The Role of U.S. Airports in the National Economy

DETAILS

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 132

The Role of U.S. Airports in the National Economy

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

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The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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FOREWORD

By Theresia H. Schatz
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ACRP Report 132: The Role of U.S. Airports in the National Economy quantifies the economic role of U.S. public use airports and the national airport system ("airports") to the national economy in order to communicate the national aggregate value of airports to communities and to aviation stakeholders. The research includes total direct, national economic impacts of U.S. airports and multiplier effects, and national average on-airport economic impact by different types of airports [primary (large, medium, small, and non-hub); non-primary and reliever; and general aviation]. The report also examines how changes in airport connectivity between regions could be beneficial to the U.S. economy and the national economic effects of changes in airfares. There is also a discussion of the available evidence showing the importance of airports in supporting domestic and international commerce, economic growth and tourism, and the extent to which airports enhance urban agglomeration economies.

The economic impact of airports is typically assessed at a local or regional level to educate communities about how their airport(s) contribute to the area's economy and to support airport infrastructure investments and ongoing expenditures to policy makers. Various entities have published reports quantifying the impact of the civil aviation industry, but not the specific economic impact of airports to the national economy. A need exists at the national level to educate policy makers and the public about the economic impact and the importance of airports and the airport system to the United States.

Under ACRP Project 03-28, research was conducted by Economic Development Research Group, Inc., in association with Dr. David Gillen, ICF SH&E, Kramer aerotek, Inc., and Mead & Hunt, Inc. to develop this report. The economic analysis included documentation of the existing contributions of 3,300 airports in the National Plan of Integrated Airport Systems (NPIAS) with an impact of changes in airport connectivity, air cargo, and airfares.

In addition to this report, there is a PowerPoint presentation and brochure that describes the key features of this report as well as the technical appendices that provide all the underlying data associated with this research effort available on the TRB website at www.TRB.org/main/blurbs/172111.aspx.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

SUMMARY

The Role of U.S. Airports in the National Economy

Introduction

The objective of ACRP Project 03-28 is to estimate the economic role of U.S. public use airports and the national airport system (airports) in the national economy. It can be used to educate communities and aviation stakeholders on the national value of airports.

This research project breaks new ground in taking two approaches to airport economic analysis that are distinct from regional and state analyses commissioned by airports, airport authorities, and state departments of transportation. A framework was constructed and applied to identify in detail the current role of the U.S. airport network in the national economy, and, importantly, how changes in the network could result in benefits to the U.S. economy.

The economic analyses in this research include documentation of the existing contributions of 3,330 airports in the National Plan of Integrated Airport Systems (NPIAS),[1] and how those contributions will be affected given changes in airport connectivity, air cargo, and airfares. The 3,330 NPIAS airports account for about 65% of U.S. public use airports; 17% of all airports, including those privately used; and 99.8% of all enplanements in 2012.[2]

The examination is limited to the operation of the airports, spending by international visitors, and international air cargo. It differs from most regional and state studies as it does not include estimates of domestic visitor spending and domestic air-cargo shipments that redistribute economic effects among regions or states, but do not add to the economy of the nation. In addition spending of international visitors to the United States is net of the spending of U.S. residents who are traveling internationally.

Second, the research team estimated how airport changes will affect the U.S. economy by positing increases in direct air connections between regions, increases in air cargo shipments, and decreases in airfares. This project provides a significantly advanced methodology in identifying the wider economic benefits of airports based on airports' roles in connecting regions across the United States and of connecting regions in the United States to world markets. The team's developed methodology complements straightforward economic impact studies and allows the use of large data sets to undertake new analysis and provide more detailed assessments of specific policy proposals and management strategies.

Multiple estimates defining the national economic contributions of airports are calculated for these different approaches. While estimates are presented for jobs, labor income, value added, and gross output, the core measure to assess the contribution of U.S. airports to productivity in the national economy is through dollars of value added. Value added equals gross domestic product (GDP) when aggregated across all industries.[3]

The role of airports in the national economy is illustrated in Figure S-1. Airports facilitate services to businesses and personal travelers by providing passenger transportation and rapid long distance cargo movement. For businesses, passenger and cargo transportation services are intermediate purchases used to facilitate production or sales. For example, a company may acquire an electronic component that is part of a larger product. After production, that

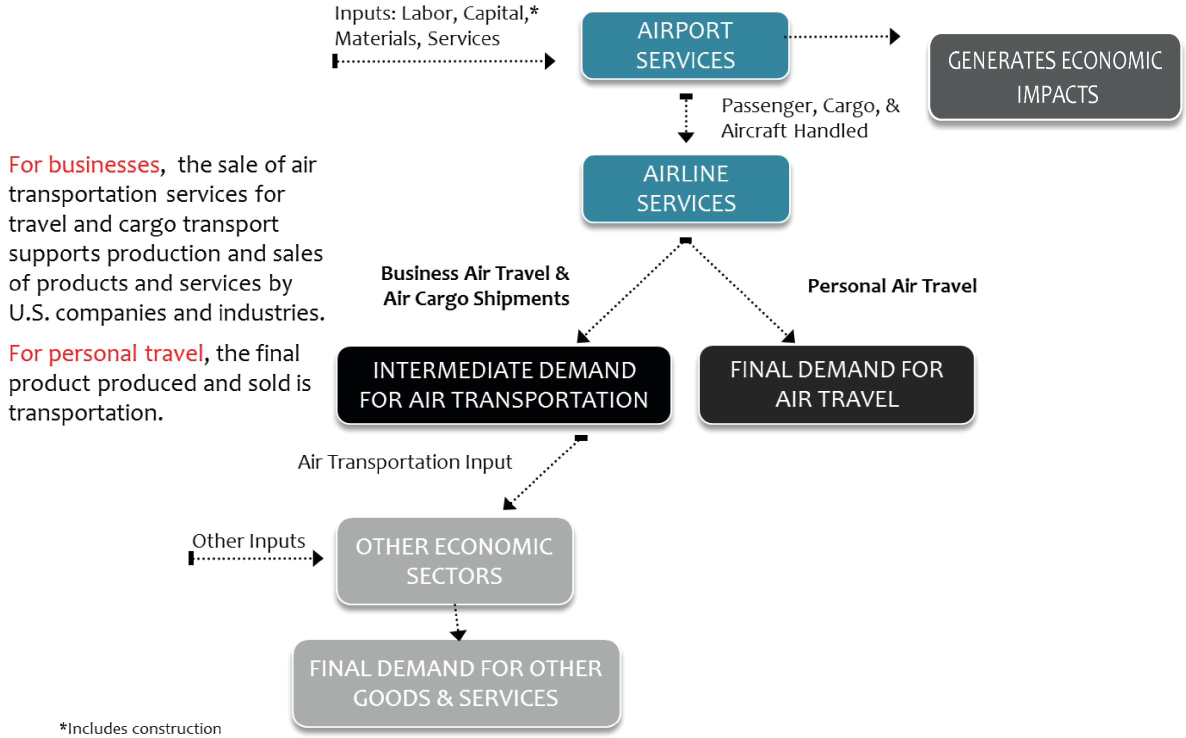


Figure S-1. Airports' role in the U.S. economy.

product may be sent by air to a customer. Similarly, business travel is a means to provide services or facilitate sales. For personal travel, however, the final product that is being purchased is air transportation.

To provide these services, airports need to be constructed, maintained, and managed. For the purposes of businesses located outside of airports, air transportation is an input that enables businesses to provide and receive services and to ship and receive products required for operations, sales, and production processes.

Approach

Four questions were investigated to trace the role of U.S. airports on the national economy:

1. What is the national economic impact of NPIAS airports?
2. To what extent do improvements in national and international connectivity add to the productivity of U.S. industries?
3. What are the interrelationships of increased air cargo to the U.S. industrial base?
4. How do decreased airfares affect the national economy?

These four assessments are complementary and do not overlap. The estimate of the national economic contributions of NPIAS airports (Number 1) documents the traditional method of accounting for economic impacts of airports. It is a static estimate that reports the footprint of airports on the national economy and measures the economic contributions of airports at a single point in time. The multifactor productivity (MFP) and consumer surplus (CS) analyses (Numbers 2, 3, and 4) present dynamic appraisals of the impacts of airports on the U.S. economy if conditions change. The analyses estimate how productivity and economic impact in the national economy will be affected if connectivity changes, if air cargo volume changes, or if the costs of personal travel change. These airport factors include connectivity of markets through greater (or lesser) air service, air cargo flows, and the cost of airline tickets.

MFP estimates the growth in value added in reaction to changes of all inputs into production processes. In this study, the research team estimated growth in net value added from: (1) strengthening non-stop connectivity among airports; and (2) increased use of air cargo by industries.

CS is the difference between what consumers are willing to pay for a good or service and what they actually pay. In the context of air service, the difference in willingness to pay for air service and what is actually spent leaves money in households' "wallets," and is available to be spent in the general economy on non-aviation goods and services.

The following sections provide additional detail on the four approaches evaluated to determine the total role of U.S. airports on the national economy.

National Economic Contribution of U.S. Airports

The standard approach of estimating the current economic contributions of airports is through a summation of on-airport and visitor spending activities. It is a snapshot of the economic contribution of airports at a given moment based on when data are collected. The prevailing economic analysis of the national airport system was constructed by evaluating and blending national data sets from public agencies, nonprofits, and private companies. In addition, this summation was tested by developing multiple regression analyses based on recently completed economic impact studies of airports and state airport systems.[4] The regression analyses estimated the total output of U.S. airports based on about 700 airport economic impact studies of the 3,330 airports in the NPIAS.[5]

As this study is of the role of the U.S. airport system in the national economy, drivers of the analysis were limited to on-airport transactions, international air cargo, and off-airport spending of international air arrivals (net of U.S. travelers spending on international travel), as shown in Figure S-2. Unlike other national, regional, or local studies, these findings did not include domestic air cargo, spending of domestic visitors who travel from region to region, or aircraft manufacturing [although on-airport fixed-based operator (FBO) services are included]. Moreover, the off-airport spending of international visitors to the United States was compared to visitor spending by U.S. residents abroad, and the net difference is applied to represent the impact of airports in the United States.[6]

Multiple metrics that estimate the economic role of airports are calculated for the analyses presented in this report, including jobs, labor income, value added, and output. Using the findings of the existing contributions of airports to the national economy, Figure S-3 illustrates the relationship of these different measures.

The total economic contributions of U.S. airports are presented in Table S-1, representing a single year total of about $1.6 trillion (output). The contribution shown specifies

Figure S-2. Drivers of national economic impact.

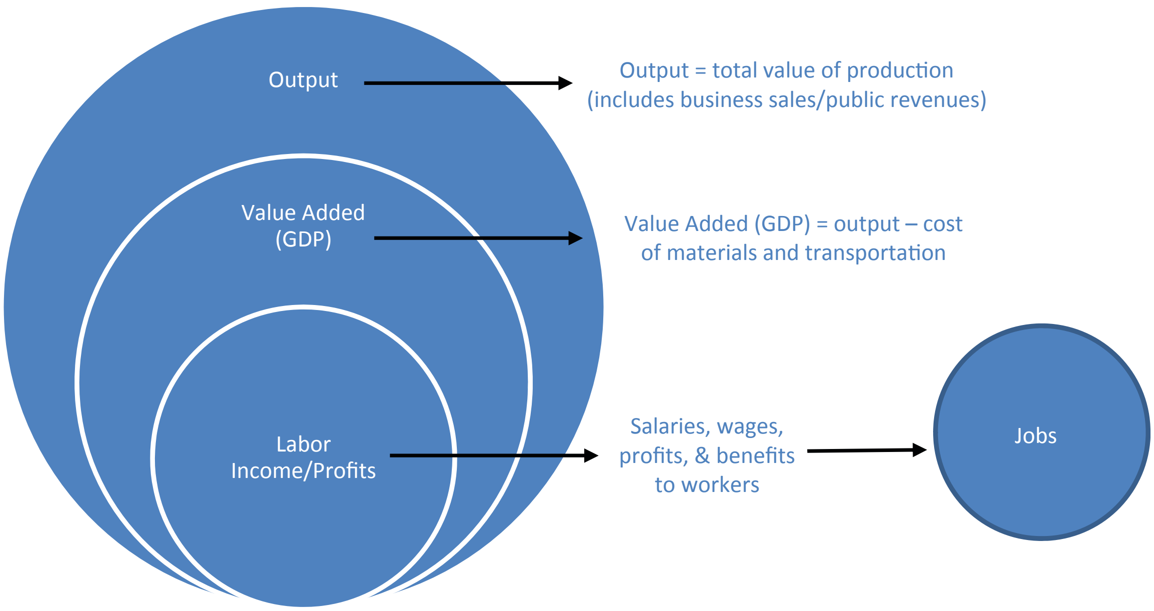


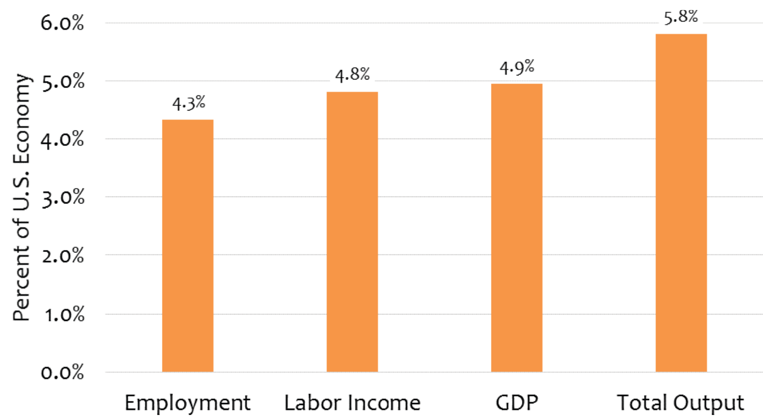
Figure S-3. Overview of the economic role of airports.

Table S-1. National economic contribution by type of impact.

Type of Economic Impact	Employment in Thousands	Labor Income in $Billions	Value Added (GDP) in $Billions	Output in $Billions
On-Airport Direct	939	$64	$98	$195
+ Airport Indirect and Induced Effects	1,563	$81	$144	$254
= Total Airport Generated	2,503	$145	$242	$449
+ International Visitor Spending	518	$19	$32	$53
+ International Air Cargo	4,608	$288	$4958	$1,096
= Total	**7,629**	**$453**	**$768**	**$1,597**

Numbers may not add due to rounding. Dollars are in 2010 value.
International visitor spending is a net of spending by international visitors in the U.S. minus U.S. travelers spending abroad.

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN Group LLC. Calculations by EDR Group using 2012 National IMPLAN model.



Sources: Data calculated by the research team to estimate direct contribution of airports, based on 2009–2013 data. National economy is from U.S. Bureau of Economic Analysis, U.S. Department of Commerce, 2012.

Figure S-4. Total impact of U.S. airports as percent of U.S. economy.

on-airport activities (direct and multiplier effects[7]), the net impact for international visitor spending, and total contributions (including multipliers) associated with international air cargo shipments. As shown in Figure S-4, the contribution of airports (averaged across the four impacts) account for approximately 5% of the national economy.

MFP and CS Analyses

The MFP and CS analyses are dynamic analyses, meaning that changes in the aviation system lead to changes in the economic impact of the U.S. airports (illustrated in Figure S-5). The *MFP analyses* estimate how changes in air service (defined as improved connectivity among airports) add to industry productivity. Secondly, MFP was applied to explore the interrelationships of air cargo and productivity. While MFP explored the impacts of airports

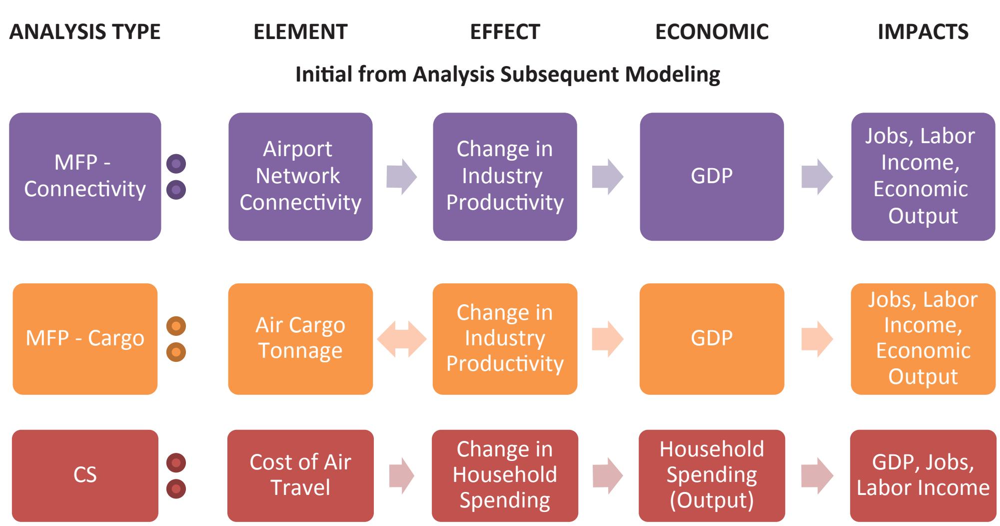


Figure S-5. Dynamic impact of U.S. airports on the national economy.

on industry sectors and how airports support industry business impacts, the *CS analysis* estimated the potential overall economic impact of airfare price changes.

For the MFP and CS analyses, 1% changes were assumed in connectivity variables, cargo tonnage, and airfares. Changes in these assumptions will alter the estimates of impact. Moreover, impacts could be negative to the economy if connectivity decreases for one or more of the variables tested, air cargo operations lose efficiency, or airfares increase.

The Impact of Improvements in National/International Connectivity on Industry Productivity

An MFP analysis was used to identify the impacts of national and international connectivity improvements on U.S. industries' productivity. This analysis estimated how changes in air service (defined as improved connectivity among airports) add to industry productivity. For this evaluation, a 1% change was applied across 11 different connectivity variables (the connectivity improvements are listed in Table S-2) and the modeled results are shown on Table S-3.

This analysis provides a useful start to identifying the relative influence of different measures of airline network connectivity. It also shows how the effect of different connectivity measures appears to differ across industry sectors if one or more connectivity characteristics grow by 1%. For example, if the number of domestic airline hubs served across the airline network (represented in this analysis by the sample of 20 regions and their airports) were to increase by 1%, the change in direct value added would be about $374 million. Moreover, if the number of hubs served increased by 10%, the MFP value would be about $3.7 billion.[8] In addition (also seen in Table S-3), impacts by industry differ according to each connectivity variable reported. For example, in terms of additional net value added, the manufacturing sector will benefit by the increased number of airlines and the number of domestic nonstop departures, but not by the increased number of domestic airline hubs served.

Table S-2. National economic contribution by source of impact.

Connectivity Measure
Two or More Daily Nonstop Domestic Flights
International Nonstop Destinations
Domestic Nonstop Destinations
Percent of the World GDP Served Daily
Five or More Daily Nonstop Domestic Flights
Airline Hubs Served-Domestic
International Nonstop Departures
Percent of the World GDP Served Nonstop
Domestic Nonstop Departures
Percent of the World GDP Served Twice or More Daily
Number of Airlines

Table S-3. Estimated impact in 20 metropolitan statistical areas (MSAs) of a 1% change in different connectivity measures on industry value added (in millions of 2010 dollars).

	Industry	Number of Airlines	Domestic Nonstop Departures	Airline Hubs Served-Domestic	Domestic Nonstop Destinations	Two or More Daily Nonstop Domestic Flights	Five or More Daily Nonstop Domestic Flights	International Nonstop Departures	International Nonstop Destinations	% World GDP Served Nonstop	% World GDP Served Daily
1	Manufacturing	$158	$85		$123	$356			$172		
2	Wholesale Trade	$43	$51		$30		$64		$38		$6
3	Information			$24		$19		$39	$23		$41
4	Finance & Insurance		$151	$226		$99		$42			$34
5	Real Estate, Rental & Leasing		$95		$176	$180	$49		$236		
6	Professional Scientific & Technical Services		$57	$112				$82			$153
7	Management of Companies & Enterprises			$8	$26			$7	$18	$16	
8	Administration & Support Waste Management Services		$11		$33			$23	$95	$51	
9	Art, Entertainment & Recreation			$3	$4		$7				$14
10	Accommodation & Food Services		$0		$20						$19
11	Other*		$3		$272				$100		$95
	Total	$201	$453	$374	$686	$654	$119	$192	$683	$68	$361

"Other" represents a grouping of the following sectors: Agriculture, Forestry, Fishing, and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Retail Trade; Transportation and Warehousing; Educational Services; Health Care and Social Assistance; Other Services (except Public Administration); and Public Administration.

Connectivity measures are shown on Row 1.

