0	2	326.47	37.163	-77.28763	23
09-Sep-08	1	0	326.52	0	0	23
17-Jun-07	0	1	326.55	0	0	04
13-Aug-05	0	0	327.025	0	0	05
02-Apr-06	0	0	327.12	0	0	05
13-Aug-08	0	1	327.12	0	0	23
29-Dec-08	0	1	327.12	0	0	23
17-Apr-07	0	1	327.129	0	0	05
17-Apr-07	0	1	327.129	0	0	05
17-Nov-05	0	1	327.148	0	0	05
17-Nov-05	0	1	327.148	0	0	05
10-Sep-10	0	0	327.29	37.159	-77.28001	23
12-Aug-09	0	0	327.29	37.156927	-77.276788	23
21-Dec-09	0	0	327.29	37.156023	-77.275377	23
11-Sep-09	0	1	327.29	37.156013	-77.275361	23
11-Sep-09	0	1	327.29	37.156013	-77.275361	23
11-Sep-09	0	1	327.29	37.156013	-77.275361	23
05-Feb-10	0	1	327.29	37.15601	-77.275356	23
29-Jul-10	0	0	327.29	37.15599	-77.27532	23
23-Aug-09	0	1	327.29	37.151454	-77.26835	23
14-Jul-10	0	0	327.29	37.14236	-77.25429	23
29-Jan-09	0	2	327.29	37.09359	-77.1652	23
15-Aug-05	0	0	328.62	0	0	05
03-May-06	0	2	329.39	0	0	05
26-Oct-07	0	0	330.23	0	0	05
18-Feb-05	0	1	330.39	0	0	05
27-Oct-05	0	0	330.39	0	0	05
17-Feb-05	0	1	330.93	0	0	05
27-May-05	0	0	331.08	0	0	05
19-Apr-06	0	0	331.39	0	0	05

CrashDocument _CRASHDATE	FATAL COUNT	INJURY COUNT	ROUTE MILE POST	LATITUDE	LONGITUDE	VEHICLE TYPE
09-Aug-06	0	0	331.63	0	0	05
27-Jul-07	0	2	332.58	0	0	05
15-May-09	0	1	332.75	37.106641	-77.198685	04
13-Jun-06	1	0	332.88	0	0	04
15-Dec-06	0	0	333.45	0	0	05
24-Sep-09	0	0	333.49	37.097136	-77.184328	23
07-Apr-10	0	0	333.49	37.093242	-77.17692	25
06-Oct-10	1	1	333.49	37.093242	-77.17692	23
14-Sep-09	0	0	333.49	37.091828	-77.173851	23
01-Oct-08	0	0	334.6	0	0	23
16-Jun-06	1	2	334.85	0	0	05
22-Feb-07	0	1	335	0	0	05
28-Jan-06	0	0	335.6	0	0	05
07-Dec-10	0	1	335.77	37.08474	-77.16252	23
25-Jun-09	0	0	336.55	37.07231	-77.14493	23
13-Mar-07	0	3	336.6	0	0	05
21-Jul-06	1	0	337.13	0	0	05
28-Jun-06	0	1	337.3	0	0	05
15-Apr-08	0	0	338.82	0	0	23
11-Dec-08	0	0	339.22	0	0	05
30-Jan-06	0	2	340	0	0	05
29-Apr-05	0	0	340.07	0	0	05
03-Dec-06	0	0	340.22	0	0	04
05-Aug-07	0	0	340.22	0	0	05
05-Oct-07	0	0	340.22	0	0	05
15-Jun-09	0	0	340.39	0	0	23
06-Aug-07	1	0	340.47	0	0	05
25-Apr-05	0	0	340.94	0	0	05
26-Jul-05	0	1	340.94	0	0	05
18-Jun-07	1	1	341.44	0	0	05
05-Jul-08	0	0	341.88	0	0	05
08-Apr-09	0	0	342.55	37.016654	-77.062665	23
08-Jun-07	0	0	342.55	0	0	05