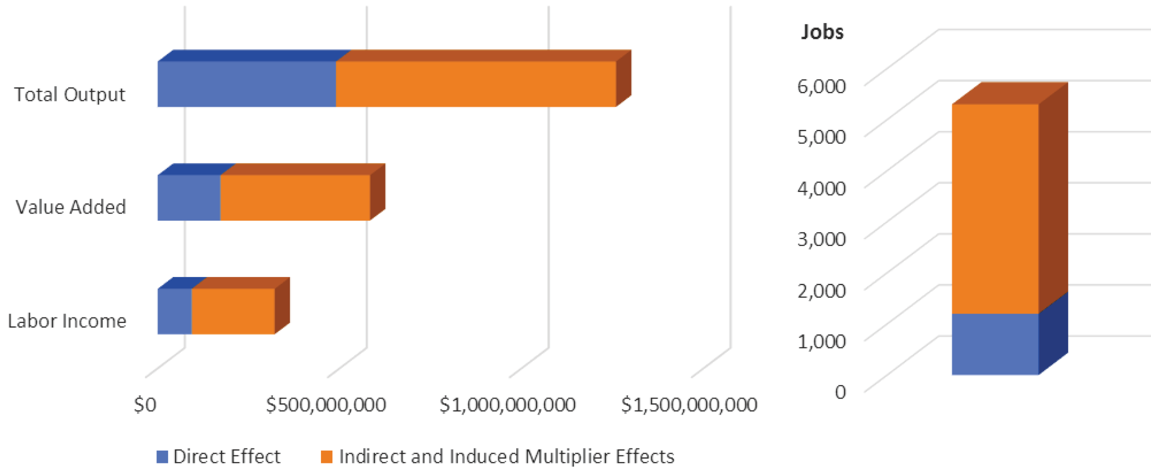


Figure S-6. Direct and total impact in manufacturing and wholesale sectors reflected by a 1% change in air cargo tonnage.

The Impact of Increased Air Cargo to the U.S. Industrial Base

A second MFP analysis was conducted to gauge the relationship of economic productivity and air cargo. It found that a 1% increase in enplaned air cargo creates a $173 million direct boost in direct value added for the manufacturing and wholesale trade sectors and a contribution of almost $600 million in value added when multiplier effects are factored (illustrated in Figure S-6).

The Effect of Changes in Domestic and International Airfare

While MFP explored the impacts of airports on industry sectors, the consumer surplus analysis estimated the potential overall economic impact of airfare price changes. The change in consumer surplus is defined as the difference between what consumers are willing to pay for a good or service and what they actually pay. This surplus is effectively dollars left in the pockets of consumers that can be used for additional spending for goods and services.

The consumer surplus analysis was conducted on a national level based on a 1% airfare decrease. Findings show that the net effect on the national economy would be an additional $249 million in value added (shown in Table S-4) after accounting for:

- Induced travel by lower prices encouraging more air travel. This is money taken from the non-aviation portion of household spending for the purchase of air transportation.
- The additional money generated by consumer surplus that becomes available for non-aviation household spending.

Table S-4. Direct economic impacts of a 1% decrease in airfare.

Activity	Employment	Labor Income	Value Added	Output
Changes in Economic Impact Generated by				
1% Decrease in Airfares	1,400	$162	$249	$553

All dollars are in $2010 millions. Jobs are rounded to the nearest hundred.

Economic Role of U.S. Airports in the National Economy

The economic analyses examined in this research include the existing contributions of U.S. airports to the national economy and how that contribution will change given changes in airport connectivity, air cargo, and airfares. While the analyses of existing contributions and consumer surplus were conducted on a national scale, the two MFP analyses were limited to a sample of 20 metropolitan statistical areas (MSAs).[9] The combined economies of the 20 MSAs represent about 23% of the national economy when comparing national GDP to the regional total. Stated differently, the national GDP is 4.3 times the combined gross regional products of the 20 MSAs.[10] As the two MFP analyses are limited to the sample of 20 metropolitan areas, the national extrapolations are shown for illustrative purposes to show order of magnitude (rough approximation) of effects.

Direct Economic Contributions

Direct contributions of U.S. airports to the national economy are summarized in Table S-5. The table includes the direct economic impact of NPIAS airports, as well as the direct impact of a 1% change in connectivity variables, air cargo tonnage, and airfares. These numbers do not include multiplier impact.

Total Economic Role of U.S. Airports in the National Economy

Total national estimates from all analyses, *including direct and multiplier impacts* (indirect and induced economic effects) are summarized below.

- The standard accounting for economic impact shows that the total economic contribution of airports to the national GDP (based on 2011–2013 data) is $768.4 billion in 2010 dollars, shown in Table S-1 and Table S-6.
- In addition to the national contribution of the current U.S. airport network to the national economy:
  - The impact of a 1% increase of nonstop airport connectivity is expected to yield total increased national value added between $700 million and $9 billion in 2010 value,

Table S-5. National direct economic impact of U.S. airports to the national economy.

Activity	Employment	Labor Income	Value Added	Output
Economic Impact of NPIAS Airports	2,172,200	$147,642	$247,424	$637,002
Changes in Economic Impact Generated by				
1% Improvement of Connectivity Variables	13,000	$795	$1,507	$3,043
1% Increase of Air Cargo Tonnage	5,100	$403	$742	$2,103
1% Decrease in Airfares	1,400	$162	$249	$553

National impacts of connectivity and air cargo are extrapolated from the 20 MSAs for illustrative purposes to show order of magnitude effects.

All dollars are in $2010 millions. Jobs are rounded to the nearest hundred.

Table S-6. National total economic role of U.S. airports in the national economy.

Activity	Employment	Labor Income	Value Added (GDP)	Output
Economic Impact of NPIAS Airports	7,628,900	$452,506	$768,402	$1,597,458
Changes in Economic Impact Generated by:				
1% Improvement of Connectivity Variables[1]	38,900	$2,272	$3,979	$7,417
1% Increase of Air Cargo Tonnage	22,700	$1,377	$2,502	$5,402
1% Decrease in Airfares	5,800	$385	$657	$1,281

[1]Data reflect the mean average of all 11 connectivity variables.

All dollars are in $2010 millions. Jobs are rounded to the nearest hundred. Total impact includes estimates of direct, indirect and induced impact.

varying by which of the connectivity variables change. (The variables are shown in Table S-2 and Table S-3.)
– A 1% increase in air cargo (not including shifts between modes) is expected to reflect increases in industrial productivity equivalent to $2.5 billion in GDP.
– A 1% decrease in airfare will generate consumer surplus for personal travelers equivalent to a $657 million increase in total national GDP.

- Note that the national impacts of connectivity and air cargo are extrapolated from the 20 MSAs for illustrative purposes to show approximate effects.

Qualitative Research

Structured interviews were conducted with representatives of airports, business associations, and corporations to verify and enrich the results of the quantitative research. In the course of this project, the research team conducted 76 interviews with companies that rely on business travel and air cargo shipments, business organizations, airport administrators, and representatives of alliances of airports, airlines, and general aviation users. The purpose of this outreach program was to review observations and conclusions suggested by data research in real world contexts. Moreover, an assessment of non-quantifiable national benefits was conducted to assure that this research reported the full breadth of the national benefits of airports. These impacts span across various industries, communities, and locations and are important to recognize alongside the quantitative impact. Whether aviation supports the research of a university group, the saving of a life, or the protection of national borders, it is critical to our health, safety, and welfare in ways that cannot be appropriately reflected in economic impact calculations.

Interviews with business executives and representatives of business organizations (such as chambers of commerce and industry associations) were conducted to provide a practical perspective to the economic impact analysis and the analysis of airport connectivity in terms of the multifactor productivity analysis, and the interrelationship of productivity and air cargo, and the consumer surplus analysis conducted as the main body of research for this report. Interviewees supported the importance of airport connectivity. Priorities identified by business travelers are listed below. Note that the first three bullets are directly applicable to connectivity:

- Frequent domestic and international service;
- A choice of nonstop domestic and international flights;
- Concentration of flights to and from particular markets during peak hours;
- Reliable schedules with minimal delays;
- Ease of rush hour commute to and from the airport; and
- Lower relative ticket costs, with competition on popular routes in order to reduce fares.

In terms of cargo, air transport is the most expensive mode. In most cases, it is the choice of last resort, except for perishable goods, high value products (notably, but not limited to, technology), just-in-time parts and supplies, other time-sensitive delivery due to long distances or production delays, or explicit requests by customers.

Companies make shipping decisions based on cost of transport or scheduled delivery time to a destination. Logistics can steer shipping requests to the lowest cost option that meets delivery requirements.

Conclusion

The multiple approaches carried out in ACRP Project 03-28 are complementary in understanding the multiple economic roles of airports to the national economy. While an economic impact analysis is a snapshot of the economic contribution of airports at a given moment, analyses based on multifactor productivity and consumer surplus account for how national economic impact of airports will change if connectivity between airports and regions, air cargo tonnage, and/or the cost of airfare change. The latter class of analyses identifies how airports are able to trigger dynamic economic impact across the national economy.

End Notes

1. The National Plan of Integrated Airport Systems (NPIAS) of the Federal Aviation Administration identifies airports significant to national air transportation.
2. Report to Congress: National Plan of Integrated Airport Systems (NPIAS), 2015–2019, p.76; Office of Airport Planning and Programming, Federal Aviation Administration September 2014.
3. Source: U.S. Bureau of Economic Analysis, http://www.bea.gov/faq/index.cfm?faq_id=1034.
4. The years of available national level data sets range for the years 2011 to 2013, and the economic impact studies used for the regression formulae were conducted from 2006 to 2012. Dollars were adjusted to 2010 value.
5. Over 1,000 economic impact studies were obtained in the course of the research. Roughly 700 contain data that were specific enough to be included in the regression analysis.
6. The data are reported by the Office of Travel and Tourism, International Trade Administration, of the U.S. Department of Commerce. Data are 2012, calculated in 2010 dollars.
7. The terminology for direct and multiplier effects are not uniform across studies. As used in this study: Direct effects take place only in the industry immediately affected, whether it is on or off airport. The multiplier impact is made up of indirect and induced effects. Indirect effects measure the purchase of supplies and services needed to produce directly supplied products and services. Induced effects measure the effects of the changes in household income, meaning the effects from the spending of wages earned by workers of directly and indirectly affected industries. The total impact is the summation of direct and multiplier (indirect and induced) effects.
8. This represents an increase in value added under the assumption that all else, such as technology of production and market shares, remains the same. Moreover, increased air cargo and value added do not assume that the gross tonnage or value of cargo transported by truck, rail, or ship will change (other than the ground transportation required to transport goods from shippers to airports and from airports to customers).
9. Metropolitan statistical areas are designated by the United States Office of Management and Budget (OMB).
10. Source: BEA National Product Accounts. The national GDP in 2010 was $15 trillion, and the portion in the 20 MSAs was a combined $3.5 trillion, or 23.3% of the national total.

CHAPTER 1

Introduction

1.1 Purpose

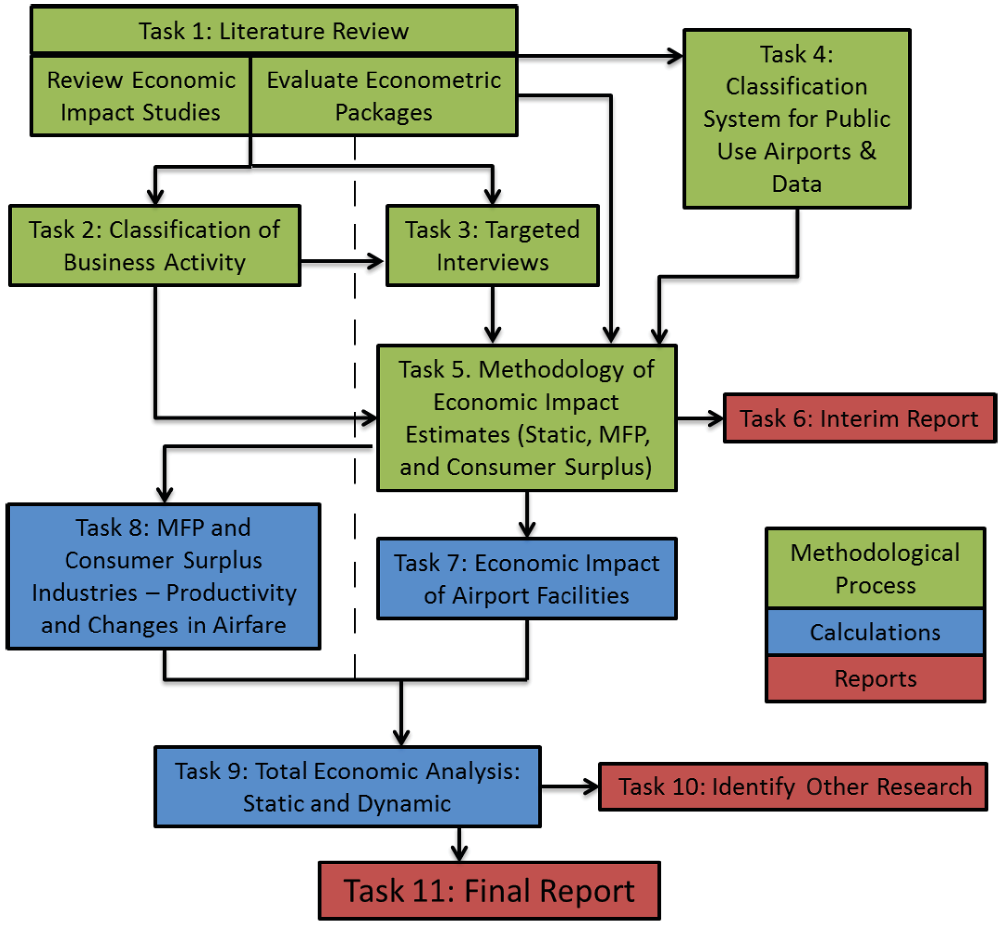
The purpose of ACRP Project 03-28 is to estimate the national economic impact of U.S. public use airports that are included in the NPIAS.[1] In conducting this investigation, the research team explored the overall economic contribution of airports in the national economy and also explored issues quantifying the linkage between airport system performance and economic activity for different types of air passenger trips and air cargo shipments.

Figure 1 illustrates the flow of tasks used to develop the data collection plan and to complete the research.

Tasks 1–5 address the theoretical underpinnings of the research. These tasks document past methodologies used to conduct airport economic impact studies; the differences between national approaches and state or regional impact studies of airports and airport systems; the roles of airports in the national aviation system cross-referenced by size and geographical characteristics; and various modeling techniques and data sources.

Following Task 6, the Interim Report, Tasks 7 and 8 use the findings of the initial five tasks to calculate the economic impact of public use airports on the national economy. These tasks explore alternative methodologies and categories of impacts, including the economic contribution of the current U.S. airport network, productivity effects if direct (nonstop) connections among airports or air cargo tonnage change, and impact stemming from changes in airfares. Task 9 discusses how the three analyses undertaken in the preceding tasks correspond with each other.

In addition to quantitative research, 76 interviews were conducted with companies that rely on business travel and air cargo shipments, business organizations, airport administrators, and representatives of alliances of airports, airlines, and general aviation users. The purpose of this outreach was to review observations and conclusions suggested by data research in real world contexts. In addition, an assessment of non-quantifiable national benefits was conducted to assure that this research reported the full breadth of the national benefits of airports. Lastly, Task 10 discusses additional research suggested by Tasks 1 through 9.



Note:

MFP estimates changes in GDP that are driven by changes of nonstop flights that connect regions;

CS is the difference between what consumers are willing to pay for a good or service and what they actually pay. In the context of air service, the difference in willingness to pay for air service and what is actually spent.

Static economic analysis shows the economic contributions or roles of airports in regional, state, or national economy at a specific point in time.

Figure 1. Research flow chart.

CHAPTER 2

Overview of Analytical Approaches

In developing this research, four questions were investigated to trace the role of U.S. airports on the national economy:

1. What are the national economic contributions of NPIAS airports?
2. To what extent do improvements in national and international connectivity add to national productivity of U.S. industries?[2]
3. What is the interrelationship of increased air cargo to the U.S. industrial base?
4. How do changes in domestic and international airfares affect the national economy?

These four assessments are complementary and do not overlap. The estimate of national economic contributions of NPIAS airports (Number 1) documents the traditional method of accounting for the economic impact of airports. It is a static measure that reports the economic footprint of airports today (or based on data sets that vary from 2011 to 2013) on the national economy. The multifactor productivity and consumer surplus analyses (Numbers 2, 3, and 4) present dynamic appraisals of the impact of airports on the U.S. economy if conditions change. They estimate how the national economy will be affected if regional and international connectivity change; and if air cargo volume changes or if costs of personal travel change. These analyses are based on relationships developed to estimate productivity of firms and resulting change in the U.S. economy from changes in airport-related factors.

The dynamic changes as modeled for this study are: (1) changes of direct air service between airports and regions; (2) change in the volume of air cargo (change of total cargo and not mode shifts); and (3) a reduction in airfares for personal travelers. These are catalytic impacts in the sense that economic changes of off-airport industries can be traced to these changes. To illustrate these changes, calculations are based on the following changes.[3]

- A 1% improvement in airport connectivity factors to account for business impacts
- A 1% increase in air cargo tonnage
- A 1% airfare reduction for personal travelers

2.1 Contributions of Airports to the U.S. Economy

The analysis of national economic contributions of NPIAS airports can be viewed as the economic footprint of airports on the U.S. economy. This analysis is equivalent to most economic impact studies developed for airports and airport systems in that the national levels of on-airport employment and construction activity is measured, along with the scale of visitor spending of air passengers and the contribution of air cargo to industry sales. It differs from the standard economic impact study in that studies for single U.S. airports or airport systems tend to measure impacts based on the geography of a region or state. This analysis covers the footprint of airports in terms of airline and aviation services; on-airport aviation support activities, concessions, and construction; off-airport spending of international visitors; and the contribution that airports make to the national economy as international cargo gateways.

As an example of the difference between a national and state approach, a state aviation department is concerned with the flows of visitor spending that support in-state hospitality industries without caring about the spending power transferred from another state. This study, however, addresses national effects and, therefore, did not count dollars that are redistributed within the United States. In addition, off-airport spending of international air arrivals was calculated by subtracting spending of U.S. residents on international travel from the total spent by foreign travelers.

These findings are presented using two different approaches. First, the multiple national level data sets uncovered as part of a literature search were reviewed, evaluated, adjusted to avoid overlaps, and aggregated. Second, the research team completed a regression analysis. The analysis was based on the NPIAS database. The database combines the facility characteristics, aviation performance data, and socio-economic data from counties and MSAs for the 3,330 NPIAS airports[4] with results from economic impact studies conducted over the years 2006–2011.

Productivity Improvements in the U.S. Economy from Enhanced Airport Connectivity

The network of U.S. airports is a key component of transportation infrastructure that allows business travelers to meet current and new customers, expand markets, and generate efficiencies for the benefit of economies. Development of the airport network that connects regions and countries facilitates efficiency improvements by providing a broader base of suppliers and access to new production techniques. It fosters greater competitiveness by facilitating investment within the United States and investment of U.S. companies outside U.S. borders, and by enhancing the ability to exploit economies of scale. Moreover, as global trade has expanded and the globalization of the supply chain has taken place, there is increasing evidence that connectivity (principally in the air transport network) and the advantage it provides for business, is a significant asset that enhances productivity and improves the performance of an economy, firm, or region.

The MFP analysis is based on these suppositions. Improving the efficiency of airport network connections enables businesses to access the best inputs in the world, ranging from high value-adding materials and components to skills and ideas. Improvements in connections widen the available market, which means higher revenues and higher potential returns on investment. Similarly, reducing the cost of travel leads to consumer surplus, which can be spent by households on other goods and services, further enhancing economic growth.[5]

Interrelationship of Cargo to Industry Productivity

The MFP cargo analysis tests the economic impact from increasing the interrelationship of air cargo and national goods producers and wholesalers. For this analysis, the change in tonnage is not a mode shift from surface or marine transport to air transport, rather the change tested is of additional cargo that is exported by air.[6]

Consumer Surplus

This study also accounts for consumer surplus, which is the difference between what households or businesses are willing to spend for air transportation services and what they actually do spend. In the case of air travel for business purposes, benefits from cost savings in air travel accrue to affected businesses and not to the travelers. The MFP analysis addresses benefits gained by businesses due to more efficient and, therefore, less costly travel. Counting business travel in the consumer surplus analysis would, in effect, be double counting. Therefore, the consumer surplus analysis concerns benefits to personal travelers only.

MFP and consumer surplus are responses to changes in the connectivity of U.S. airports (for MFP) or ticket pricing (for consumer surplus). For MFP, increased or decreased airport connectivity will lead to changes in national productivity (measured as changes in value added). The value added, in turn, can be used to derive estimates of a full range of economic impact measures (e.g., jobs, labor income, and output). Reductions in ticket pricing lead to changes in consumer surplus. Extra dollars are left in households, which can be used to purchase goods and services.

Each approach listed above assesses the contribution of airports to the national economy. While multiple measurements of economic impact are presented (jobs, labor income, value added, and output), the core measure to assess the contribution of U.S. airports to the national economy is through dollars of value added, which is the core measure of economic productivity, growth, and contraction.

The value added of a firm, an industry sector, or an aggregation of sectors is the contribution of private industry or government to overall national gross domestic product (GDP) or gross regional product/gross state product at sub-national levels. Value added equals the difference between an industry's gross output (consisting of sales/receipts and other operating income, commodity taxes, and inventory change) and the cost of its intermediate inputs (including energy, raw materials, semi-finished goods, and services that are purchased from all sources).[7] The components of value added consist of compensation of employees, taxes on production and imports (less subsidies), and gross operating surplus. The static and catalytic analyses (MFP and consumer surplus) are related as follows:[8]

- The standard (static) accounting for airports' economic role in the national economy shows that the economic contribution of airports to the national GDP (based on 2011–2013 data) is $768.4 billion in 2010 dollars.
- In addition to the national contribution of the current U.S. airport network to the national economy:
  - When accounting for total indirect and induced multiplier effects, a 1% increase associated with each airport

connectivity variable is estimated to yield total value added nationally between $700 million and $9 billion in 2010 dollars, varying among the 11 hypothesized changes in airport connectivity.

As will be discussed in Chapter 5, national totals were extrapolated from a sample of 20 metropolitan regions served by 26 commercial airports, and are presented as an illustration of the potential national impacts. The cumulative range for the 20 regions is $68 million to $700 million in value added for direct impacts and $156 million to $2.1 billion when accounting for total multiplier effects. Table 17 in Chapter 5 lists the air connectivity variables used in this study and Table 20 displays the cumulative economic impacts from the 20 regions, while Table 28 in Chapter 8 shows the illustrative national effects.

The wide variation among the 11 variables reflects the relative economic importance of the potential improvements in connectivity. For example, an increase in the number of two or more daily nonstop domestic flights to a single destination is at the high-end of the range, and an increase of the world's GDP served by nonstop from airports is at the low end. Nationally, the 1% changes represent the totals per variable for all NPIAS airports.

– A 1% increase in air cargo (not including shifts between modes) is expected to reflect total national industrial productivity that would yield $2.5 billion in value added. This national estimate is extrapolated from calculations based on the 20 metropolitan regions that show an expected $173 million in direct value added and $583 million when including full multiplier effects. The cumulative regional estimate is discussed in Chapter 5 and shown in Table 22, while the national illustration is discussed in Chapter 8 and shown in Table 29.
– A 1% decrease in airfare will generate a consumer surplus to personal travelers equivalent to $657 million increase in total value added. The consumer surplus analysis is discussed in Chapter 6 and the national economic impacts shown in Table 26.

CHAPTER 3

Core Research

The economic calculations presented in the later stages of this report are based on research conducted in the early parts of this project, including a survey of literature, development of a NPIAS database, and a review of economic impact modeling packages. These tasks are summarized here and presented in Appendices 1–5 that are available at www.TRB.org/main/blurbs/172111.aspx.

The review of the literature enabled the research team to evaluate a variety of approaches to measuring the role of the airport system in the U.S. economy, and to identify which tools were important and should be incorporated into this project. Approaches covered in the literature include MFP analysis, regression methodologies, and input-output analysis.

The majority of airport economic impact studies use data of on-airport operations, combined with survey data of on-airport businesses, off-airport businesses, and visitors to develop estimates of impacts. Some studies, however, have used regression techniques to estimate the economic impact of airports. The regression studies identify data variables that were used by the research team in the subsequent regression analysis conducted in Task 5.

Below are the categories and summaries of literature that were reviewed. The annotated literature review is found in Appendix 5 that is available at www.TRB.org/main/blurbs/172111.aspx.

3.1 National Studies and Regression Analyses

The literature search included economic impact studies of airports based on regression modeling (primarily from academic sources); national level studies that do not employ regression; and a sample of the many economic impact studies of airports and airport systems that use input–output analysis.

These studies were valuable resources, but they included research objectives that did not match the objectives of ACRP Project 03-28. For example:

- Some of the literature quantifies the impact of civil *aviation* in the United States, including aircraft manufacturing, for example, whereas ACRP Project 03-28 examines the economic role of U.S. *airports only*;
- Several studies are limited to the national economic impact of general aviation airports or to commercial airports, while ACRP Project 03-28 evaluates all 3,300 NPIAS airports;
- Many studies are limited to a state/regional airport system or to a single airport; and
- Some research did not attempt to separate the national impact from a compilation of local or regional impacts. The objective of the ACRP Project 03-28 is to find the contribution of U.S. airports to the national economy.

Air Cargo

The research team reviewed literature of air cargo studies, with an emphasis on the role of air cargo in the overall U.S. economy. Limited studies have been conducted to measure the gross impact of access to air cargo on the economy. Using data from 1980–2000, the studies found a high correlation between air cargo and GDP, and that growth in air cargo has outpaced growth of trade and GDP. They also found strong positive correlations between bilateral agreements[9] and levels of air cargo, trade, GDP, and foreign direct investment. In general, the literature suggests that accessibility to air cargo services has positive effects on local (and national) economies. Although the impacts vary by airport size and regional economic base, air cargo activity has been shown to increase job creation and regional productivity.

Productivity

The research team reviewed literature that explores the relationships between infrastructure and productivity growth, and that evaluates the association between transportation and productivity growth. This part of the literature review provided the foundation for evaluating the link between intermodal connectivity and productivity growth, and became the basis for the multifactor productivity analysis conducted in this project.

Research analyzing the relationship between intermodal connectivity and productivity is in preliminary stages. Current research is incomplete and relatively few researchers have addressed this topic, which has focused on surface transportation modes. Some research specifically looks at how one mode of transportation influences productivity growth. However, several studies find that the overall impact of multimodal transport is greater than the impact from any of the individual transport modes. These studies provide useful starting points for isolating the productivity impacts of airports in the national economy. Value added by industry, and GDP nationally [or gross regional product (GRP), regionally] are used in this study as indicators of changes in economic productivity.

Economic Data Sets

The research team reviewed national economic data sets that potentially could be used to develop a standard national level approach for the impact analysis of airports. The data sets reviewed are summarized in Table 1.

Airport Economic Impact Studies Based on Survey Data and Input–Output Models

Airport economic impact studies that utilize survey data and input–output models[10] were reviewed because they cover a range of types of airports and airport systems, study objectives, calculation methodologies, and modeling tools. The studies reviewed cover impacts of Lansing Capital City Airport, Hartsfield-Jackson Atlanta International Airport, General Mitchell International Airport (Milwaukee County), and the airport systems of South Dakota and Virginia.

Economic Impact Models

In estimating the national–level impact of airports, the research team reviewed the capabilities of two types of economic models: static input–output (I-O) analysis models

Table 1. National data sets.

Source	Data Series	Data Measured						Highest NAICS[D] Levels	Update Frequency[E]
		Population	Jobs	Income	Firms	Sales/ Output	GDP/GRP/[C] Value Added		
Census	Decennial Census and American Community Survey	x	x	x				6	Varies
Census	Economic Census		x	x	x	x		6	5 Years
Census	Foreign Trade Division							6	Monthly
Census	County Business Patterns		x	x	x			6	Annual
BLS	Quarterly Census of Employment and Wages		x	x	x			6	Quarter
BLS	Current Employment Statistics Survey		x	x				6	Monthly
BLS	Occupation Employment Statistics Survey		x	x				5[A]	Annual
BLS	National Compensation Survey			x				2[A]	Varies
BEA	U.S. Economic Accounts		x	x			x	4	Varies
IRS	Statistics of Income (SOI)	x		x				6	Annual
Nielsen Claritas	Business-Facts database		x		x	x		6	Monthly
IMPLAN, LLC[F]	Aggregation of National data sets	x	x	x		x	x	5[B]	Annual

Notes: A – Employment data are reported for detailed occupations, not industry;
B – Data are in 2-5 digit NAICS (North American Industrial Classification System);
C – Gross Domestic Product/Gross Regional Product;
D – North American Industrial Classification System;
E – Update frequency varies by program or data product;
F – Formerly Minnesota IMPLAN Group, Inc.

and dynamic computable general equilibrium (CGE) models. Examples of the former are the U.S. Bureau of Economic Analysis (BEA) national I-O model and its RIMS-II regional data product, and the IMPLAN model (from the IMPLAN Group). Examples of the latter are the REMI Policy Insight PI+ model (from Regional Economic Models, Inc.) and the INFORUM-LIFT model (from the University of Maryland). The static I-O models are most commonly used to calculate the existing economic role of airports in the economy and impact of changes in airport activity levels—both tied to levels of direct economic activities at the airport and in off-airport impacts such as visitor spending. The dynamic CGE models are most commonly used to calculate the broader economic impact of shocks to the economy that involve price or cost changes, though they can also be used to calculate the impact of simple activity level changes. Features of these model systems are summarized in Table 2. A notable feature is the trade-off between the high level of industry detail enabled in the static I-O models and the more aggregate level of industry breakdown provided in the dynamic models. Another notable feature is the difference in price, which in 2014 ranged from about $700 to $15,000 and up for a national level model.

Tools were evaluated in the course of this research and it was determined that a static I-O model with its more detailed industry breakdown is well suited to calculate the existing role of the airports in the U.S. economy and for calculating job equivalents of results of the multifactor productivity and consumer surplus analyses developed in this research. It should be noted, however, that a static tool cannot assess the national impact of investment scenarios, but neither can a CGE model that is limited to the U.S. economy. In the latter case, closed CGE models such as REMI (that operate just within the U.S. economy) can assess dynamic changes by shifting fixed labor and capital resources among industries and regions, with associated price changes. However, a CGE model that also includes bilateral international trade modules (such as INFORUM-LIFT) can also calculate the national impact on growth of the U.S. economy that comes from capturing a larger share of investment and output at the expense of international trading partners. However, that kind of policy research and modeling is far beyond the scope of this specific ACRP study.

This project relies largely on statistical analysis outside of I-O or CGE modeling to derive productivity measures, and utilizes economic models and data primarily for allocation of productivity effects among elements of the economy. Given the scope of this project, the research team recommended and the project panel approved the use of the IMPLAN I-O model to aid in the industry analysis for ACRP Project 03-28. In addition, the detailed IMPLAN national metrics of employment, labor income, and GDP are very close to the levels reported by the BEA, ranging from 98.4% to 100.5% of BEA totals (see Table 3).

3.2 Airport Database

The research team created a comprehensive database for the 3,330 NPIAS airports (the database is in Appendix 3A). The database contains airport identifying information, facilities data, and aviation activity data for passengers, cargo, and aircraft operations, and airline service levels. It also includes the economic findings from the impact studies conducted for state and regional air systems and for single airports—accounting for 1,013 of the airports in the NPIAS system. These airports represent all segments of the NPIAS system, as noted in Table 4.

The airport economic impact data include:

- On-airport jobs, personal income, business sales (economic output)
- Air reliant impacts (contribution of air cargo, both domestic and international)
- Domestic and international visitor spending
- Multiplier effects (supplier sales and spending of wages by workers, i.e., indirect and induced effects)

As expected with data compiled from different sources for many airports, it was collected using similar but not identical methodologies and covered different years (studies added to the database range from 2006–2011). Some studies do not separate international and domestic activities. Also, studies vary in how air reliance of off-airport industries is addressed, if at all. Similarly, inclusion of impacts from airport construction are not consistent among studies, including whether one year of expenditures is covered or if multiple years of expenditures are averaged for the analysis.[11] Some studies count full-time equivalent workers, while others report head-counts. In addition, studies treat multipliers differently: some separate direct, indirect, and induced effects; others separate direct, but combine indirect and induced; while others provide one number for both direct and multiplier impacts or combine direct and indirect. As study years vary, some findings are reported in 2011 dollars, while others are reported in earlier year dollars.

Standardized Economic Impact Data

To standardize data across studies, the research team:

1. Adjusted dollars to 2010 values using the Consumer Price Index (CPI) to adjust for inflation.[12]
2. Isolated and used direct effects only, thus avoiding confusion over multipliers. National multipliers are applied uniformly in the project analysis to gauge national economic contributions.

Table 2. National economic impact analysis products.

ASPECT ⬇	RIMS-II multiplier data	IMPLAN model	REMI Policy Insight (PI+) model	LIFT Model
Vendor	Bureau of Economic Analysis – U.S. Department of Commerce	IMPLAN Group LLC, Huntersville, NC	Regional Economic Models, Inc. Amherst, MA	INFORUM, University of Maryland, College Park, MD
Availability of Model	Purchase	Purchase	Software lease (6- or 12-month)	Subcontract to be run by INFORUM staff
Type of Model	Static I-O	Static input-output	Dynamic CGE – closed to U.S. economy	Dynamic CGE – includes bilateral trade modules
Adjustable production functions	NO	YES	YES	Partly
# of Industries addressed	406 detailed; 62-aggregate	440 (can be aggregated)	23 or 70	51 value added industries; 97 commodities
Temporal component	NONE	NONE	Annual impact forecasting through 2055	Annual impact forecasting through 2040
Accounts for cost changes?	NO	NO	YES	YES
Foreign export impact?	NO	NO	YES (must be entered into model)	YES
Impact Results Resolution	Industry-specific & aggregate economy			
Impact Result Metrics	Jobs, labor income, gross domestic product, output			

Table 3. Comparison of 2012 U.S. BEA national data and data aggregated by IMPLAN, LLC (dollars in billions).

Metric	U.S. BEA	IMPLAN LLC	IMPLAN (as Percent of BEA)
Employment	179,613,300	176,746,000	98.40%
Labor Income	$9,866.7	$9,844.9	99.78%
GDP (Value Added)	$16,163.2	$16,244.6	100.50%

Sources: www.bea.gov, accessed August 2014: Tables 1.12 National Income by Type of Income; U.S. GDP in Current Dollars and Total Employment Table SA25N, and the National Data set of IMPLAN, LLC for 2012.

Table 4. Economic data by classification of NPIAS airports.

Airport Class	NPIAS Airports	Airports with Economic Study Data	Percent of Airports with Economic Data
Large Hub	29	14	48%
Medium Hub	36	14	38%
Small Hub	74	30	42%
Commercial, Non Hub, and Non-Primary	360	101	28%
Reliever	268	102	38%
General Aviation	2,563	752	29%
Totals	**3,330**	**1,013**	**30%**

3. Separated domestic and international visitor spending to estimate the value of visitor spending to the U.S. economy versus the redistribution of spending from one region of the country to another.

Analyze Airport Impact in Consideration of Regional Socio-Economic Data

A series of data was added to the database for each of the NPIAS airports. MSA data is relevant for large hub airports and, perhaps, medium hub airports,[13] while county-level data is more appropriate for smaller airports.[14] The following county and MSA level metrics were added to the data set:

- Median household income
- Poverty (percent below the poverty level)
- Personal income
- Population
- Per capita personal income
- Distress composite index (based on Appalachian Regional Commission)
- Employment by industry, both full and part time based on the NAICS

The research team used the sample of airports it assembled to estimate the national economic impacts of all NPIAS-designated airports in a regression analysis. Results include:

- Compilation of a base of impact data, including individual airport analyses and groups of airports analyses when necessitated by data availability, for the bottom-up approach.
- Tabular analysis of the incidence of positive/negative/nil impact cases and group results by impact type, airport type, and observation timing (analysis year).
- Statistical analysis of the relationship between various local setting characteristics and various impact types, for each airport type.
- Comparative analysis of the extent to which past studies support conclusions drawn from the tabular and statistical analysis of data compiled for this study.

The database is provided in a spreadsheet in Appendix 3A.

CHAPTER 4

National Economic Impact of Airports in the NPIAS

The first step for the research team in estimating the contribution of the U.S. airport system to the national economy was to evaluate the multiple national data sources (summarized in Table 3). Six data sources are available for air transportation services employment, with job totals ranging from 426,000 to 478,000.[15] The same six data sources provide total annual labor compensation ranging from $25.3 billion to $39.9 billion. Three of these data sources provide value added and two provide output. Data sets and sources for on-airport airside and terminal employment, airport construction, visitor spending, and the value of air cargo were discussed and evaluated by the research team and with the project panel. Table 5 provides a summary of the research team and panel's consensus of the data sources by segment and metric that are used for this analysis.

These data sources represent direct economic impacts for seven distinct segments of airport economic activity. However, four measures (jobs, labor income, output, and value added) are generally used in economic impact studies to convey direct contributions for each segment, and the core data account for just one to three of these measures per sector. Based on core data, the IMPLAN modeling package was used to estimate the missing direct data by activity segment.

Findings derived from the approaches described above are found in Chapters 4, 5, and 6. Chapter 4 describes the contributions of U.S. airports to the national economy. Chapter 5 explains findings of the multifactor productivity analysis, reporting: (1) research findings from improving air connectivity among regions and between the United States to international destinations can increase national productivity; and (2) the interrelationship of air cargo and national productivity. Chapter 6 describes how changes in the cost of passenger air travel affect the national economy.

4.1 Role in the National Economy

The static measurement of economic impacts of on-airport activities, visitor spending, and air cargo, and the total national economic impact of U.S. airports is calculated to be:

- $1.6 trillion in output (the summation of the value of goods and services produced)
- $768 billion in value added (airports' overall contribution to the national GDP and to national economic productivity)
- 7.6 million jobs across the nation that pay workers a combined total of $453 billion

These total contributions of airports to the U.S. economy account for 5.8% of national output and 4.9% of national GDP. Airports generate 4.3% of all jobs in the United States which, in turn, pays 4.8% of labor income earned nationally. Total impact accounts for economic activities generated on-airport, by international visitor spending and by the value of air cargo exported to international markets. The totals include the direct, as well as indirect and induced multiplier effects of each activity (Table 6).

On-Airport and Off-Airport Effects

To understand in more detail how airports support the national economy, the services and activities that occur on-airports can be isolated from off-airport supplier purchases (indirect effects) and the off-airport spending of wages by airport based workers (induced effects), as well as visitor spending and cargo. In terms of value added, on-airport activities account for almost $100 billion (Table 7) of the total of $768 billion.

The economic role of U.S. airports is mostly outside of airport fences and in the general economy of the United States. As shown in Table 8, airports generate $1.4 trillion

Table 5. Direct economic contributions of airports based on national data sets.

Economic Segment	Primary Metric	Jobs and Value	Year	Source
Air Transportation Services	Jobs	458,000	2011	BEA
	Labor Income	$39,908 (mill)	2011	
	Value Added	$69,600 (mill)	2011	
Support Services for Air Transportation	Jobs	159,000	2011	BLS-CES
	Labor Income	$6,094 (mill)	2011	
Public Sector On-Airport/Airport Security	Jobs	151,000	2011 and 2012	U.S. Census Bureau, U.S. Budget
Construction	Expenditures	$13,264 (mill)	2009-2013 (average)	FAA Form 127 & NPIAS
Concessions*	Expenditures	$7,506 (mill)	2011	ACI-NA
Visitor Spending	Expenditures	$22,337 (mill)	2010-2012	U.S. Department of Commerce
Air Cargo	Value of Cargo	$430,908 (mill)	2013	U.S. Census FTD

** Includes car rental, parking and ground transportation, retail, food and beverage, in-terminal services, on-airport hotels, and land rents and non-terminal concessions.*

Table 6. Total economic contribution of airports to the U.S. economy.

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	2,172,200	$147,641,741,000	$247,424,063,000	$637,002,396,000
Indirect Effect	2,422,000	$160,934,429,000	$266,403,253,000	$535,376,204,000
Induced Effect	3,034,600	$143,929,511,000	$254,574,998,000	$425,079,660,000
Total Effect	7,628,900	$452,505,681,000	$768,402,314,000	$1,597,458,260,000

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 values.

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S.Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN LLC. Calculations by EDR Group using 2012 National IMPLAN model.

Table 7. Direct impact of on-airport activities in the U.S. economy.

Activity	Employment	Labor Income	Value Added	Output
Air Transportation	458,000	$39,139,222,000	$66,986,205,000	$147,403,033,000
Support Activities for Air Transportation	159,000	$5,976,600,000	$6,419,540,000	$11,198,659,000
State, Local, and Federal Employment including TSA	150,700	$11,380,311,000	$14,175,671,000	$16,746,516,000
Non-Aeronautical Revenues	87,300	$2,995,511,000	$4,932,607,000	$6,907,625,000
On-Airport Construction	84,200	$4,898,218,000	$5,297,665,000	$12,762,214,000
Total	939,200	$64,389,862,000	$97,811,688,000	$195,018,047,000

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 values.

Sources: BEA, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN LLC. Calculations by EDR Group.

Table 8. Off-airport contribution to the national economy generated by U.S. airports in $2010 dollars.