08-Jun-07	0	0	342.55	0	0	04
12-Nov-06	0	0	344.71	0	0	05
05-Sep-06	0	0	345.91	0	0	05
10-Aug-07	0	0	345.91	0	0	05
10-Jun-09	0	0	346.6	36.985582	-77.012274	25
12-Feb-09	0	0	347.129	0	0	04
27-Jul-05	0	0	347.36	0	0	05
27-Dec-07	0	0	347.43	0	0	05
25-Oct-08	0	1	347.43	0	0	05
29-Nov-07	0	0	347.54	0	0	05
19-Aug-09	0	1	347.6	36.974149	-76.989027	23
23-Dec-09	0	0	347.71	36.973298	-76.987297	25
10-Mar-09	0	0	347.71	0	0	23
18-Apr-07	0	2	347.79	0	0	05
12-May-05	0	1	347.9	0	0	04
29-Aug-05	0	0	347.9	0	0	05
18-Nov-07	0	0	347.9	0	0	04
10-Jun-08	0	1	347.9	0	0	05
23-Feb-08	0	1	347.909	0	0	05
31-Oct-06	0	0	347.92	0	0	05
19-Mar-07	0	1	347.944	0	0	05
14-Jan-09	0	0	348.07	0	0	23

CrashDocument _CRASHDATE	FATAL COUNT	INJURY COUNT	ROUTE MILE POST	LATITUDE	LONGITUDE	VEHICLE TYPE
19-Jun-09	0	0	348.07	0	0	23
04-Nov-05	0	0	348.15	0	0	25
27-Jan-10	0	0	348.233	36.96917	-76.98142	04
06-Dec-10	0	0	348.99	36.95902	-76.9704	23
04-Dec-06	0	0	349.32	0	0	05
15-May-06	0	0	350.12	0	0	05
12-Feb-10	0	1	350.25	36.948877	-76.958006	23
05-Jul-06	0	0	351.29	0	0	05
09-Jul-08	0	0	351.29	0	0	05
20-Aug-09	0	0	352.46	36.927125	-76.924385	23
22-Feb-06	0	1	352.87	0	0	05
27-Jun-06	0	1	352.87	0	0	05
27-Jun-06	0	1	352.87	0	0	05
10-Sep-06	0	0	353.36	0	0	05
16-Jul-07	0	0	353.61	0	0	05
25-Sep-09	0	0	353.73	36.54867	-76.54337	23
11-Jan-09	0	1	354.03	36.5536	-76.55058	23
16-May-05	0	2	354.36	0	0	05
06-Feb-07	0	0	354.6	0	0	06
01-Dec-09	0	0	354.67	36.905544	-76.891616	23
04-Oct-06	0	1	355.45	0	0	05
06-Nov-07	0	0	356.91	0	0	05
25-Oct-10	0	0	357.08	36.8858	-76.8615	25
20-Oct-09	0	0	357.08	36.884097	-76.858889	23
19-Nov-07	0	0	358.72	0	0	05
15-Dec-10	0	0	358.85	36.86813	-76.83453	04
15-Dec-10	0	0	358.85	36.86813	-76.83453	13
16-Sep-05	0	1	358.85	0	0	05
26-Sep-06	0	0	358.85	0	0	05
25-Feb-09	0	0	359.02	0	0	23
22-Jun-05	0	1	359.258	0	0	05
19-May-10	0	0	359.39	36.865539	-76.827224	23
05-Oct-07	0	0	359.97	0	0	04
24-Jan-06	0	0	360.3	0	0	04
13-May-08	0	0	360.3	0	0	05
01-Mar-05	0	0	360.4	0	0	05
13-Nov-06	0	0	360.4	0	0	05
13-Nov-06	0	0	360.4	0	0	05
25-Oct-10	0	0	360.57	36.854332	-76.813538	25
21-Aug-08	1	2	361.3	0	0	05
17-Feb-08	0	1	361.6	0	0	05
22-Jul-10	0	0	361.92	36.839894	-76.792237	04