Activity	Employment	Labor Income	Value Added	Output
Direct Impacts				
International Visitor Spending	314,100	8,877,566,000	13,720,831,000	22,002,778,000
Air Cargo	918,900	$74,374,314,000	$135,891,544,000	$419,981,571,000
Subtotal Direct Off-Airport Impact	***1,233,000***	***$83,251,880,000***	***$149,612,375,000***	***$441,984,349,000***
Indirect Suppliers of Goods & Services				
Air Transportation	457,700	$26,711,470,000	$49,744,533,000	$93,874,615,000
Support Activities for Air Transportation	51,100	$2,674,087,000	$3,923,265,000	$6,370,341,000
State, Local, and Federal Employment including TSA	16,900	$979,523,000	$1,590,756,000	$2,678,204,000
Non-Aeronautical Revenues	17,300	$997,537,000	$1,670,171,000	$2,893,725,000
On-Airport Construction	60,200	$3,750,481,000	$6,012,475,000	$11,409,886,000
International Visitor Spending	79,200	$4,370,449,000	$7,276,746,000	$12,799,908,000
Air Cargo	1,739,500	$121,450,882,000	$196,185,306,000	$405,349,524,000
Subtotal Indirect Suppliers of Goods & Services	***2,421,900***	***$160,934,429,000***	***$266,403,252,000***	***$535,376,203,000***
Induced Impact–Spending Workers' Wages				
Air Transportation	642,100	$30,385,013,000	$54,336,692,000	$91,350,165,000
Support Activities for Air Transportation	82,000	$3,879,341,000	$6,936,748,000	$11,662,653,000
State, Local, and Federal Employment including TSA	116,900	$5,531,830,000	$9,892,118,000	$16,631,496,000
Non-Aeronautical Revenues	37,600	$1,778,801,000	$3,179,144,000	$5,345,239,000
On-Airport Construction	81,600	$3,858,890,000	$6,897,526,000	$11,597,032,000
International Visitor Spending	125,200	$5,921,940,000	$10,587,534,000	$17,800,903,000
Air Cargo	1,949,300	$92,573,695,000	$162,745,236,000	$270,692,172,000
Subtotal Induced Impact–Spending Workers' Wages	***3,034,600***	***$143,929,510,000***	***$254,574,998,000***	***$425,079,660,000***
TOTAL NATIONAL IMPACT GENERATED OFF-AIRPORT	**6,689,500**	**$388,115,819,000**	**$670,590,625,000**	**$1,402,440,212,000**

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 value.

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN LLC. Calculations by EDR Group using 2012 National IMPLAN model.

of output outside of the airports in the general economy of the U.S., and contribute $671 billion to the national GDP in 2010 dollars. The impact of international visitor spending is accounted for here, as is the off-airport production value of air cargo.[16] Indirect economic effects are triggered when directly affected industries use their earned business revenues (or budgets, in the case of public agencies) to purchase supplies and services which, by definition, occurs primarily off-airport. Similarly, induced effects occur when workers spend wages earned by virtue of revenues generated by directly or indirectly affected businesses. Examples of induced effects are when employees of directly and indirectly affected businesses purchase groceries, smart phones, and clothing, or hire family lawyers.[17]

As shown in Table 9, activities on-airport are responsible for about one-third of the total contribution of U.S. airports to the national economy. The contribution of air cargo represents about 60% of all effects and international visitor spending contributes the balance.[18] Note that hospitality industries are generally low-wage and labor intensive compared to cargo producing industries. Thus, direct employment pays workers an average of $28,000 per job and accounts for an average of $44,000 per job in value added. In contrast, many of the manufacturing sectors that export commodities not only pay high wages but also use significant automation processes. Therefore, international exports generate $81,000 in labor income and $148,000 in value added per job.

4.2 Regression Analysis

The research team conducted a regression analysis based on findings of airport economic impact studies conducted between 2006 and 2012 and according to the classifications of airports in the national NPIAS. This exercise validated the method of piecing together data sets and using the modeling tools described above.

The advantages of the regression analysis are that economic impacts can be attributed to different NPIAS airport classifications and variables that predict economic impacts can be isolated. The disadvantages concern the wide number of years

Air Cargo

Air cargo represents a significant proportion of the economic contribution of airports to the national economy. The $431 million in value of commodities produced in the United States and shipped by air to international destinations introduced in Table 5 is the aggregate of sales prices (or costs if not sold) by U.S. shippers to the foreign parties. This represents the value of production in the U.S. economy, including labor income, taxes paid, profits, and the expenditures for materials and services that are inputs to these commodities. The sales of these commodities to international markets are enabled by airports and air transportation.

Exports to Canada and Mexico account for about 6% of the total air cargo exported by U.S. industries and air cargo is less than 5% of the total value of cargo exported from the U.S. by all modes to these two nations (according to the U.S. Census Bureau Foreign Trade Database, as assembled by WISER-Trade). As the Canada–Mexico markets account for a relatively small amount of total air cargo, and air cargo accounts for a small portion of U.S. exports to these destinations, the research team decided not to make guesses about the levels of current air cargo that could be shipped by truck or rail, and included air cargo value to Canada and Mexico among the total.

The $430.9 million in air exports shown in Table 5 is in 2013 value. Using industry-specific output deflators from the U.S. Bureau of Economic Analysis (through the 2012 IMPAN model) results in a 2010 value of almost $420 billion, shown as direct impacts of output in Table 8, Row 2. The value added to the U.S. economy from these shipments, $135.9 billion, is also shown on Table 8.

Table 9. National economic contribution by source of impact.

Economic Impact Source	Employment	Labor Income	Value Added	Output
On-Airport Direct	939,200	$64,389,862,000	$97,811,688,000	$195,018,047,000
Airport Indirect and Induced Effects	1,563,400	$80,546,973,000	$144,183,429,000	$253,813,356,000
Total Airport Generated	2,502,600	$144,936,835,000	$241,995,117,000	$448,831,403,000
International Visitor Spending	518,400	$19,169,955,000	$31,585,111,000	$52,603,589,000
International Air Cargo	4,607,800	$288,398,892,000	$494,822,086,000	$1,096,023,267,000
Total	7,628,800	$452,505,682,000	$768,402,314,000	$1,597,458,259,000
Percent of Impact				
Airport Facilities	33%	32%	31%	28%
International Visitor Spending	7%	4%	4%	3%
International Air Cargo	60%	64%	64%	69%

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 value.

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group using 2012 National IMPLAN model.

Table 10. Classifications of NPIAS airport groups from regression analysis.

Airport Classifications	NPIAS	Airports in Regression Analysis	Percent of Total Class in Database
Large Hub Airports	29	6	21%
Medium Hub Airports & Small Hub Airports	110	27	25%
Non-hub Primary Airports	239	65	27%
Non-primary Commercial Service Airports, Reliever Airports, & General Aviation Airports	2,952	546	18%
Totals	**3,330**	**644**	**19%**

Sources: Task 5 NPIAS Database. Calculations by EDR Group.

over which the studies were completed[19] and the disparate data collected and reported, data collection methodologies, and geographies (counties, multi-county regions, and states) that were delineated for economic impacts. Though usable economic impact results were available for more than 600 of the 3,330 NPIAS airports [drawn from the 1,013 airports reviewed and stored in the NPIAS database (Appendix 3A)], the differences in the economic impact studies limited the functionality of the regressions and required consolidation of classifications. In addition, there are just 29 large hub NPIAS airports, and the database was limited to six observations. Table 10 shows airports by classification in the regression analysis. The 644 airports with usable economic metrics were drawn from 675 studies that provided output analysis and 714 studies that provided employment totals.

Table 11 summarizes the findings of each regression model. Although the regressions are limited, all explanatory variables are highly significant and show the expected relationship.

Table 11. Summary of regression results.

Classification	Explanatory Variables	Results
Large Hub*	Total enplanements	All else constant, an additional 10,000 total enplanements per year are correlated with an estimated 3.3 million dollars of direct airport revenue.
Medium and Small Hub	Square root of total enplanements	For both medium and small hubs, all else constant, an additional 10,000 total enplanements are correlated with approximately $1.8 million of revenue.
Non-hub Primary Airports	Square root of domestic enplanements; Maximum runway length (in feet); Military operations	All else constant, an additional 10,000 total enplanements at a non-hub primary airport are correlated with a $1.66 million increase in direct revenue. Additionally, a 1,000-foot increase in runway length is correlated with $0.13 million in direct revenue, and 1,000 military operations at $.05 million in direct revenue.
Non-primary Commercial Service Airports, Relievers, and GA Airports	Maximum runway length converted to 1000s of feet and squared (by Airport Classification); Total GA operations (Not Classification Specific)	For lack of better predictors, the research team relied on the interaction of airport classifications and maximum runway length as a proxy estimator of the type of activity enabled by different length runways, and the scale of operations. The simple interpretation for this regression is that a 1,000-foot runway length explains $0.01 million in direct revenues for relievers, $.002 million for non-primary commercial service airports, and $.001 million for GA airports. This interpretation can be followed when looking at the reliever airports and commercial services airports (by swapping out the parameter estimates). Additionally, 1,000 GA operations (itinerant plus local) each of the three classifications correlate to $882 in revenue.

Findings for all four regression equations are significant at least at the 95th percentile confidence level with P values below .05.

** Modeling is limited because there were so few populated airports regarding direct revenue for large hub airports, but findings are significant.*

Table 12. Total on-airport economic contribution from aggregated national data sets and regression analysis.

Analysis	Jobs	Labor income	Value added	Output
Aggregated Data Bases	2.5 million	$145 billion	$242 billion	$449 billion
Regression Analyses	2.9 million	$164 billion	$261 billion	$471 billion

Sources: Task 5 NPIAS Database, BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group conducting using 2012 National IMPLAN model.

Direct output was $198 billion for the regression analysis and $195 billion from the data sets. The data bases, as displayed in Table 7, are available by business types on airports (e.g., concessions, airlines, and others) and often by employment as well as output. In the Task 5 NPIAS Data Base, however, the economic impact studies did not uniformly break out different segments of on-airport activity. This introduced some modeling differences and the comparative total results.

To derive meaningful findings, medium hub airports and small hub airports were combined, and non-primary commercial service airports and reliever airports were combined with general aviation airports. Large hub airports were not combined because the size of these airports overwhelms any other classification.

The regressions used the aviation characteristics of each airport, socio-economic data for relevant counties and MSAs, and the findings of the 1,013 economic impact studies to estimate national output. The significant explanatory variables that were found (differing by airport classification) include connecting enplanements, O&D enplanements, commercial operations, general aviation (GA) operations, and maximum runway length.

Comparing Regression Estimates to Analysis of National Data Sets

Total on-airport direct economic output is estimated at $198 billion across the NPIAS airports from the four regression models in 2010 dollars, which is similar to the $195 billion (2010 value) on-airport direct output that is calculated by aggregating national databases (displayed in Table 9). As shown in Table 12, the total economic impacts (including direct, indirect, and induced effects) derived from the regression analyses are slightly higher, but are comparable to the total impacts based on the national level data sets.[20]

CHAPTER 5

Findings: MFP

The analysis of MFP examined how improvements in connectivity between the U.S. airports and between the U.S. and international airports can add to the national economy. The research approach was based on an empirical model that examines how changes in air service connectivity result in improved productivity. A set of variables was defined that capture differing aspects of connectivity provided by the airline network. Next, a set of regression models were estimated that relate changes in connectivity measures to changes in multifactor productivity and, hence, the resulting changes in real economic or income growth.

The data selected for exploring the relationship of airport connectivity to economic productivity was developed for the airports serving a sample of U.S. metropolitan regions (see Table 13), a set of foreign international hub airports that link the U.S. economy to the rest of the world, and 11 industry sectors (Table 14) based on NAICS codes for the years 1995, 2000, 2005, and 2010. Ten of the 11 industry sectors for which sector–specific models were developed were chosen on the basis of the likely role of air travel in sector productivity. The other industry sectors were combined into a single group labeled "other."

These airports were selected to include a variety of types and sizes: gateway airports; airline hubs; large, medium, and small hub airports; non-hub airports; and de-hubbed airports that were formerly airline hubs. Airports were also chosen to represent the geographic spread of the domestic U.S. travel market.

The international airports used to measure international connectivity were: Amsterdam, London (Heathrow), Frankfurt, Munich, Paris (Charles de Gaulle), Madrid, Hong Kong, Singapore, Shanghai, Beijing, Dubai, Seoul (Incheon), Tokyo (Narita), Copenhagen, and Rome. These were chosen because they are the 15 largest international airline hubs outside the United States that provide air service connectivity to the rest of the world and are major international destinations in their own right.

5.1 Estimating Regional MFP Values

Measures of MFP by industry over time at the national level are available from the U.S. Bureau of Labor Statistics (BLS). Data at the metropolitan statistical area level were assembled to allow calculations of a measure of labor productivity for each industry sector for a given MSA.

As MFP measures are not available by industry at the MSA level, the research team needed to address how to translate the national MFP measures to the regional level. To do this, the research team defined the multifactor productivity measure for each industry sector at the national level and defined a measure of labor productivity for each industry by measures of value added and labor input (hours or numbers of employees), and further defined labor productivity per industry sector based on data for relevant MSAs.

Values for the MFP for each sector at the national level were obtained from the BLS data on employment and the BEA for GDP by sector. Values for the MFP at regional levels for the 20 MSAs were obtained from Moody's Analytics and the BLS Regional Economic Accounts. Several of the larger regions consist of more than one MSA, so the data at the MSA level were combined to give regional totals.

A detailed description of how the multifactor productivity analysis was developed can be found in Appendix 1. A summary of the method to calculate the regional MFP follows.

Air Service and Other Variables

The air service variables assembled for each airport in the 20 MSAs are shown in Table 15, with the means and standard deviations of these variables across the regions in the sample for each year. These variables were chosen to measure the level of air traffic activity at each airport, as well as provide different measures of airline network connectivity and to distinguish between domestic and international connectivity. Most of the connectivity measures are self-explanatory. The

Table 13. Airports selected for the analysis.

Code	Airport/region	Multi-airport Regions
SF Bay	*San Francisco Bay Area*	SFO, OAK, SJC
Chicago	*Chicago metropolitan region*	ORD, MDW
ATL	Hartsfield-Jackson Atlanta International Airport	
CVG	Cincinnati/Northern Kentucky International Airport	
STL	Lambert-St. Louis International Airport	
PIT	Pittsburgh International Airport	
RDU	Raleigh-Durham International Airport	
DEN	Denver International Airport	
Phoenix	*Phoenix metropolitan region*	PHX, AZA
SLC	Salt Lake City International Airport	
Boston	*Boston metropolitan region*	BOS, MHT, PVD
PHL	Philadelphia International Airport	
DTW	Detroit Metropolitan Wayne County Airport	
SAN	San Diego International Airport	
PDX	Portland International Airport	
TPA	Tampa International Airport	
MCI	Kansas City International Airport	
TUL	Tulsa International Airport	
SAT	San Antonio International Airport	
BNA	Nashville International Airport	
Airports in the Four Multi-Airport Regions		
SFO	San Francisco International Airport	
OAK	Oakland International Airport	
SJC	Mineta San Jose International Airport	
ORD	Chicago O'Hare International Airport	
MDW	Chicago Midway Airport	
PHX	Phoenix Sky Harbor International Airport	
AZA	Phoenix-Mesa Gateway Airport	
BOS	Boston Logan International Airport	
PVD	Theodore Francis Green State Airport (Providence)	
MHT	Manchester-Boston Regional Airport	

Table 14. Eleven industry sectors included in the modeling.

NAICS Code	Sector
31-33	Manufacturing
42	Wholesale Trade
51	Information
52	Finance and Insurance
53	Real Estate and Renting and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
Other*	A grouping of the following sectors: Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Retail Trade; Transportation and Warehousing; Educational Services; Health Care and Social Assistance; Other Services (except Public Administration); and Public Administration

**By themselves, sectors in "Other" did not show significant results. However, when combined, results for three of the connectivity measures were significant.*

Translating National MFP for Regions

The U.S. BLS provides measures of MFP by industry over time at the national level. The issue is how to translate the national measures to be meaningful at the MSA level. We use measures of labor productivity since these can be calculated for productivity for a specific industry for a specific MSA. The transformation was undertaken in the following way.

Define MFP_i^N as the multifactor productivity for industry *i* at the national level, and define $\hat{L}_i = Q_i / L_i$ as labor productivity for industry *i* where Q is value added output and *L* is labor input (hours or numbers of employees).

Further define $\hat{L}_i^k$ as the labor productivity of industry *i* in MSA *k*.

Consider the following relationship which states national MFP for industry *i* at the national level is a function of labor productivity plus some other factors that we have no information about that would be captured in a constant α and an error term ε:

$$MFP_i^N = \alpha + \beta \cdot \hat{L}_i^N + \varepsilon \qquad (1)$$

For simplicity, and due to lack of information, rewrite (1) as:

$$MFP_i^N = \beta \cdot \hat{L}_i^N \qquad (2)$$

which can be re-written as:

$$\beta^N = MFP_i^N / \hat{L}_i^N \qquad (3)$$

where we expect $\beta^N > 1$. We could also reproduce (2) and (3) for MFP and labor productivity for an MSA, as

$$\beta^k = MFP_i^k / \hat{L}_i^k \qquad (4)$$

The relationship between β^N and β^k is unclear, but if we assume they are similar, then making an assumption, set:

$$\beta^k = \beta^N = MFP_i^N / \hat{L}_i^N = MFP_i^k / \hat{L}_i^k \qquad (5)$$

set $MFP_i^k = X$, the unknown in these equations. Manipulating (5) find X as

$$X = \left(L_i^k / L_i^N \right) \cdot MFP_i^N \qquad (6)$$

Equation 6 states that a measure of MFP for MSA *k* for industry *i* can be calculated by taking the ratio of labor productivity in industry *i* in MSA *k* to the productivity of labor at the national level for the same industry *i* and multiply this by the MFP for industry *i* at the national level. Essentially what we have done is to weight the labor productivity at the MSA level by the labor productivity of the industry at the national level; L_i^k may be $\leq$ or $\geq$ than L_i^N.

Table 15. Summary statistics for airport air service variables used in regressions.

	1995		2000		2005		2010	
Air Service Variable	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
Number of airlines	18.25	12.79	19.20	14.79	19.50	14.77	17.45	13.48
Percent of flights by dominant carrier	52%	21%	52%	22%	49%	22%	44%	20%
Total nonstop departures								
Domestic	138,992	105,285	159,329	117,204	180,435	129,056	154,895	129,024
International	4,245	4,993	7,272	9,814	7,880	8,239	9,405	12,533
Airline hubs served (domestic)	24.95	9.49	28.50	11.63	28.55	11.43	28.95	10.66
Nonstop destinations								
Domestic	69.50	37.81	74.30	41.55	88.55	47.24	82.85	50.39
International	10.20	9.81	12.20	14.21	14.05	15.36	15.80	19.94
Percent of world GDP served by								
Nonstop flights	22%	24%	26%	25%	24%	23%	22%	22%
At least daily nonstops	16%	21%	21%	22%	20%	22%	17%	20%
2 or more daily nonstops	7%	13%	10%	16%	11%	15%	9%	13%
Total air cargo (metric tons)								
Enplaned domestic	26,200	28,764	24,715	25,691	116,503	113,613	92,384	75,869
Enplaned international	31,595	64,291	42,161	82,885	42,569	92,839	43,424	95,478
Deplaned domestic	26,103	25,927	25,695	26,194	124,665	108,816	98,510	73,129
Deplaned international	28,120	60,630	54,227	113,480	60,217	136,591	55,384	131,683
International hubs served								
At least daily nonstops	1.35	2.03	2.25	3.21	2.45	3.62	2.60	3.94
3 or more daily nonstops	0.35	0.81	0.55	1.23	0.55	1.23	0.50	1.10
Total passengers (000)								
Domestic	20,499	16,495	25,434	19,607	26,387	21,609	24,744	21,395
International	1,191	1,629	2,069	2,987	2,072	2,755	2,273	3,352
Domestic nonstop destinations								
2 or more daily nonstops	53.20	32.16	60.70	37.05	70.15	41.47	60.10	41.38
5 or more daily nonstops	25.50	21.52	29.55	22.31	35.15	27.10	29.10	26.38

percentage of the world GDP served by flights at different frequencies is based on the total GDP of countries with airports served by nonstop flights at the frequency in question (irrespective of the geographical size of the country or the number of airports within each country that are served at the relevant frequency).

Air service data only counted: (1) scheduled service and the number of nonstop departures in a market and (2) service by airlines operating at least 50 flights annually to a given destination. This latter criterion was applied to exclude occasional seasonal service or flights that made unscheduled technical stops (e.g., diversions or refueling stops). Regional affiliates were considered to be part of the mainline carrier when counting the number of airlines or the percentage of flights by the dominant carrier at an airport. Flights to Canada were included in international service.

In addition to air service variables, the regression models of MFP included regional population to control for size differences between the regions and dummy variables for three of the four years used in the analysis to capture the effects of time.[21] Regional population data was obtained from the U.S. BEA, which uses U.S. Census Bureau mid-year population estimates.

5.2 Model Results

Table 16 lists the results of the regressions for the 11 industry sectors across the 20 MSA regions in the sample. Coefficients in bold are statistically significant at least at the 90th percentile confidence level (the fit of the variables in explaining GDP estimates are shown in the second to last row, titled "Adjusted R^2"). The degree of explanatory power ranges from a low of 64% for the "Arts, Entertainment, and Recreation" sector to a high of 92% for the "Information" sector. The Stata econometric software package was used to generate these findings using standard ordinary least squares (OLS).

In addition to the air service connectivity variables, the regression variables included the regional population to explore how market size may affect MFP and dummy variables for three of the four years of data to capture any time-related trends.

In all cases, the estimated coefficients for the regional population are positive and generally significant, indicating that the size of the region has an impact on multifactor productivity. The coefficients for the time dummy variables are positive except in two cases (the values for which are not statistically significant) and generally significant. The values for 2010 are not always larger than for 2000 and 2005, showing that productivity growth has varied significantly across industries, as well as over time.

Since the model was estimated in log-linear form, the coefficients can be interpreted as giving the percentage change in MFP for a one-percent change in the selected airport variable. As an example, the results for the manufacturing sector show that a 1% increase in the number of airlines serving a region would lead to a 0.044% (0.044 of 1%) increase in the MFP for manufacturing, while a 1% increase in the number of domestic nonstop flight departures would increase manufacturing MFP by 0.024%. A 1% increase in the number of nonstop domestic and international destinations served will increase manufacturing MFP by 0.082%.

Table 17 shows the average elasticity[22] for each *statistically significant* connectivity measure across industries for each of the airport variables included in the model. On average, considering only values that were statistically significant, two or more daily domestic nonstop flights is the most important connectivity measure affecting productivity. The second most important measure is the number of international nonstop destinations, the third is the number of domestic nonstop destinations, and the fourth is the percentage of the world GDP accounted for by countries that are served by daily international flights. This last variable points out that while adding flights or destinations is important, the flights should be to destinations important in terms of the overall level of economic activity (as measured by GDP) in the regions or countries served by those destinations.

The relative impact of each connectivity measure is illustrated in the fourth column of Table 17. The elasticity of each measure is compared to that of the measure with the greatest impact on MFP, which is the number of domestic destinations having two or more daily nonstop flights. The measure with the highest elasticity is two or more daily nonstop flights. If we take the measure with the second highest elasticity (the number of international nonstop destinations), this latter measure would have to increase from its current value by 2.5 times as the former to have the same impact on MFP. For example to match a 1% increase in the "number of domestic destinations having two or more daily nonstop flights," the "number of international nonstop destinations" would have to increase by 2.5%.

These results also imply that destinations and departures provide about the same amount of connectivity and that frequency is important. The remaining variables have about 20% of the impact of the connectivity measure with the greatest impact on MFP. Using the average values displayed in Table 17 is useful to gauge the overall effects of each connectivity measure. However, they can be misleading for any particular industry and assessing which variables matter and their relative importance should be based on the elasticity values in Table 16.

Table 16. Estimation results for multifactor productivity regressions.

Industry Sector	NAICS 31-33	NAICS 42	NAICS 51	NAICS 52	NAICS 53	NAICS 54
Dependent Variable: Ln MFP for Region Independent Variable	Manufacturing	Wholesale Trade	Information	Finance & Insurance	Real Estate, Rental & Leasing	Professional Scientific & Technical Services
Constant	**-1.0913**	**6.4783**	**9.1860**	**0.5697**	**9.0946**	4.5121
Year 2000 Dummy	-0.0546	0.0395	-0.0004	**0.0601**	**0.0223**	**0.0689**
Year 2005 Dummy	0.0608	**0.0657**	**0.2552**	**0.1264**	**0.6151**	0.0151
Year 2010 Dummy	**0.2107**	**0.2486**	**0.3492**	**0.2622**	**0.4221**	0.0115
Ln Regional Population	**0.0037**	**0.0015**	0.0013	**0.0433**	**0.0252**	0.0447
Ln Number of Airlines	**0.0439**	**0.0215**	0.0596	0.0048	0.0797	0.0435
Ln Domestic Nonstop Departures	**0.0237**	**0.0257**	0.0192	**0.0479**	**0.0213**	**0.0182**
Ln Airline Hubs Served-Domestic	0.0423	0.6624	**0.0151**	**0.0716**	0.0316	**0.0361**
Ln Domestic Nonstop Destinations	**0.0344**	**0.0152**	0.0074	0.0711	**0.0397**	0.0504
Ln Two or More Daily Nonstop Domestic Flights	**0.0991**	0.0607	**0.0121**	**0.0312**	**0.0406**	0.0112
Ln Five or More Daily Nonstop Domestic Flights	0.0531	**0.0318**	0.0192	0.0697	0.0256	0.0096
Ln International Nonstop Departures	0.0163	0.0003	**0.0244**	**0.0132**	0.0039	**0.0262**
Ln International Nonstop Destinations	**0.0479**	**0.0191**	**0.0144**	0.0375	**0.0532**	0.0275
Ln Percent of the World GDP Served Nonstop	0.0174	0.0117	0.0147	0.0911	0.0246	0.0107
Ln Percent of the World GDP Served Daily	0.0263	**0.0214**	**0.0257**	**0.0107**	0.0612	**0.0491**
Ln Percent of the World GDP Served Twice or More Daily	**0.0157**	0.0032	0.0201	0.0072	0.0079	0.0205
No Observations	80	80	80	80	80	80
Adjusted R^2	0.74	0.79	0.92	0.89	0.84	0.81
Log-Likelihood	633.25	449.62	345.76	318.98	329.87	366.77

(continued on next page)

Table 16. (Continued).

Industry Sector	NAICS 55	NAICS 56	NAICS 71	NAICS 72	NAICS Other
Dependent Variable: Ln MFP for Region Independent Variable	Management of Companies & Enterprises	Administration & Support Waste Management Services	Art, Entertainment, & Recreation	Accommodation & Food Services	Other[b]
Constant	**1.9440**	**3.9618**	**3.9720**	**5.8501**	**1.2294**
Year 2000 Dummy	**0.0318**	**0.0983**	0.0416	0.0163	**0.8700**
Year 2005 Dummy	0.1104	**0.0130**	**0.0263**	0.0541	**0.0812**
Year 2010 Dummy	0.0287	**0.0112**	**0.0693**	0.1218	**0.5798**
Ln Regional Population	**0.0185**	**0.0004**	**0.0113**	**0.0529**	0.0981
Ln Number of Airlines	0.0152	0.0519	0.0562	0.0161	0.1004
Ln Domestic Nonstop Departures	0.0843	**0.0104**	0.0817	**0.0001**	**0.0004**
Ln Airline Hubs Served-Domestic	**0.0106**	0.0226	**0.0093**	0.0456	0.0285
Ln Domestic Nonstop Destinations	**0.0321**	**0.0301**	**0.0132**	**0.0229**	**0.0371**
Ln Two or More Daily Nonstop Domestic Flights	0.0151	0.0269	0.0191	0.0153	0.0227
Ln Five or More Daily Nonstop Domestic Flights	0.0749	0.0074	**0.0197**	0.0885	0.0452
Ln International Nonstop Departures	**0.0091**	**0.0211**	0.0217	0.0691	0.0142
Ln International Nonstop Destinations	**0.0227**	**0.0877**	0.0215	0.0526	**0.0136**
Ln Percent of the World GDP Served Nonstop	**0.0203**	**0.0472**	0.0576	0.0231	0.0946
Ln Percent of the World GDP Served Daily	0.0579	0.0357	**0.0399**	**0.0222**	**0.0129**
Ln Percent of the World GDP Served Twice or More Daily	**0.0779**	0.0176	0.0291	0.0883	0.0907
No Observations	80	80	80	80	80
Adjusted R^2	0.85	0.71	0.64	0.74	0.62
Log-Likelihood	352.81	444.81	338.91	282.95	227.13

Notes: a) Bold coefficients are significant at the 90^{th} percentile confidence level or higher.
b) "Other" sector includes Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Retail Trade; Transportation and Warehousing; Educational Services; Health Care and Social Assistance; Other Services (except Public Administration); and Public Administration.

Table 17. Average values of air service elasticities across industries.

Connectivity Measure	Elasticity (average)	Rank	Relative Weight
Two or More Daily Nonstop Domestic Flights	0.0915	1	1.00
International Nonstop Destinations	0.0375	2	0.41
Domestic Nonstop Destinations	0.0284	3	0.31
Percent of the World GDP Served Daily	0.0259	4	0.28
Five or More Daily Nonstop Domestic Flights	0.0258	5	0.28
Airline Hubs Served–Domestic	0.0254	6	0.28
International Nonstop Departures	0.0182	7	0.20
Percent of the World GDP Served Nonstop	0.0169	8	0.18
Domestic Nonstop Departures	0.0164	9	0.18
Percent of the World GDP Served Twice or More Daily	0.0161	10	0.18
Number of Airlines	0.0160	11	0.17

Table 18 illustrates how these elasticities can be used to measure the impact on GDP, measured for year 2010. Based on data for the 11 industries and aggregating across the 20 regions, the increase in each industry's value added is calculated for a one-percent change in those connectivity measures that were statistically significant for that industry sector. The last row in the table reports the value added change for the aggregate of the 20 regions (across all 11 industry sectors) for a change in each connectivity measure.

The coefficients in Table 18 are the calculated changes in value added per industry based on a 1% change in selected airport connectivity variables. As an example, in Column 3, a 1% increase in the number of airlines serving the 20 MSAs would lead to an increase of GDP across the regions of $201 million, of which $158 million is an increase in value added for manufacturing. In Column 4, a 1% increase in the number of nonstop domestic departures would increase GDP by $453 million, but in this case manufacturing value added accounts for $85 million of the total. A 1% increase in the number of nonstop domestic destinations served (Column 6) will increase GDP by $686 million, with value added in the manufacturing sector contributing $123 million.[23]

Results shown in Table 18 identify which connectivity measures have the strongest effect on economic output for different industries. In Table 17, the number of airlines is ranked 11th in terms of its effect on productivity based on the average elasticity values. However, this measure has a fairly strong effect on the output of the manufacturing sector, which forms a large proportion of total GDP. The number of airline hubs served strongly affects the finance and insurance sector. If the number of domestic airline hubs served across the airline network (represented in this analysis by the sample of 20 regions and their airports) were to increase by 1% (31,000 flights), the change in value added generated by increased MFP from the enhanced connectivity across all sectors for which this variable was significant (Table 4) would be about $374 million. Moreover, if the number of hubs served increased by 10%, the MFP value would be about $3.7 billion.

Full Economic Impacts of MFP—Connectivity

It is possible to construct a variety of different scenarios for national investment in airports that can lead to direct changes in productivity, and those changes can lead to broader impacts on national competitiveness, capital investment, labor force utilization, output growth, and export changes. Depending on the specifics of those scenarios, different airports and mixes of associated activities may benefit. To illustrate the potential magnitude of broader impacts, the study team simply applied a national input/output model to portray how growth associated with productivity benefits can potentially spread across the economy.[24] For instance, the earlier analysis showed that a 1% change in the aviation connectivity variables will generate between $68 million (for "percent of GDP served nonstop") and $686 million (for "number of nonstop destinations") in direct productivity (value added) across industries, depending on which variable is affected. In turn, the direct impact of these additional contributions to U.S. GDP are equivalent to 500 to 6,900 jobs; $43 million to $369 million in labor income (gross payroll); and $168 million[25] to $1.7 billion in total economic output.[26] The direct impacts per variable are summarized in Table 19.

National economic growth associated with those productivity changes can potentially lead to further indirect and induced effects. In this illustration using the IMPLAN national model, the broader impact on total value added is estimated to range from $221 million to $2.1 billion by variable, which in turn yield estimates of:

- 2,000 to 19,000 jobs
- $100 million to $1.2 billion in labor income
- $247 million to $4.5 billion in total economic output

Table 18. Impact of 1% changes in different connectivity measures on industry value added aggregated across all 20 regions (millions of 2010 dollars).

Industry	GRP over 20 MSAs *(3)*	Number of Airlines	Domestic Nonstop Departures	Airline Hubs Served-Domestic	Domestic Nonstop Destinations	Two or More Daily Nonstop Domestic Flights
Manufacturing	$358,857.91	$157.54	$85.05		$123.45	$355.63
Wholesale Trade	$199,956.26	$42.99	$51.39		$30.39	
Information	$158,156.77			$23.88		$19.14
Finance & Insurance	$315,875.87		$151.30	$226.17		$98.55
Real Estate, Rental & Leasing	$444,512.52		$94.68		$176.47	$180.47
Professional Scientific & Technical Services	$311,416.85		$56.68	$112.42		
Management of Companies & Enterprises	$80,042.52			$8.48	$25.69	
Administration & Support Waste Management Services	$108,779.27		$11.31		$32.74	
Art, Entertainment & Recreation	$34,213.83			$3.18	$4.45	
Accommodation & Food Services	$87,114.85		$0.09		$19.95	
Other*	$734,242.98		$2.94		$272.40	
Total	**$2,833,169.64**	**$200.53**	**$453.44**	**$374.14**	**$685.55**	**$653.79**

Industry	Five or More Daily Nonstop Domestic Flights	International Nonstop Departures	International Nonstop Destinations	Percent of World GDP Served Nonstop	Percent of the World GDP Served Daily	Percent of the World GDP Served with Two or More Daily Flights
Manufacturing			$171.89			$56.34
Wholesale Trade	$63.59		$38.19		$6.40	
Information		$38.59	$22.77		$40.65	
Finance & Insurance		$41.70			$33.80	
Real Estate, Rental & Leasing	$48.90		$236.48			
Professional Scientific & Technical Services		$81.59			$152.91	
Management of Companies & Enterprises		$7.28	$18.17	$16.25		$14.33
Administration & Support Waste Management Services		$22.95	$95.40	$51.34		
Art, Entertainment & Recreation	$6.74				$13.65	
Accommodation & Food Services					$19.34	
Other*			$99.86		$94.72	
Total	**$119.22**	**$192.11**	**$682.77**	**$67.59**	**$361.46**	**$70.67**

**"Other" represents a grouping of the following sectors: Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Retail Trade; Transportation and Warehousing; Educational Services; Health Care and Social Assistance; Other Services (except Public Administration); and Public Administration.*

Table 19. Aggregated direct economic impacts for the 20 MSAs driven by a 1% change in each variable (in millions $2010).

Variable	Jobs	Labor Income	Output	Value Added
Number of Airlines	1,300	$106	$651	$201
Domestic Nonstop Departures	3,100	$218	$858	$453
Airline Hubs Served-Domestic	2,900	$228	$582	$374
Domestic Nonstop Destinations	6,900	$369	$1,270	$686
Two or More Daily Nonstop Domestic Flights	4,000	$268	$1,749	$654
Five or More Daily Nonstop Domestic Flights	800	$46	$168	$119
International Nonstop Departures	1,900	$129	$293	$192
International Nonstop Destinations	6,400	$317	$1,357	$683
Percent of World GDP Served Nonstop	1,300	$56	$99	$68
Percent of the World GDP Served Daily	4,300	$257	$543	$362
Percent of the World GDP Served Two or More Daily	500	$43	$232	$71

Jobs rounded to the nearest 100. Dollars in Millions $2010. Calculations based on the MFP calculations previously presented.

The most robust aggregate impacts across industries are generated by an increase in the number of destinations with two or more daily nonstop flights. The variable with the smallest return differs according to jobs, labor income, economic output, or value added, based on the industry mix affected. The smallest total value added and economic output increases result from changes in percent of the world GDP served daily. The smallest total impacts on jobs and labor income occur from changes in destinations with five or more daily nonstop domestic flights. Potential total impacts by variable are summarized in Table 20.

Similar to the industry/connectivity variable results presented for value added (Table 18), jobs per industry sector vary by type of connectivity improvement. For example, as seen in Table 18, the employment impact of a 1% change in the number of airlines serving airports directly benefits only the manufacturing and wholesale trade sectors. However, looking at the variable domestic airline hubs served (the number of hubs served from a given airport), shows that a 1% increase is primarily beneficial to the finance and insurance sector. Table 21 shows the percent of direct jobs

Table 20. Aggregated total economic impacts for the 20 MSAs driven by a 1% change in each variable including direct, indirect, and induced effects (in millions $2010).

Variable	Jobs	Labor Income	Output	Value Added
Number of Airlines	7,500	$471	$1,725	$794
Domestic Nonstop Departures	9,900	$614	$2,025	$1,118
Airline Hubs Served-Domestic	7,600	$493	$1,340	$831
Domestic Nonstop Destinations	17,400	$963	$3,030	$1,676
Two or More Daily Nonstop Domestic Flights	19,200	$1,161	$4,455	$2,135
Five or More Daily Nonstop Domestic Flights	1,900	$106	$336	$221
International Nonstop Departures	4,400	$267	$689	$429
International Nonstop Destinations	17,500	$949	$3,240	$1,742
Percent of World GDP Served Nonstop	2,300	$108	$247	$156
Percent of the World GDP Served Daily	9,100	$517	$1,291	$807
Percent of the World GDP Served Two or More Daily	2,800	$176	$635	$291

Jobs rounded to the nearest 100. Dollars in Millions $2010. Calculations based on the MFP calculations shown in Appendix 1.

Table 21. Differences in direct job impacts by connectivity variable and industry sector.

Industry	Number of Airlines	Domestic Nonstop Departures	Airline Hubs Served-Domestic	Domestic Nonstop Destinations	Two or More Daily Nonstop Domestic Flights	Five or More Daily Nonstop Domestic Flights	International Nonstop Departures	International Nonstop Destinations	Percent of World GDP Served Nonstop	Percent of the World GDP Served Daily	Percent of the World GDP Served Two or More Daily
Manufacturing	79%	19%		18%	54%			25%			80%
Wholesale Trade	21%	11%		4%		53%		6%		2%	
Information			6%		3%		20%	3%		11%	
Finance & Insurance		33%	60%		15%		22%			9%	
Real Estate, Rental & Leasing		21%		26%	28%	41%		35%			
Professional Scientific & Technical Services		12%	30%				42%			42%	
Management of Companies & Enterprises			2%	4%			4%	3%	24%		20%
Administration & Support Waste Management Services		2%		5%			12%	14%	76%		
Art, Entertainment & Recreation			1%	1%		6%				4%	
Accommodation & Food Services		0.02%		3%						5%	
Other*		1%		40%				15%		26%	
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Impacts are driven by direct value added in specific sectors and then filtered through the IMPLAN model to calculate direct employment change in those sectors.

**"Other" represents the grouping of Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Retail Trade; Transportation and Warehousing; Educational Services; Health Care and Social Assistance; Other Services (except Public Administration); and Public Administration.*

Table 22. Estimated value added generated by a 1% increase in air cargo tonnage.

Sector	Significant Variables	Productivity Impacts as Value Added ($millions)
Manufacturing	Domestic enplaned air cargo	$100.46
Wholesale Trade	International enplaned air cargo	$72.36
Total		**$172.82**

Table 23. Direct economic impacts of a 1% increase in air cargo in the 20 sample MSAs (dollars in 2010 value).

Impact Type	Employment	Labor Income	Output	Value Added
Direct Effect	1,200	$94	$490	$173
Total "Spinoff" (multiplier) Effect	4,100	$228	$769	$411
Indirect Effect	*2,000*	*$128*	*$464*	*$228*
Induced Effect	*2,100*	*$100*	*$306*	*$183*
Total Effect	**5,300**	**$321**	**$1,259**	**$583**

Employment is rounded to nearest thousand, and dollars are rounded to nearest million. Numbers may not add due to rounding.

by industry sector according to a 1% change in each connectivity variable.

5.3 MFP Air Cargo

Air cargo is well developed in the United States; however, the analysis shows only a small impact of air cargo activity on MFP. Part of the explanation may lie in the (two-digit NAICS) major industry delineation being too aggregated to measure the importance of air cargo. For example, medical devices, fresh seafood, and fresh cut flowers are dependent on air cargo connectivity, but manufacturing and agriculture products also move by truck, rail, inland waterway, and marine modes.

Calculations of the effects of air cargo services are based on manufacturing and wholesale trade sectors, which rely on transport of commodities, and are analyzed for the 20 MSAs. Based on the MFP analysis, variables that have significant impacts on the statistical relationship of air cargo to productivity for the highly aggregated industries in the sample and the years selected are:

- Manufacturing (only the amount of domestic enplaned air cargo)
- Wholesale trade (international enplaned air cargo)

An assumed 1% increase in enplaned air cargo reflects $173 million boost in direct value added, as shown in Table 22. (This is in addition to the $136 billion in value added from current air cargo services previously shown in Table 8.) Tons of air cargo reflect the production and sales of commodities by U.S. industries. Cargo movements, as shown in the MFP analysis, are outcomes from the additional sales by U.S. industries and mode choices to utilize air cargo. They are not necessarily a catalytic impact of airports.

The $173 million in value added is the equivalent of $490 million in direct economic output,[27] which supports 1,200 jobs and $94 million in labor income in the 20 MSAs (see Table 23). These direct impacts lead to indirect and induced effects that support an additional 4,100 jobs that pay $228 million in labor income to workers, and generate an additional $411 million in value added and $769 million in output across the national economy.