10-Mar-06	0	0	362.78	0	0	04
06-Dec-07	0	2	363.86	0	0	05
04-Sep-07	0	0	363.96	0	0	05
06-Apr-10	0	0	364.13	36.820677	-76.762968	23
24-Jan-05	0	0	364.35	0	0	04
18-Jan-06	0	0	364.83	0	0	05
26-Aug-06	0	0	364.83	0	0	05
26-Aug-06	0	0	364.83	0	0	05
12-Aug-05	0	0	364.85	0	0	05
15-Nov-05	0	1	364.85	0	0	23
27-Apr-05	0	0	364.97	0	0	04
18-Sep-10	0	0	365.02	36.81259	-76.7507	23
13-Jan-06	0	2	365.05	0	0	05

CrashDocument _CRASHDATE	FATAL COUNT	INJURY COUNT	ROUTE MILE POST	LATITUDE	LONGITUDE	VEHICLE TYPE
08-Nov-06	0	0	365.3	0	0	05
01-Feb-08	0	1	366.86	0	0	25
15-Feb-08	0	1	366.86	0	0	05
19-Dec-05	0	1	367.55	0	0	05
16-Aug-07	1	0	367.55	0	0	05
07-Feb-06	0	0	367.65	0	0	04
01-Apr-09	0	0	367.72	0	0	25
12-Aug-05	0	1	367.75	0	0	04
09-Dec-09	0	0	367.82	36.799383	-76.705698	23
11-Jan-07	0	0	367.86	0	0	13
11-Aug-09	0	0	368.02	36.47801	-76.41558	23
16-Feb-09	0	1	368.49	0	0	04
19-May-08	1	0	368.52	0	0	04
30-Oct-06	0	1	368.63	0	0	04
05-Jan-09	0	1	368.69	36.79588	-76.68885	25
30-Sep-09	0	0	368.79	36.47724	-76.41228	25
30-Sep-09	0	0	368.79	36.47724	-76.41228	25
06-Dec-05	0	0	369.05	0	0	23
21-May-05	3	3	369.55	0	0	05
12-May-06	0	0	369.65	0	0	04
12-May-06	0	0	369.65	0	0	05
06-Nov-09	0	0	369.82	36.791015	-76.667177	23
16-Apr-07	0	0	369.85	0	0	23
05-Nov-09	0	1	370.37	36.789385	-76.659658	25
13-Feb-08	0	0	370.45	0	0	05
27-Jan-05	0	0	370.71	0	0	05
13-Mar-06	0	0	370.96	0	0	05
30-Mar-07	0	4	371.14	0	0	13
15-Feb-06	0	0	371.4	0	0	25
10-Mar-08	0	0	371.66	0	0	25
18-Oct-06	0	0	371.71	0	0	05
27-Feb-08	1	0	371.71	0	0	23
16-May-05	0	0	371.805	0	0	05
15-Jul-09	0	0	371.88	36.78375	-76.63319	23
01-Aug-07	0	0	372.25	0	0	05
17-Dec-07	0	1	372.25	0	0	05
28-Feb-07	0	0	372.93	0	0	05
18-Jul-05	0	0	372.94	0	0	06
10-Nov-06	0	0	372.94	0	0	05
11-Feb-08	0	0	372.98	0	0	23
11-Feb-08	0	0	372.98	0	0	23
22-Nov-06	0	2	373.14	0	0	23
14-Jul-06	0	1	373.38	0	0	05
10-May-05	0	0	373.55	0	0	25
19-Jan-06	0	0	373.62	0	0	05
26-Jul-05	0	0	373.66	0	0	04
15-Nov-06	1	0	373.66	0	0	05
06-Aug-09	0	0	373.871	36.513084	-76.171431	14
05-Jun-09	0	0	373.881	0	0	14
30-Jun-09	0	0	373.89	36.767225	-76.603681	13

Table C-2. U.S. 29 Raw Truck Crash Data for Concept Demonstration Study Area (page 1 of 2)