CHAPTER 6

Findings: Consumer Surplus

Consumer surplus is defined as the difference between what consumers are willing to pay for a good or service and what they actually pay. In the context of air service, the difference in willingness to pay for air service and what is actually spent leaves money in households' "wallets," and is available to be spent in the general economy on non-aviation goods and services. Economic effects are generated by the net of: (1) savings accruing to air travelers from the reduction in fares, which is then spent on other consumer goods and services; and (2) the new spending on air travel induced by price reductions, where dollars are taken from other goods and services and spent on air transportation. Derived economic impacts are more robust from household spending on goods and services other than air transportation than they are for air transportation itself. Thus, dollars spent redirected from non-aviation goods and services to induced air travel have a negative economic impact (the impact of the purchase of air transportation minus the impact of other household spending). On the other hand, the consumer surplus dollars are equivalent to additional household income. These dollars are available to be spent on non-aviation purchases, which generate a positive economic impact when compared with the impact if the dollars were spent on air travel.

The number of domestic O&D passenger trips in each airport-pair market[28] together with the average airfare paid by those passengers was obtained from the 10% O&D Survey data reported to the U.S. Department of Transportation by U.S. airlines, also referred to as Database 1B (DB1B).

Although the international DB1B dataset provides data on passenger traffic in international airport-pair markets, the DB1B data is only reported by U.S. airlines and, therefore, excludes passenger traffic on foreign flag airlines, unless those travelers flew part of their itinerary on a U.S. airline or were traveling on a ticket issued by a U.S. airline (such as passengers on a code-sharing flight). In many markets, this could omit a significant proportion of the traffic, particularly markets that are only served by foreign flag airlines. However, both U.S. and foreign flag airlines report segment passenger count data on Schedule T-100 for flight segments beginning or ending in the United States. Therefore, that dataset was used to identify the top 30 international nonstop airport-pair markets from U.S. gateway airports, based on the on-flight O&D rather than the true O&D of the passengers. The international DB1B dataset was used to determine the average airfare paid by air passengers in each international nonstop airport-pair market.

In order to estimate the proportion of passenger trips in a given market that were undertaken for personal purposes (since only personal travel is included in the consumer surplus analysis), data from the most recent air passenger surveys performed at 10 airports that were available to the research team were analyzed to determine the split between personal and business travel in the markets included in the sample. These surveys included respondents who were making trips in many of the sample domestic markets. For other domestic markets between airports for which air passenger surveys were not available, or where the number of responses in the surveys was considered too small to be representative, the proportion of personal trips in the markets was estimated from similar markets for which data was available. For the international markets, the proportion of personal trips was estimated from the results of a survey of international air travelers departing from U.S. airports that is undertaken annually for the Office of Travel and Tourism Industries (OTTI) of the U.S. Department of Commerce. A full discussion of the methodology behind the consumer surplus calculations is found in Appendix 2.

As illustrated in Figure 2, change in consumer surplus is non-linear since part of the change is due to the attraction of additional passengers, which varies with the change in fare.[29] In the current analysis, consumer surplus is calculated based on an assumed 1% drop in fares for both domestic and international travel.

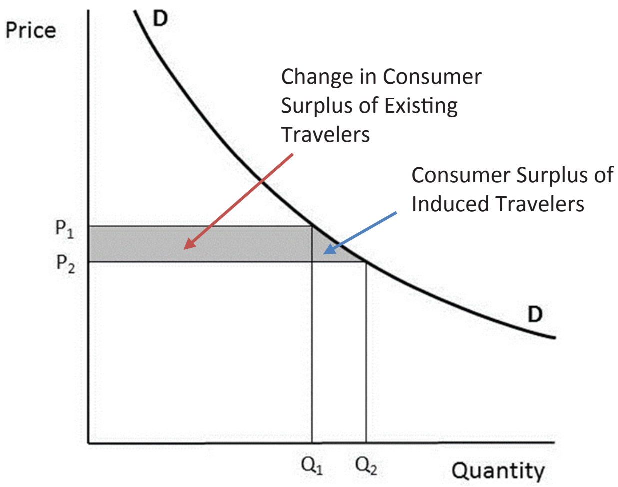


Figure 2. Illustration of consumer surplus.[30]

The research team estimated the number of air passengers by analyzing a representative sample of domestic and international airport-pair markets (See Appendix 2A). In the sample travel, the average airfare for domestic personal travel is $162 and the average fare for international personal travel is $686.

A 1% drop in airfare produces average ticket price declines of almost $2 for domestic personal travelers and $7 for international personal travelers. Table 24 illustrates the changes in consumer surplus and dollars spent on induced travel based on this 1% change in airfares. The 1% airfare reductions are expected to create an aggregate of $991 million in passenger welfare[31] that translates into an aggregate of $671 million and $320 million in new demand for domestic and international air travel, respectively. Moreover, the consumer surplus accruing to air travelers amounts to $815 million, $506 million for domestic travelers and $310 million to U.S. resident international travelers.

The calculated change in air travel expenditures for international trips is much smaller than that for domestic trips. In addition, the increased expenditure for the induced trips is almost completely offset by the savings to the existing travelers.[32]

Two sets of calculations were applied for the consumer surplus findings:

The impact of household spending. The ACRP Project 03-19 study includes a survey of air travelers to document the distribution of household incomes by income cohort of air travelers. In this analysis, the ACRP Project 03-19 study's survey results were used to estimate the household income of personal air travelers who are expected to benefit from the estimated change in consumer surplus. The IMPLAN model package was used to analyze the economic impact of changes in household spending for eight income cohorts. The survey results were used to adjust the percentage of households in each income cohort in the model to reflect the income distribution of air travelers. In addition, the research team adjusted the spending patterns in each cohort by deleting air transportation purchases. Accounting for the different spending patterns in each income cohort, and excluding purchases of air transportation services, Table 25 shows that more than seven direct jobs and 14.5 total jobs (including direct effects, and indirect and induced economic multipliers) are generated by every $1 million of household spending.

The impact of the purchase of air transportation services. Household spending on general goods and services returns more economic impact than the purchase of air travel services in terms of jobs, payroll, and value added. As an illustration, Table 25 shows that the purchase of $1 million of air services generates 2.7 direct jobs and 8.3 jobs including multipliers. These are lower impacts than the spending on general household services. Thus, the overall economic impact of redirecting $1 million from general household spending to air

Table 24. Consumer surplus and induced expenditure based on 1% drop in domestic and international airfare.

Market	Change in Consumer Surplus ($m)	Total Induced Air Travel Expenditure ($m)
Effect of a One-Percent Fare Decrease		
Domestic	$505.8	$670.5
International	$309.5	$320.3
TOTAL	**$815.3**	**$990.8**
Sensitivity Test Based on a Five-Percent Fare Decrease		
Domestic	$2,599.2	$3,378.1
International	$1,581.0	$1,602.8
TOTAL	**$4,180.2**	**$4,980.9**

Table 25. Economic impacts based on $1 million household spending on goods and services and $1 million spent on air transportation.

	Impact Type	Employment	Labor Income	Value Added
1. Household Spending on General Goods and Services	Direct Effect	7.2	$302,000	$552,000
	Total Effect	14.5	$677,000	$1,209,000
2. Purchase of Air Transportation Services	Direct Effect	2.7	$217,000	$349,000
	Total Effect	8.3	$508,000	$878,000
3. Redirected General Household Spending to Air Transportation	Direct Effect	-4.5	-$85,000	-$202,000
	Total Effect	-6.2	-$169,000	-$332,000

Modeling based on IMPLAN, LLC National Model, using 2012 structural matrix. Dollars are in 2010 value and rounded to the nearest thousand dollars.

transportation services is the subtraction of 7.2 jobs (from non-air services household spending) and the addition of 2.7 jobs generated by the purchase of air transportation services, which is a net −4.5 direct jobs. In terms of total economic impacts, redirecting $1 million in purchases from general household spending to air transportation services results in an overall loss of 6.2 jobs.

The research team determined the economic impacts of the consumer surplus generated by a one-percent reduction in airfares by summing these two modeling approaches noted above. First, the $991 million paid for induced air travel due to the lower fares are considered to be dollars diverted from the general economy to air transportation. This switch in spending produces a negative economic effect because, as noted in Table 25, the impacts of the purchase of air transportation services is less than the impacts of the equivalent amount of general household spending. Second, the $815 million of consumer surplus is recognized as money that travelers are able to spend on goods and services; this is, in effect, money left over "in their pockets." The net impact of the additional consumer surplus is derived from adding the money diverted from household spending to air travel (which is negative) to the impacts of spending $815 million on goods and services other than air transportation (which is positive).

The calculated national economic direct effect of the $991 million in induced air transportation and $815 million in consumer surplus is $553 million in direct output, $249 million in value added and about 1,400 direct jobs. Total impacts, including multiplier effects, are estimated at $1.3 billion in output, $657 million in value added and 5,800 jobs. These economic impacts are presented in Table 26[33] and the calculations are displayed in Table 27.

Table 26. Economic impacts based on $991 million of induced travel expenditure and $815 million of additional consumer surplus.

Impact Type	Employment	Labor Income	Output	Value Added
Direct Effect	1,400	$162	$553	$249
Indirect Effect	1,800	$101	$361	$190
Induced Effect	2,600	$122	$367	$218
Total Effect	5,800	$385	$1,281	$657

Totals do not add due to rounding. Employment is rounded to the nearest hundred. Dollars are rounded to the nearest thousand and are in 2010 value using 2012 national IMPLAN model.

Table 27. The economic impact of consumer surplus equals (A) the economic impact of spending the consumer surplus plus (B) the difference in removing dollars from consumer spending to purchase airline tickets and the lower impacts of purchasing in the air transportation sector.

Impact Type	Employment	Labor Income	Value Added	Output
A) $815.3 Million Consumer spending - bundle of goods except aviation services (Relates to Table 25, #1)				
Direct Effect	5,900	$247	$450	$728
Indirect Effect	2,400	$135	$231	$415
Induced Effect	3,600	$171	$305	$513
Total Effect	11,800	$552	$986	$1,655
B) $990.8 Million Induced Spending on Air Travel and $990.8 Million not Spent (or Invested) in the Rest of the Economy (Relates to Table 25, #3)				
Direct Effect	(4,500)	($85)	($200)	($175)
Indirect Effect	(600)	($34)	($41)	($53)
Induced Effect	(1,000)	($49)	($87)	($146)
Total Effect	(6,000)	($167)	($329)	($374)
C) $ Net Impact of Consumer Surplus (A + B)				
Direct Effect	1,400	$162	$249	$553
Indirect Effect	1,800	$101	$190	$361
Induced Effect	2,600	$122	$218	$367
Total Effect	5,800	$385	$657	$1,281

CHAPTER 7

Qualitative Research

Structured interviews were conducted with representatives of airports, business associations, and corporations to verify and enrich the results of the quantitative research. In the course of this project, the research team conducted 76 interviews with companies that rely on business travel and air cargo shipments, as well as business organizations, airport administrators, and representatives of alliances of airports, airlines, and GA users. The purpose of the outreach program was to review observations and conclusions suggested by data research in "real world" contexts. Moreover, an assessment of non-quantifiable national benefits was conducted to ensure that this research reported the full breadth of the national benefits of airports. These impacts span various industries, communities, and locations and are important to recognize alongside the quantitative impacts. Whether aviation supports the research of a university group, the saving of a life, or the protection of national borders, it is critical to health, safety, and welfare in ways that cannot be appropriately reflected in economic impact calculations. A complete accounting of the qualitative research conducted for this project is presented in Appendix 4.

7.1 Non-Quantifiable Impacts

Qualitative benefits of U.S. airports can be recognized at many levels, whether it is local, regional, statewide, or national. Numerous agencies, individuals, and populations benefit from the qualitative impacts of U.S. airports. These impacts span various industries, communities, and locations and are important to recognize alongside the quantitative impacts. Aviation is critical to our health, safety, and welfare in ways that economic impact calculations cannot reflect.

Airports generate a wide range of activities that do not involve monetary transactions and they sponsor activities in which the full value is often not reflected in money circulated in the economy. Such activities do not result in economic impact benefits, or the benefits that are counted understate the full values attributable to airports. An example of the latter is medical air evacuations. The economic impacts of medical evacuation services can be estimated by accounting for operating costs of the services and the costs of the eventual medical care. However, economic impact analyses (distinct from benefit–cost analyses) do not factor in the value of life or pain and suffering. An example of a non-monetary, community outreach activity is airport-produced air shows offered as free entertainment, which often does not result in new dollars being brought into the United States.

7.2 Business Interviews

The research team conducted interviews with business owners, staff of business organizations, and airport personnel to verify, modify, or enrich the MFP findings. Business interviews with firms in sectors highly dependent on air transportation best illustrated how air service can improve productivity for off-airport businesses. For companies where reliance on air travel is moderate or low, the qualitative analysis was less conclusive as many other factors also are important to location decisions and productivity. However, for heavily air reliant businesses, the addition or loss of direct air service affects the cost of doing business and the opportunities for market expansion within the United States and in other countries. These sectors include manufacturing; professional, scientific, and technical services; finance; and the import/export of perishable foods.

The interviews also confirmed the importance of nonstop domestic and international destinations. Additions to air service at an airport can open up markets previously not available to off-airport businesses. The interviews found that increased air service are most important to businesses that already use air transportation extensively for customer service and shipments.

Cities where airlines have closed hubs experienced large losses in connectivity that resulted in many company relocations away from the area and difficulties in attracting new firms to the area. However, cities with expanding hub airports experienced the opposite effects. For example, industries located in Atlanta have been direct beneficiaries of a decision by Delta Air Lines to add connecting flights at the airport. Airports that serve as international gateways also are magnets for businesses that require direct intercontinental air service. Interviews with business executives and representatives of business organizations (such as chambers of commerce and industry associations) were conducted to provide a practical perspective to the data intensive economic impact analysis and the analysis of airport connectivity.

Business Travel

Interviews supported the importance of airport connectivity for business travel. Priorities identified by business travelers are listed below. Note that the first three bullets are directly applicable to connectivity:

- Frequent domestic and international service
- Choice of nonstop domestic and international flights
- Concentration of flights to and from particular markets during peak hours
- Reliable schedules with minimal delays
- Ease of rush hour commute to and from the airport
- Lower relative ticket costs, with competition on popular routes in order to reduce fares

Though not surprising, the interviews confirmed that air travelers prefer direct flights between their particular city-pairs of choice, and they want a variety of carrier options in order to ensure competitive pricing for tickets. Demand for tourism and travel contribute heavily to an airline's city-pair decision. For example, inbound tourist travel from Asia to San Francisco has supported an increase in flight frequency. In 2013, 150,000 Chinese travelers arrived at Boston's Logan Airport via an intermediate city airport. Direct air service from Beijing to Boston started in 2014. Boston is also pursuing a direct flight to Tel Aviv because more than 200 businesses in Massachusetts have Israeli connections. In addition, foreign flag carriers are introducing service to U.S. destinations that are not U.S. carrier international hubs. For example, Japan Airlines, Copa Airlines (based in Panama), Turkish Airlines, Emirates (based in Dubai), and Hainan Airlines (based in China) chose Boston as a new nonstop destination.

Interviews confirmed that the frequency of flights and the number of nonstop flights can improve competitive standing, improve productivity, and reduce costs by optimizing employee time. In this context as well, international flights make it possible to develop global markets and partnerships. (The availability of international passenger flights also makes it possible to transport high-value air cargo as belly cargo.)

Face-to-face meetings with customers, company personnel, and suppliers are a vital part of business success and, in this context, air service is extremely important. In addition, it was pointed out that reliable nonstop air service and good connecting service supports tourism and improves the likelihood of attracting companies to a region.

The use of air travel for sales and on-site service continues to be the preferred mode for some internal company meetings or meetings with clients and customers, except, perhaps, in short-haul markets where air travel has become more limited and ground transport options save time. Companies that serve remote locations also depend on private or commercial air service. The preferences for business air travel is with the recognition that Internet services are replacing the need for some long distance business trips.

Cargo

In terms of cargo, air transport is the most expensive mode. In most cases, it is the choice of last resort, except for perishable goods, high-value products (notably, but not limited to, technology), just-in-time parts and supplies, other time-sensitive delivery due to long distances or production delays, or explicit requests by customers.

Interviews confirmed that shippers select a mode of transport based on cost or scheduled delivery time to the destination. Once a shipment is consigned to a carrier or logistics firm, the firm responsible for transportation makes the decision whether to carry the shipment by air, ground, rail, or ship.

Technology improvements have streamlined modal decisions and itineraries for cargo shipments. Technologies that support time-definite air delivery have been adapted by many ground delivery services provided by integrated carriers, such as FedEx and UPS. This has allowed companies to select time-definite ground transport as the lower cost option to air transport. The integrated carriers have responded to this shift by expanding ground transport capabilities and delivery options. Integrator agreements with the U.S. Postal Service and access to postal distribution networks are also offering companies an even lower cost ground shipping option. Like the purchase of air travel, product shipment has become a commodity business. Even when a company has a contract carrier in place, the logistics department will search for the lowest cost option from that carrier as pricing changes constantly.

Moreover, logistics software is also available to company shipping departments to search for the lowest cost option for transport and to steer internal company shipping requests to the lowest cost option that meets delivery requirements. This software is modifying old habits that air transport is the only assured way for time-definite delivery and tracking capability.

Trade-offs Between Air and Other Modes

Interviewees noted trade-offs, particularly in cargo. For example, for perishable goods (e.g., flowers, drugs, fish) air transport does not usually provide climate controlled environments, but shortens the time the product is at risk of perishing. Otherwise, refrigerated trucks and rail provide more controlled environments. Heavy manufactured parts and equipment tend not to be shipped by air unless absolutely necessary.[34] To control transportation costs, companies are more likely to locate in their sales region for service and shipping reasons. A good example of this trend is the automotive manufacturing industry in which Japanese and German auto makers are producing their U.S. destined automobiles almost entirely in the United States.

In practice, many location decisions are not dependent necessarily on air access. Instead, they are determined by the owner's desire to live in a particular place, access to venture capital, and/or the location's desirability to the employees required to produce the product. For products designed in the United States and manufactured in Asia, business location is driven by access to venture capital (VC). For example, the company's business is based in San Francisco near its VC firms. The company's factory in Asia is located within a two-hour drive from a major airport with direct services from San Francisco International Airport. Many VC firms prefer to do business with companies that are within driving distance of the VC's office.

In small to medium size businesses with domestic customers, people travel via car to an airport, then fly to another airport closest to the destination, then travel via rental car to the destination. Nonstop flights are best and closer to the destination is better.

In locations where nonstop service has been discontinued and there is a direct flight airport option within driving distance, travelers will often drive to a hub airport in lieu of taking a connecting flight.

7.3 Interviews with Airport Managers and Staff of Aviation Organizations

Interviews with professional membership organizations provided insight into the creation and the end use of the economic impact data created for the aviation industry. Many membership organizations commission reports from private consulting firms either independently or cooperatively with other organizations. The FAA and the U.S. Census Bureau produce monthly and annual reports that are also valued throughout the aviation industry. Primarily, the economic data is used to lobby for policy changes, funding, and regulatory initiatives at the federal level. Reports and presentations are developed for use at the state level and for the media. Catchphrases are developed from benchmarks to communicate the value of aviation in simple and direct terms.

The aviation organizations interviewed all reported that they use the economic impact data primarily to create messages to legislators and regulators on Capitol Hill. In addition to advocating for funding to maintain airports or to promote additional investment in specific airports, other issues include FAA Pilot Rules, levels of customs staffing at U.S. Ports of Entry, business aviation use, the federal cap on local passenger facility charges and airfield access for pilots of GA aircraft.

Some organizations said that they use economic impact data to address state elected officials, including governors and legislators, when aviation topics are on the state agenda. Others reported getting involved in airport-specific issues when there are actions being considered that will result in restricting airport access or reducing operational capacity. At least one organization also reported an occasional need to educate its members about the economic impact of aviation.

Interviews with airport administrators were conducted to also confirm and enhance the data collection from the initial project research and literature review. Research reported in the early phases of this project identified computer and electronic products, miscellaneous manufactured commodities, machinery, medical equipment and supplies, and apparel and accessories as top imports by industrial sector. The export list is similar. During the interview process, all of these items were identified as significant to airport cargo operations. One item added to the initial research was the importance of cargo movement related to perishable products including flowers, fruits and vegetables, and seafood. Several airport executives reported associated business development at or near their airports as a result of the cargo operations, including freight forwarders.

Interviews also confirmed use of airports for business travel. These businesses include entertainment, technology, finance, pharmaceuticals, communications, automotive, health care, and real estate companies. There was confirmation that Fortune 500 companies locate near airports for employee business travel, although privacy protocols at each airport dictated that specific businesses or travelers were not generally known. Some anecdotal stories support location of sports teams and media operations near the airport.

It was difficult to directly confirm research on the topic of industry-sensitivity to airport access and industries that purchase large amounts of aviation service. One exception was the confirmation by the Van Nuys Airport manager that a large percentage of the airport's GA activity was related to the motion picture industry. Several airport managers were aware of Fortune 500 company headquarters in their areas. They could also report on the high level of corporate aviation use as a percentage of overall operations. However, the airport managers at the three GA airports were emphatic about the need for discretion with corporate clients and could not say specifically which companies traveled in and out of their airports.

CHAPTER 8

National Implications

The economic analyses examined in this research include the existing contributions of U.S. airports to the national economy and how that contribution could change given changes in airport connectivity, air cargo, and airfares. While the analyses of existing contributions and consumer surplus were conducted on a national scale, the two MFP analyses were limited to the sample of 20 MSAs.

The combined economies of the MSAs represent about 23% of the national economy when comparing national GDP to the regional total. Stated differently, the national GDP is 4.3 times the combined GRPs of the 20 MSAs.[35]

The MFP analyses are extrapolated to the national level, which must be read with caution since the MFP only considers 20 metropolitan regions and 11 aggregated sectors of the economy. The extrapolation is for illustrative purposes only to reflect an approximation.

Given this uncertainty, low, medium, and high estimates are provided for the impact, where the medium represents the extrapolation of impacts for the 20 MSAs. The low and high estimates reflect 20% lower-bounds and 20% upper-bounds of the national factor of 4.3, creating expansion estimate ranges of 3.44 to 5.16.

Table 28 shows the direct impacts and total impacts for each variable of the MFP connectivity analysis for jobs and value added (contribution to the national GDP), expanded to these national scales. As the significant impacts of each of the 11 variables affects different sectors of the economy, the relationships among value added, jobs, labor income, and economic output vary. Impacts in the middle cohort presented in Table 28 range from 2,100 to almost 30,000 direct jobs, and from $305 million to almost $3 billion in value added. Total impacts, including direct and multiplier effects, range from 8,200 to 82,400 jobs, and from almost $700 million to more than $9 billion in value added.

The national impacts of the interrelationship of air cargo with productivity are estimated using the same approach as the MFP connectivity presented, applying the 4.3 ratio of national GDP to the aggregate product of the 20 MSAs. Also, the −20% and +20% bounds were placed around this point to establish a range reflecting low and high estimates. Total national estimates from all analyses are presented in Tables 29 and 30. In addition to the existing contributions of U.S. airports to the national economy, the three impact estimates based on calculating and applying elasticities are driven by:

- A 1% improvement in airport connectivity factors
- A 1% increase in air cargo tonnage
- A 1% airfare reduction for personal travelers

In Table 29, the mid-range estimate of direct national productivity impacts given for a one-percent increase in air cargo is $742 million in value added, which will support 5,100 jobs. Total impacts, including multiplier effect, are estimated at $2.5 billion in value added and almost 23,000 jobs.

Of course, changes in these assumptions will alter the estimates of impacts, both in the 20 MSA regions and in terms of nationwide estimates. Moreover, if connectivity decreases, air cargo operations lose efficiency. If airfares increase, impacts could be negative to the economy. Table 30 summarizes direct impacts of each analysis on the U.S. economy and Table 31 summarizes total impacts, including direct, indirect, and induced effects, based on 1% increases in MFP and air cargo tonnage, and a 1% decrease in the cost of airfares. To concisely present results of the 11 different connectivity factors that were analyzed for the MFP analyses, the tables refer to the mean impacts of the variables, although values from any of the variables may be substituted for the means (see Table 28).

Table 28. Potential national impact of MFP connectivity analysis.

Impacts based on 1% change in the variables below.	Low Estimate		Mid-Range Estimate		High Estimate	
	Jobs	Value Added	Jobs	Value Added	Jobs	Value Added
(a) Direct Effects						
Number of Airlines	4,500	$690	5,600	$862	6,700	$1,035
Domestic Nonstop Departures	10,600	$1,555	13,300	$1,944	16,000	$2,333
Airline Hubs Served-Domestic	9,900	$1,284	12,400	$1,605	14,900	$1,926
Domestic Nonstop Destinations	23,700	$2,355	29,600	$2,944	35,500	$3,532
Two or More Daily Nonstop Domestic Flights	13,800	$2,245	17,200	$2,806	20,600	$3,368
Five or More Daily Nonstop Domestic Flights	2,700	$409	3,400	$511	4,100	$613
International Nonstop Departures	6,600	$659	8,200	$824	9,800	$989
International Nonstop Destinations	22,000	$2,345	27,500	$2,931	33,000	$3,517
% of World GDP Served Nonstop	4,500	$233	5,600	$292	6,700	$350
% of the World GDP Served Daily	14,800	$1,243	18,500	$1,553	22,200	$1,864
% of the World GDP Served Two or More Daily	1,700	$244	2,100	$305	2,500	$366
Mean Direct Impacts of All Variables	**10,400**	**$1,206**	**13,036**	**$1,507**	**15,600**	**$1,808**
(b) Total Effects (Direct, Indirect, and Induced)						
Number of Airlines	25,800	$2,726	32,200	$3,407	38,600	$4,088
Domestic Nonstop Departures	34,000	$3,838	42,500	$4,797	51,000	$5,757
Airline Hubs Served-Domestic	26,100	$2,853	32,600	$3,566	39,100	$4,279
Domestic Nonstop Destinations	59,800	$5,753	74,700	$7,192	89,600	$8,630
Two or More Daily Nonstop Domestic Flights	65,900	$7,329	82,400	$9,161	98,900	$10,993
Five or More Daily Nonstop Domestic Flights	6,600	$759	8,200	$948	9,800	$1,138
International Nonstop Departures	15,100	$1,473	18,900	$1,841	22,700	$2,209
International Nonstop Destinations	60,100	$5,980	75,100	$7,475	90,100	$8,970
% of World GDP Served Nonstop	7,900	$536	9,900	$669	11,900	$803
% of the World GDP Served Daily	31,200	$2,770	39,000	$3,463	46,800	$4,155
% of the World GDP Served Two or More Daily	9,600	$999	12,000	$1,249	14,400	$1,498
Mean Direct Impacts of All Variables	**31,100**	**3,183**	**38,864**	**3,979**	**46,600**	**$4,775**

National impacts are provided for illustrative purposes and are approximations.

Total impacts are the sum of direct, indirect, and induced effects.

Dollars in Millions $2010. Calculations based on the MFP calculations for value added previously presented.

National impacts based on GDP data from Bureau of Economic Analysis.

Table 29. Interrelationship of U.S. productivity with a 1% increase in cargo tonnage.

Impacts based on 1% change in air cargo	Low Estimate		Mid-Range Estimate		High Estimate	
	Jobs	Value Added	Jobs	Value Added	Jobs	Value Added
Direct Effect	4,100	$594	5,100	$742	6,100	$891
Total Effect	**18,200**	**$2,001**	**22,700**	**$2,502**	**27,200**	**$3,002**

National impacts are provided for illustrative purposes and are approximations.

Total impacts are the sum of direct, indirect, and induced effects.

Dollars in Millions $2010. Calculations based on the MFP calculations for value added previously presented.

National impacts based on GDP data from Bureau of Economic Analysis.

Table 30. Direct national economic role of U.S. airports to the national economy.

Activity	Employment	Labor Income	Output	Value Added
Economic Impact of NPIAS Airports	2,172,200	$147,642	$637,002	$247,424
Changes in Economic Impacts Generated by				
1% Improvement of Connectivity Variables	13,000	$795	$3,043	$1,507
1% Increase of Air Cargo Tonnage	5,100	$403	$2,103	$742
1% Decrease in Air Fares	1,400	$162	$553	$249

All dollars are in $2010 millions. Jobs are rounded to the nearest hundred.

Table 31. Total national economic role of U.S. airports to the national economy including direct, indirect, and induced effects.

Activity	Employment	Labor Income	Output	Value Added
Economic Impact of NPIAS Airports	7,628,900	$452,506	$1,597,458	$768,402
Changes in Economic Impacts Generated by:				
1% Improvement of Connectivity Variables	38,900	$2,272	$7,417	$3,979
1% Increase of Air Cargo Tonnage	22,700	$1,377	$5,402	$2,502
1% Decrease in Air Fares	5,800	$385	$1,281	$657

All dollars are in $2010 millions. Jobs are rounded to the nearest hundred. National impacts for MFP analysis are approximations for illustrative purposes.

CHAPTER 9

Future Research

Data that support the estimation of the overall national economic impact of airports, multifactor productivity, and consumer surplus will tend to become obsolete over time, to varying degrees, because of changes in the economy, changes in technology, and new research findings. While the overall framework may remain applicable, future research will be necessary to both update and enhance the factors shown in this report. In addition, future research may help to refine and establish the robustness of the values used in this study.

9.1 Economic Contributions of U.S. Airports to the National Economy

The economic impact studies reviewed for ACRP Project 03-28 were over a 2005–2011 time frame (the regression analysis was limited to 2006–2011). Also, the studies reviewed were highly diverse regarding methodologies and economic elements counted and reported. This project benefitted by having three firms on the research team (EDR Group, ICF SH&E, and Mead & Hunt) that each had a library of previous studies they and others had conducted. However, in addition, the team was aware of many other studies (and particularly the underlying data associated with those studies) that were not obtainable for this research effort. This is particularly true for large hub airports—where studies are often conducted independently of state system economic impact studies. A future research project could develop a method to establish a repository for the timely collection of research data or technical appendices that underlie airport economic impact studies. In addition to the issues of funding and maintaining such a repository, an important consideration in creating such a repository is that many of these studies are consultant work products and/or the property of the project sponsors. Therefore, the project sponsors and their consultants will need to be confident of the neutrality of the administration of the repository and the confidentiality of the source data in the repository, as well as appropriate use of data aggregation.

To improve tools used to estimate the economic contributions of airports to off-airport industries in their vicinity, a potentially valuable research project would be a study of the value of international air cargo flows of imports and exports to the national economy, as noted below:

- Imports: While a portion of imports are consumer goods, imports are widely used in production processes by U.S. industries. There is a need to avoid double counting, as some of the intermediate goods are turned around and exported as finished products with relatively little value added, whereas others have significant value added. Economic contributions of air imports are positive if: (1) intermediate commodities allow U.S. industries to manufacture products that otherwise would not be developed in the U.S. and (2) imported goods for final sale allow households and firms to purchase more local goods and services than would be possible without lower cost imports. However, these positive economic contributions must be balanced against potentially negative impacts if imports displace U.S. production.
- Exports: Well-established methodologies are available to estimate economic benefits derived from the export of commodities through airports. Research is needed to develop more accurate estimates of the impact of airports by integrating mode choices available to shippers, understanding that mode choice is more important for domestic goods, for which truck and air modes could be substituted, rather than international exports,[36] other than shipments to Canada or Mexico.
- Another research topic suggested by the findings of this study is to estimate the value of international business travel. In part, the productivity effects of business travel are incorporated in the MFP. However, as airports enable air cargo shipments in international markets, airports also enable business travel to attract and service international customers. The

danger of double counting between the economic benefits of air cargo and air travel is that business travel often leads to merchandise sales. Therefore, care is necessary to avoid double counting the impacts of business travel and cargo exports. Further research is needed to break out business travel for service sectors from goods-producing sectors of the national economy. As technology evolves, the contribution of aviation to the service sector will change. In this context, an important distinction must be made between domestic and international travel. Domestic travel is typically more business-oriented than international travel, although, this varies by market.[37] Therefore, the way in which international connections are considered in the analysis must reflect these differences.

9.2 Multifactor Productivity

An important future research effort should focus on the linkages between enhancements in air service connectivity and changes in productivity. The research undertaken in this project has established a statistical relationship, but it has not established why this occurs. Future research could explore linkages between connectivity and changes in productivity to further our understanding of why some industries' productivity appears more affected by one connectivity measure and not others. This research would require a greater emphasis on modeling the relationships, rather than just undertaking a statistical investigation.

The MFP analysis reported here is based on 11 industry sectors represented by two-digit NAICS codes, 20 metropolitan regions (encompassing 26 commercial airports), and the discrete years 1995, 2000, 2005, and 2010, which span a period that included years of economic expansion and two recessions, but does not include any of the recession years. However, the MFP analysis estimates of the productivity impacts of connectivity changes for U.S. airports would be more robust if a future research project incorporates a continuous time series of data and more detailed economic data for at least three-digit NAICS codes (89 sectors, although many are not sensitive to airport connectivity). A three-digit approach would allow for a finer differentiation between productivity related to cargo and productivity generated by passenger connectivity. In addition, the sample of MSAs and, therefore, airports could be enlarged to provide a more comprehensive sample of the U.S. economy. Lastly, research could be undertaken to determine whether GA airports (at least large GA facilities) can be usefully incorporated into the MFP framework.

More generally, further research should be conducted to better understand and quantify the economic contribution of air cargo and, specifically, what actions airport operators can take to enhance an air cargo analysis. The current research project has explored the relationship between air cargo activity at airports in a sample of metropolitan regions and changes in productivity in selected industry sectors in those regions. However, it is unclear whether the changes in air cargo activity are the cause or effect of changes in productivity.

The level of air cargo activity is the result of shipping decisions by a wide range of economic actors, including producers, integrators, and third party logistics firms that are independent of integrators. Shipping decisions made by these firms depend on logistics costs, including the value of time service levels of the air cargo industry in relation to the competing service levels offered by other modes (in some cases the same firms provide alternative services by different modes). Therefore, it is necessary to develop an improved understanding of the economic consequences of changing service levels on competing modes and how decisions by airport operators can influence the service levels offered by the air cargo industry (e.g., by improving air cargo handling facilities at the airport or truck access to those facilities).

A major difficulty in performing research on the economic effects of air cargo, which constrained the research undertaken as part of this project, is the absence of publicly available data on domestic air cargo shipment patterns that are analogous to the O&D data available for air passenger trips or data on domestic air cargo shipments by industry sector. Data from the Freight Analysis Framework (FAF) and the Commodity Flow Survey (the survey on which FAF is based) provides country-to-country flows and modes, but not by specific points of where one mode begins and another ends.[38] For example, a commodity originating in Jacksonville, FL might be transported by air to a destination in Springfield, MO. But, through FAF, it is not known if the commodity that flew from Jacksonville International Airport was trucked to Tampa from Miami International Airport or Hartsfield-Jackson Atlanta International Airport, or if it landed in Springfield-Branson National Airport or Lambert-St. Louis International Airport. The preceding are examples, as many more airport pairs are conceivable from the data. Therefore, a major focus of future research should be the integration of existing data on air cargo activity that is currently available, and the development and administration of surveys to begin to assemble the missing data on a regional or national basis.

9.3 Consumer Surplus

The consumer surplus analysis incorporated data from air passenger surveys to differentiate business and personal travel. The airport survey data were critical to estimate the number of trips by purpose (business or personal) in each O&D market. The analysis relied on seven surveys covering 10 airports. These survey results were obtained through personal contacts of the research team. The consumer surplus analysis would be enhanced by incorporating the findings from more air passenger surveys. A rich data set that might be explored is the Airport Service Quality Survey conducted at more than 40 airports each quarter by ACI-NA. In addition, passenger survey data are collected for most commercial airports. A future project could include collecting the findings of these surveys in one location to enable use for future research. However, the issue of confidentiality and reluctance of survey sponsors to part with detailed survey data is a major constraint.

Future research could also improve the analysis of consumer surplus undertaken in the current project. It could focus on several aspects: (1) expanding the number of markets considered in the analysis, particularly international markets, in order to provide a more representative sample of U.S. air travel; (2) refining the air travel demand elasticity values used in the analysis; (3) distinguishing between inbound and outbound international travel, in the same way that the analysis of domestic travel considered the directional travel in each O&D market; and (4) refining the trip purpose estimates for international travel. The analysis performed in the current project assumes a constant demand elasticity for each market, distinguishing only between short-haul and long-haul domestic markets (with long-haul markets defined as those over 1,500 miles), and a separate demand elasticity of international trips. These values were based on a review of the literature on past studies and represent the median value found in the range of estimates given in the relatively small number of studies identified in the literature. Unfortunately, there have not been many studies that give comparable estimates of air travel demand elasticity. Therefore, it would be useful to undertake a more comprehensive air travel demand analysis with an objective to better understanding how air travel demand elasticity varies with market characteristics.

The data delineating business and personal trip purpose for international travel was obtained from a fairly large survey of overseas air travelers to and from the United States, conducted on an ongoing basis each year for the OTTI of the U.S. Department of Commerce. However, the tabulations of the survey results do not show the trip purpose split for individual airport-pair markets, but rather by country of origin or destination (and only for a few selected destination countries in the case of U.S. residents, with other countries grouped into world regions) and port of entry (but only for visitors to the U.S. and only for the major ports of entry, and not by country of origin). In general, more detailed tabulations would not be supported by the sample size; although, more customized analysis is available for a fee. Furthermore, the survey does not include travelers to or from Canada and Mexico (which are not classified as "overseas" by the OTTI). However, data on trip purpose of international travelers in specific markets (at least at the level of country of destination) is available from air passenger surveys conducted from time to time at the gateway airports. Therefore, it would be possible to integrate data from multiple surveys to obtain a better understanding of the trip purpose split in the international markets used in the consumer surplus analysis.

9.4 Modeling

An additional research topic is to integrate investments in air transportation into general equilibrium models and demand-response analyses. These tasks are particularly worthwhile if fees to air travelers or prices charged by airlines rise, and instead of consumers having more money from consumer surplus, airlines and airports have more money to invest in aircraft, air transportation support, and airport facilities. Benefits from increased fees or ticket prices to fund investments in airports will generally play out over time on-airport and off-airport, and may attract more travelers due to better facilities or more convenient services, even if prices rise. A CGE model can estimate impacts played out in the economy over time as additional construction is implemented, aircraft and other equipment is purchased and operated (and older equipment is retired), and additional operating funds are expended. However, it should be noted that demand-response is not part of CGE model, and estimates of new passenger attraction would have to be estimated separately and then integrated into the model.

CHAPTER 10

Conclusions

The objective of ACRP Project 03-28 is to measure the economic impact of U.S. public use airports and the national airport system ("airports") in the national economy. It can be used to educate communities and aviation stakeholders on the national value of airports.

The four approaches used are complementary in understanding the economic importance of airports to the national economy. The standard approach of estimating the impact of airports through a tabulation of on-airport and visitor spending activities is a snapshot of the economic contribution of airports at a given moment based on when data are collected.[39] The three catalytic MFP/consumer surplus approaches account for how national economic impacts of airports will change if connectivity between airports and regions, air cargo tonnage (not including modal substitution), and/or the cost of air travel change.

10.1 Static Economic Impact Analysis

The national direct economic impact of airports, estimated using national data sets, accounts for $637 billion of direct output, which includes $247 billion of value added and supports 2.2 million direct jobs. Including multiplier effects (direct and induced impacts), the contribution of U.S. airports to the national economy totals $1.6 trillion in output (business sales), almost $800 billion in value added, and 7.6 million jobs. Overall, U.S. airports account for 5.1% of the national GDP and 4.3% of the national job base.

These impacts were partly validated by the regression analysis developed from the NPIAS database and airport economic impact studies that were reviewed. On-airport direct economic output is estimated at $198 billion (in 2010 dollars) across the NPIAS airports from the four regression models, which is similar to the $195 billion (in 2010 dollars) on-airport direct output that is calculated by aggregating national databases (excluding international visitor spending and international cargo contributions). Moreover, the total contributions to U.S. GDP from on-airport activities (including indirect and induced effects) are estimated at $242 million from the national data sets and $261 million from the regression analysis.

These impacts are also in line with recent national studies conducted by public agencies and private organizations (see Table 32). It is important to note that each study addressed different aspects of the economic impacts of aviation. This study is the only analysis that is limited to the economic effects of U.S. public airports on the national economy. Other national studies include aircraft and parts manufacturing, and effects of domestic air cargo and domestic visitor spending, all of which were explicitly not counted in this study.

In addition to quantifying the current economic impact of U.S. airports, the research team investigated how changes in airports will affect the U.S. economy. Specifically, research was conducted on U.S. productivity if air connectivity factors change among domestic airports or between domestic and international airports (MFP); the interrelationships of economic productivity and air cargo (MFP); and economic impacts triggered by changes in airline ticket prices (consumer surplus).

10.2 Catalytic Role of Airports

The MFP research has generated a useful start and identified the relative importance of different connectivity variables. It has also shown how the importance of the variables differ across industries. However, the sample used was limited to 20 MSAs and to 11 industries and to four discrete analysis years (1995, 2000, 2005, and 2010). Given the aggregation to major industry sectors, the estimated elasticities should be seen as representative and are not constant among all industries within each sector. The results present a first step in understanding how changes in air service connectivity influence productivity in different sectors of the economy. However, more work is needed to refine and extend these results

Table 32. Comparison of economic impacts to those of other national level studies (dollars in millions).