CrashDocument _CRASHDATE	FATAL COUNT	INJURY COUNT	ROUTEMILE POST	LATITUDE	LONGITUDE	VEHICLE TYPE
17-Apr-09	0	0	139.404	38.058546	-78.494523	23
11-Sep-10	0	0	139.412	38.058651	-78.494441	23
06-Jul-10	0	3	139.42	38.05875	-78.49436	23
15-Nov-05	0	0	139.46	0	0	05
15-Nov-05	0	0	139.46	0	0	05
18-Sep-06	0	0	139.46	0	0	05
27-Nov-06	0	0	139.46	0	0	05
16-Dec-08	0	1	139.474	0	0	04
28-Sep-10	0	0	139.522	38.05993	-78.493448	23
19-Aug-10	0	0	139.551	38.0601	-78.492972	23
20-May-10	0	0	139.609	38.06075	-78.492472	23
05-Oct-07	0	0	139.676	0	0	04
05-Mar-05	0	1	139.68	0	0	06
02-Nov-06	0	0	139.68	0	0	04
17-Jul-08	0	0	139.68	0	0	05
18-May-10	0	1	139.69	38.061656	-78.491775	04
10-Nov-09	0	0	139.71	38.06216	-78.491685	04
04-Jun-09	0	0	139.711	38.061891	-78.491578	23
22-Dec-10	0	0	139.711	38.062173	-78.491673	25
27-Jul-10	0	0	139.723	38.0623	-78.49154	23
10-Jul-09	0	3	139.778	38.062935	-78.49096	04
26-Sep-09	0	0	139.814	38.063129	-78.490464	04
26-Mar-10	0	0	139.886	38.064014	-78.489677	14
22-Nov-10	0	0	139.932	38.064722	-78.489336	04
19-Aug-09	0	0	140.012	38.065526	-78.488322	23
22-Mar-06	0	0	140.05	0	0	04
17-Jan-08	0	0	140.05	0	0	05
25-Jun-08	0	0	140.088	0	0	23
19-Dec-05	0	0	140.25	0	0	04
20-Jun-05	0	1	140.38	0	0	04
16-Jul-05	0	0	140.38	0	0	05
16-Jul-05	0	0	140.38	0	0	04
09-Jul-07	0	0	140.399	0	0	05
01-Jul-10	0	0	140.4	38.070006	-78.48429	04
05-Oct-10	0	0	140.4	38.0701	-78.48451	23
31-Mar-10	0	0	140.401	38.070018	-78.484298	04
01-Nov-10	0	0	140.401	38.07002	-78.48429	25
01-Dec-10	0	0	140.523	38.071479	-78.483289	04
23-May-07	0	0	140.62	0	0	04
15-Jan-08	0	2	140.62	0	0	04
13-Jul-07	0	0	140.64	0	0	23
23-Nov-09	0	0	140.729	38.073934	-78.480789	04
18-Aug-05	0	0	140.86	0	0	05
10-Aug-06	0	0	140.86	0	0	04
12-May-07	0	0	140.86	0	0	05
20-Jun-07	0	0	140.86	0	0	05
18-Jan-08	0	0	140.861	0	0	04
09-Nov-09	0	0	140.931	38.076174	-78.478782	23
05-Mar-10	0	0	140.961	38.076525	-78.478458	04
23-Oct-09	0	0	141.018	38.077228	-78.477838	04
10-Jun-06	0	0	141.031	0	0	05
16-Jun-05	0	0	141.05	0	0	04
30-Mar-06	0	1	141.05	0	0	05
16-Aug-06	0	1	141.05	0	0	05

CrashDocument _CRASHDATE	FATAL COUNT	INJURY COUNT	ROUTE MILE POST	LATITUDE	LONGITUDE	VEHICLE TYPE
09-Feb-08	0	0	141.05	0	0	05
01-Apr-05	0	1	141.14	0	0	05
27-Aug-07	0	0	141.2	0	0	04
04-Jan-06	0	0	141.206	0	0	05
11-Dec-06	0	1	141.335	0	0	04
11-Dec-06	0	1	141.335	0	0	05
17-Aug-09	0	1	141.4	38.081923	-78.473947	23
29-Oct-10	0	0	141.404	38.08198	-78.473932	13
04-Oct-09	0	0	141.405	38.081745	-78.473785	04
24-Apr-07	0	0	141.406	0	0	04
05-Nov-10	0	0	141.406	38.081781	-78.473815	04
26-Jan-10	0	0	141.406	38.082001	-78.473917	23
02-Feb-06	0	0	141.425	0	0	05
23-Jan-10	0	0	141.473	38.082791	-78.473398	13
03-May-05	0	0	141.52	0	0	05
16-Jun-05	0	0	141.52	0	0	04
01-Jul-05	0	0	141.52	0	0	05
13-Jul-05	0	4	141.52	0	0	04
17-Jan-07	0	2	141.52	0	0	23
11-Mar-10	0	0	141.548	38.08371	-78.472872	25
04-Dec-10	0	1	141.596	38.08434	-78.472512	04
04-May-09	0	0	141.658	38.085144	-78.472052	23
14-May-07	0	0	141.7	0	0	23
15-Sep-05	0	1	141.72	0	0	05
25-Nov-08	0	0	141.85	0	0	05
29-Jul-09	0	0	141.87	38.087915	-78.470466	08
10-Jun-09	0	0	141.889	0	0	23
06-May-05	0	1	142.22	0	0	05
19-Dec-05	0	0	142.22	0	0	05
09-Dec-05	0	3	142.239	0	0	04
05-Nov-09	0	1	142.57	38.097106	-78.464623	04
21-Oct-10	0	0	142.64	38.0979	-78.46399	25
21-Oct-10	0	0	142.64	38.0979	-78.46399	25
02-Oct-08	0	0	142.691	0	0	04
14-Oct-05	0	2	142.7	0	0	05
15-Apr-07	0	0	142.7	0	0	04
17-Sep-07	0	0	142.7	0	0	04
31-Mar-08	0	0	142.7	0	0	05
31-Mar-08	0	0	142.7	0	0	04
31-Mar-08	0	0	142.7	0	0	04
07-Nov-08	0	0	142.7	0	0	04
24-Feb-06	0	0	142.9	0	0	04
25-Apr-08	0	1	142.9	0	0	06
14-Oct-06	0	1	143.28	0	0	25
17-Nov-10	0	0	143.417	38.107195	-78.45686	04
19-Dec-08	0	0		38.06057	-78.49294	14
12-Aug-08	0	0		38.06544	-78.48835	23
12-Aug-08	0	0		38.06544	-78.48835	23
15-Nov-08	0	0		38.07832	-78.47682	04
01-Aug-08	0	0		38.08698	-78.47106	04

Table C-3. U.S. 460 FAF Segments and AADTT for Concept Demonstration Study Area

Raw FAF Data		Segment Truck DVMT	Consolidated Segments by AADTT		
Segment Mileage	2007 AADTT		Mileage	2007 AADTT	Truck DVMT
3.1	1918	5974	3.6	1918	6930
0.5	1918	956			
9.9	2012	19947	24.6	2012	49496
6.2	2012	12407			
8.4	2012	16858			
0.1	2012	284			
6.3	2271	14217	13.0	2271	29630
6.8	2271	15413			
3.8	3744	14130	8.8	3744	32964
3.4	3744	12916			
1.4	3744	5172			
0.2	3744	745			
Total: 50.1	-	119020	50.1	-	119020
Wtd. Average:	2377	-	-	2377	-