Study	Metric	Direct	Total	Notes
ACI–NA 2013	Jobs	5,305,350	9,596,340	Includes local/regional and national visitor spending impacts
	Payroll	$167.6	$357.9	
	Value Added			
	Output	$496.8	$1,135.2	
Global Insight 2002	Jobs	4,234,000	11,248,000	Includes aircraft and parts manufacturing
	Payroll			
	Value Added	$343.4	$903.5	
	Output			
FAA 2012	Jobs		11,790,000	Includes aircraft and parts manufacturing, and domestic and international cargo & visitor spending
	Payroll		$459.4	
	Value Added		$847.1	
	Output		$1,533.8	
ACRP Project 02-28 2011-2012	Jobs	2,172,200	7,628,900	Limited to contributions to the national economy
	Payroll	$147.6	$452.5	
	Value Added	$247.4	$768.4	
	Output	$637.4	$1,597.5	

using a more complete set of time series data covering the intermediate years. This will more fully account for temporal trends in other factors that may have influenced productivity, and could also include a finer disaggregation of industries within each sector to test the robustness of the results.

These catalytic impacts should be seen as first steps that have yielded initial estimates. It is important to emphasize that the investigations conducted as part of this research are initial steps in understanding how changes at airports could generate national productivity effects, measured by industry or in aggregate. More work is needed using a larger set of data to test the robustness of the results. In particular, the exploration into the MFP effects for U.S. airports demonstrates that the network of airports and air cargo services stimulate robust economic impacts throughout the nation and significantly add to national productivity, with less pronounced impacts from similar changes in consumer surplus accumulated by personal travelers. Impacts to the national economy that are reported by the research team are based on presumed changes in connectivity, cargo tonnage, and airfare pricing.

Different assumptions will lead to different results. However, these are not linear measures. So, a 5% connectivity improvement on a given connectivity variable, air tonnage moved, or airfare price reduction will not lead to precisely five times the impacts demonstrated in this report. Different assumptions could be made for each of the various significant connectivity variables. Similarly, future research in cargo effects could stratify tonnage by type of airport (e.g., different primary and GA airports) or cross tabulate with type of cargo service (e.g., belly cargo, integrators, and other cargo-only aircraft). Moreover, decreases in connectivity, air tonnage, and increased airfares will lead to negative effects in the U.S. economy.

End Notes

1. The National Plan of Integrated Airport Systems of the Federal Aviation Administration identifies airports significant to national air transportation. The 3,330 NPIAS airports account for about 65% of U.S. public use airports; 17% of all airports, including those privately used; and 99.8% of all enplanements in 2012 Report to Congress: National Plan of Integrated Airport Systems (NPIAS), 2015–2019, p.76; Office of Airport Planning and Programming, Federal Aviation Administration September 2014; and NPIAS 2013–2017 (September 2012).
2. Connectivity in the context of the analyses undertaken for this study refers to air-connections between regions and international destinations. Table 17 in Chapter 5 lists the different air connectivity variables used in this study. Briefly, the 11 connectivity changes address combinations of increasing the number of nonstop destinations, frequencies of nonstop destinations to specific markets, and the GDP of markets served.
3. While these are positive changes, impacts could also be based on negative effects (reduced connectivity, reduced production and transport of commodities shipped by air cargo, and increased ticket prices).
4. Report to Congress: National Plan of Integrated Airport Systems (NPIAS), 2013–2017; Office of Airport Planning and Programming, Federal Aviation Administration September 2012.
5. The issue is not lack of an air network since, at this point in the development of aviation, most everyone has access to an air network of some sort. Rather, the issue is how well that network meets the needs of its users.
6. Unlike visitor spending, which includes flows of dollars brought into the nation by international visitors and taken overseas by U.S. travelers, air cargo impacts represent economic gains in the national economy, and therefore are not subtracted from the value of air cargo imported to the United States.
7. Definition of value added is drawn from the U.S. Bureau of Economic Analysis.
8. Impacts below represent total contributions to GDP from direct, indirect, and induced economic effects.
9. For aviation, a bilateral agreement between two nations allows international commercial air transportation to operate between the two countries.
10. Input-Output modeling tracks the relationships between the industries of an economy estimating the scale of what each industry sells to other industries and what each industry buys from other industries. This includes what industries sell to households, and what is purchased from industries by households. The circulation of dollars from these purchases and sales is how multiplier effects are generated.
11. In many studies, multiple years of capital expenditures are averaged to avoid year-to-year fluctuations.
12. Alternately, the research team could apply the Producer Price Index to industry measures (such as output). However, given that these studies are within the past 10 years, and most are within five years, a general inflation index as provided by CPI is acceptable.
13. These are the largest NPIAS classifications for commercial airports. In the United States, 499 airports are classified as "Commercial," including 29 large hub airports and 36 medium hub airports.
14. Including 434 commercial airports not classified as large or medium hubs, reliever airports, or general aviation airports.
15. The six sources are: County Business Patterns (U.S. Census Bureau); Moody's, Inc.; IMPLAN LLC (private aggregators and vendors of public data); the Bureau of Economic Analysis (U.S. Department of Commerce); the Bureau of Labor Statistics' Current Employment Statistics; and Bureau of Labor Statistics' Quarterly Census of Employment and Wages (U.S. Department of Labor).
16. On-airport visitor spending is captured in the analysis of terminal concessions. Also, on-airport cargo handling services are included in NAICS 4881, Support Activities for Air Transportation. Cargo flights are reported in NAICS 481112 and 481212, Scheduled Freight Air Transportation and Nonscheduled Chartered Freight Air Transportation, respectively.
17. It is understood that employees of commercial airports will eat lunch or otherwise spend some of their income in the terminal. As a result, the induced impacts of airport workers may be slightly overstated in this analysis.
18. International visitor spending counted in this report is the difference of spending by visitors to the United States minus the spending of U.S. residents visiting international destinations.
19. Moreover, study data often predates publication dates by 1–2 years.
20. This comparison is for on-airport impacts, and thus does not include impacts relating to international visitor spending or international cargo.
21. Dummy variables are used to distinguish years. For example, Dummy 1995 means this variable is coded 1 for all data that is 1995 data and is coded 0 for all other data.
22. Elasticity is a measure of the sensitivity of change between two variables—how much the quantity of one variable will change if another variable changes.
23. The one-percent change is evaluated at the mean of the variable.
24. The IMPLAN model was used for this analysis.

25. Due to the difference in industries that are affected, a one-percent increase in the percent of the world's GDP served by "two or more daily flights" account for more output ($232 million) than destinations with "five or more daily nonstop domestic flights" ($168 million).
26. Output is primarily the aggregate value of business sales, budget expenditures (for public and nonprofit entities), produced but unsold inventory, breakage, and spoilage (for perishable products).
27. The research team used the 2012 IMPLAN national model, adjusted to 2010 dollars. Output for the manufacturing and wholesale sectors were calculated separately, using the ratio "output/value added." Output is primarily business sales, but also includes value of inventory, damaged products, and spoilage.
28. An airport-pair market is defined as the air travel between two airports, and is bi-directional. For example, the airport-pair market of JFK-LAX (between New York Kennedy International Airport and Los Angeles International Airport) included passengers boarding in New York and landing in Los Angeles, and those boarding in Los Angeles and landing in New York.
29. In the research team's calculations, the change in consumer surplus of the induced air travelers varies with the change in fare.
30. The consumer surplus of induced travelers may also include the added consumer surplus of existing travelers who decided to increase the amount they traveled due to lower prices.
31. A welfare benefit is derived from individuals' consumption of goods and services. In this regard, the total benefit from a 1% drop in airfares is $991 million, of which a portion is income not spent on air travel and available for other household spending or investing.
32. This is due to the demand elasticity for international trips (−1.04) being quite close to −1.0. An elasticity of 1.0 implies that a given percentage change in airfare produces the same percentage increase in travel, with no change in the total spending on air travel.
33. Note that direct income is disproportional to direct jobs. This is the result of comparing the impact of two different ways that households can spend income: air travel and other goods and services. The research team determined the economic impacts of the consumer surplus generated by a 1% reduction in airfares by summing the two modeling approaches. First, the $991 million paid for induced air travel due to the lower fares are considered to be dollars diverted from the general economy to air transportation. This switch in spending produces a negative economic effect because, as noted in Table 25, the impacts of the purchase of air transportation services is less than the impacts of the equivalent amount of general household spending. Second, the $815 million of consumer surplus is recognized as money that travelers are able to spend on goods and services—this is, in effect, money left over "in their pockets." The net impact of the additional consumer surplus is derived from adding the money diverted from household spending to air travel (which is negative) to the impacts of spending $815 million on goods and services other than air transportation (which is positive).

    In Table 25, labor income per worker in air transportation is almost twice that in sectors related to general household spending. But, labor intensity (jobs per dollar of spending) is almost 2.7 times greater in the general bundle of household spending than for air transportation services. Thus in the aggregate, labor income accounts for $0.22 of every dollar of spending on air transportation and $0.30 of every dollar on general household spending. These results represent overall differences in the national economy effects reflected by the spending substitution. In this analysis, more dollars are being transferred from the bundle of general household spending to air transportations than are spent on general goods and services.
34. The reason is often customer driven. One example is a manufacturer of off-shore oil drilling equipment shipping parts by air to fix a damaged oil ring. The reason for the air shipment is that the money lost daily due to a malfunctioning rig dwarfs the cost by air transportation.
35. Source: BEA National Product Accounts. The national GDP in 2010 was $15 trillion, and the portion in the 20 MSAs was a combined $3.5 trillion, or 23.3% of the national total.
36. The profile of commodities shipped by marine mode is very different than the profile of air cargo.
37. This observation is based on surveys analyzed for the consumer surplus analysis. Please see Appendix 2 and Appendix 2A for details.
38. The Freight Analysis Framework is administered by the Federal Highway Administration of the U.S. Department of Transportation.
39. In the case of the Task 7 analysis, the data sets range from 2011 to 2013, and the economic impact studies used for the regression formulae were conducted from 2006 to 2012.

Glossary

Term/Definition

Adjusted R^2/"Best Fit" Adjusted R^2 indicates the amount of variation of the dependent variable that can be explained by the independent variable(s) where the adjustment is the number of right hand side variables used. The highest adjusted R^2 among regression multiple regression analyses using different selections/combinations of independent variables to explain the same dependent variable is often referred to as "the best fit." (Please see the definition for OLS.)

Airfare The amount paid by an air passenger for a one-way nonstop ticket, inclusive of fees and taxes. For the consumer surplus portion of this study, airfares were analyzed for personal travel between U.S. airports and between U.S. airports to international destinations.

Catalytic (Dynamic) These terms are used to indicate when changes in the airport network (i.e., change of connections between airports, amount of air cargo served, and cost of airfare) affect the U.S. economy.

Coefficients In the results of a regression analysis, (one or more) coefficients are numbers used to multiply (one or more) significant independent variables to explain variations for a dependent variable. For example, if "airport output" is a dependent variable, and "length of runway" is a significant independent variable used to explain variation in airport revenues, then the coefficient is a way to interpret the magnitude of the effect of "length of runway" on-airport output.

Confidence Level Confidence is defined in terms of the likelihood the outcome being predicted will occur. It measures how well the variables used explain the variation in the data. For example a 95% confidence level means 95 of 100 times the dependent variable being measured (the dependent variable) can be explained by the independent variables used (the data elements that are being used to explain the differences in the dependent variable across all observations).

Connectivity (this is the basis of the multifactor productivity analysis) Connectivity refers to the total resource costs in time and out-of-pocket expenditure to move between two places. The connectivity analysis estimates the economic impacts by industry sector of cost changes due to changes in connectivity. This study looked at types of connectivity changes among 20 U.S. regions (hosting 26 commercial airports) and of connections between those regions and 15 international markets (15 airports in Europe and Asia).

Consumer Surplus (CS) CS is the difference between what consumers are willing to pay for a good or service and what they actually pay. In the context of air service, the difference in willingness to pay for air service and what is actually spent leaves money in households' "wallets," and is available to be spent in the general economy on non-aviation goods and services.

Direct Effects The terminology around direct and multiplier effects are not uniform across studies. Defined in this study: direct effects take place in the industry immediately affected, whether it is on or off airport. These include on-airport activities, spending by air visitors off-airport, and the production of air cargo.

Dummy Variable A dummy variable is used in regression analysis to control for the influence of subgroups of a sample in a study. Dummy variables are categorical, meaning they take one of two values, e.g., gender. In this study, dummy variables were used to separate the influence of each year (1995, 2000, 2005, and 2010) on the value of MFP. There are likely factors that occur in a given year that affect the value of MFP (the dependent variable) but are not captured by any of the explanatory variables. Therefore, for example, Dummy 1995 means this variable is coded 1 for all data that is 1995 data and is coded 0 for all other data. The coefficient estimated for this dummy variable will represent the shift up (if it is positive) or down (if the coefficient is negative) of the value of MFP. The dummy variables act as a control so the influence of the connectivity variables on MFP is not biased upward or downward.

Economic Footprint (Standard or Static Economic Analysis) This is a portrait of the economic impact of one or more airports for one point in time. These studies generally measure jobs, labor income, value added, and business sales (total output) generated by: airport administration; businesses and government agencies on-airport; on-airport construction spending; off-airport spending by visiting passengers; and, at times, the contribution to industry by providing air cargo services, and the impact of off-airport aeronautical industries. In its simplest meaning it is the breadth of effect, in this study it is the extent of the effect of airports on the economy.

Economic Impacts Economic impacts are effects on the level of economic activity in a given region, or in the case of this research, in this study it is the contribution of airports to the level of economic activity in the U.S. Economic impacts are shown as (1) jobs; (2) business output (essentially business sales and expenditures by public agencies); (3) labor income; and (4) value added (or GDP).

Elasticity (or Elasticities) Elasticity is a measure of the degree of sensitivity of change between two variables; how much the quantity of one variable will change if another variable changes. Price elasticity of demand is used in the consumer surplus (airfare) analysis to measure how the quantity demanded changes with price. Also, for example, elasticities associated with air service are used in the MFP analysis to show how value added of industries change if the quantity of nonstop flights, for example, changes.

Empirical Model An empirical model attempts to verify assumptions and convert qualitative hypothesis into metric outcomes. In this study, connectivity among regions is hypothesized to yield economic benefits. The empirical model was developed to test whether the data would support the hypothesis.

Hub Airports (Hubs) Colloquially, hubs are airports where passengers transfer from one airplane to another to reach their intended destination. By the FAA's formal definition, a hub airport accounts for at least 0.05% of national passenger boardings. Large hubs account for at least 1% of all boarding; medium hubs account for at least 0.25%, but less than 1% of boardings; and small hubs account for at least 0.05% and less than 0.25% of boardings.

Indirect and Induced Multiplier Effects The terminology around direct and multiplier effects is not uniform across studies. Defined in this study: multiplier impacts are made up of indirect and induced effects. Indirect effects measure the purchase of supplies and services needed to produce directly supplied products and services. Induced effects measure the effects of the changes in household income, meaning the effects from the spending of wages earned by workers of directly and indirectly affected industries. Total impact is the summation of direct and multiplier (indirect and induced) effects.

Input-output I-O tracks the relationships between the industries of an economy estimating the scale of what each industry sells to other industries and what each industry buys from other industries. This includes what industries sell to households, and what is purchased from industries by households. The circulation of dollars from these purchases and sales is how multiplier effects are generated.

Intermediate Commodities Intermediate commodities are imports that are used as part of a U.S. company's production process, such as imported fabric used by furniture makers. They are not sold as final goods or services.

Labor Income (gross) Labor income includes total compensation for work, including gross wages, salaries, proprietor income, employer provided benefits, and taxes paid to governments on behalf of employees.

Log-linear Format Log-linear format is a type of specification of a relationship between variables. It explicitly restricts (or assumes) the relationship between two or more variables is linear in the logarithmic values of the variables. The notation Ln is used to indicate that model results presented are from a log-linear model format.

Metropolitan Statistical Area (MSA) MSAs are geographic entities delineated by the Office of Management and Budget (OMB) for use by federal statistical agencies in collecting, tabulating, and publishing federal statistics. An MSA contains a core urban area of 50,000 or more population. Each MSA consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties that have a high degree of social and economic integration (as measured by commuting to work) with the urban core.

Multifactor Productivity (MFP) MFP estimates the growth in GDP in reaction to changes of all inputs into production processes. In this study, the research team estimated growth in net value added from: (1) strengthening nonstop connectivity among airports; and (2) increased use of air cargo by industries (net additional cargo, not modal shifts).

NAICS (North American Industrial Classification System) NAICS is the means used by federal statistical agencies to classify business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS is organized by sectors and each sector is numbered. The specificity of a sector is analogous to the number of "digits" represented by that sector. For example, Sector 48–49 (considered a two-digit sector) is Transportation and Warehousing; Sector 481 is Air Transportation; and Sector 4811 is Scheduled Passenger Transportation.

National Economic Impact As used in this study, national economic impact is a measure of the importance of airports in sustaining and expanding the national economy. This includes aviation, passenger services in terminals, and administrative/operations activities required to maintain airports facilities and/or services. It also includes the role of airports in expanding hospitality industries by facilitating travel by international residents to the United States and by enabling U.S.-based businesses to export goods and services to international customers. It does not include recirculating sales from one region in the U.S. to another.

NPIAS (National Plan of Integrated Airport Systems) The NPIAS identifies existing and proposed airports that are significant to national air transportation and thus eligible to receive federal grants under the Airport Improvement Program (AIP). It also includes estimates of the amount of AIP money needed to fund infrastructure development projects that will bring these airports up to current design standards and add capacity to congested airports. The FAA is required to provide Congress with a 5-year estimate of AIP eligible development every 2 years. The NPIAS contains all commercial service airports, all reliever airports, and selected GA airports.

On-airport Activities occurring on an airport. These activities broadly include airside activities, terminal services to passengers (including concessions), air-related services by government agencies, construction, and airport administration.

Ordinary Least Squares (OLS) OLS is a statistical method of estimating a "best" statistical relationship between observed sets of data by minimizing the sum of squared deviations between observed and expected values. For example, when trying to look at the economic impact for 3,330 airports and having economic impact studies for 1,000 airports, the 1,000 airports are observed values and OLS is used to estimate expected values (economic impacts) for the remaining 2,300 airports.

Output Value added plus the cost of its intermediate inputs (including energy, raw materials, semi-finished goods, and services that are purchased from all sources). This is largely the value of sales or receipts and other operating income along with any inventory change.

P-Value The p-value for each term tests the hypothesis that the coefficient has no effect. A predictor that has a low p-value (< 0.05) is likely to be meaningful because changes in the predictor's value are related to changes in the independent variable.

Productivity Productivity is a measure of the efficiency of how well output is produced. It is an economic measure of output per unit of input. Inputs include labor and capital, while output is typically measured in revenues and other GDP component. In the MFP portion of this study, inputs are changes in regional and international connectivity through airports and the output measured is value added by industry.

Regression Model Regression modeling is a statistical technique used to investigate relationships between one variable (called the dependent variable) and one or more other variables (independent variables). The intent is to ascertain the type and magnitude of effect of one variable upon another.

Standard Deviation Standard deviation is a measure of the extent that a series of numbers are spread out from the mean average of the series, which is essentially how spread out numbers are.

Statistically Significant Statistical significance is a measure of the likelihood that a result or relationship is caused by something other than mere random chance. In regression analysis, statistical hypothesis testing is traditionally employed to determine if a result, an estimated coefficient, is statistically significant or not. Statistical significance is generally measured at the 99, 95, and 90 percent level of confidence.

Value Added/GDP The value added of a company or an industry consist of compensation of employees, taxes paid on production and imports, and gross operating surplus. Value added equals the difference between an industry's gross output and the cost of its intermediate inputs. Value added for companies across industries and across the United States is a measure of GDP.

Visitor Spending In this study, "visitor spending" is defined as off-airport spending by international visitors who arrive by air to the United States. Other studies may define visitor spending as international and domestic inter-regional visitors who spending money in the United States or in a specified region. Still other studies include passenger spending in terminals, although this requires care not to double count the impacts of airport terminals. Typical spending categories are retail purchases, food and drink, entertainment, lodging, and off-airport transportation services (or may include car rental services on-airport). Generally, a visitor is considered someone is resides outside of the geographic area that is being studied.

Welfare Benefit In the context of this study, welfare benefits are benefits derived by individuals from the consumption of good and services and are measured in dollar terms.

APPENDICES

Appendices 1 through 5 of the contractor's final report for ACRP Project 03-28 are not published here but are available on the TRB website at www.TRB.org/main/blurbs/172111.aspx. The appendices titles are the following:

Appendix 1: Multifactor Productivity
Appendix 2: Consumer Surplus
Appendix 2A: Calculations for Consumer Surplus
Appendix 3: Economic Role of U.S. Airports
Appendix 3A: NPIAS Database
Appendix 4: Qualitative Research
Appendix 5: Literature Review

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation