



**THE IMPORTANCE OF AIR TRANSPORTATION TO THE U.S.  
ECONOMY: ANALYSIS OF INDUSTRY USE AND PROXIMITY TO  
AIRPORTS**

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# **The Importance of Air Transportation to the U.S. Economy: Analysis of Industry Use and Proximity to Airports**

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## ABSTRACT

This thesis investigates broader impacts of air transportation on U.S. economic productivity, as well as market access and business location, in order to help identify how aviation supports the national economy. More traditional economic impacts are reviewed before turning to enabling impacts. Mechanisms by which air transportation might enhance economic productivity are proposed and a production model is constructed as a framework for exploring the validity of these mechanisms. Two analyses are conducted which should provide new insights to the FAA on the importance of air transportation to the U.S. economy. Focusing on the demand side of the economy, a detailed analysis of input-output (I-O) data from the Bureau of Economic Analysis (BEA) identifies where air transportation appears to be especially critical to economic production. On the supply side, U.S. Census Bureau data is used to map distributions of population, business establishments, and Fortune 500 headquarters from hub airports. Additional distribution analyses are performed for cargo airports and for select metropolitan areas. Analyses of intermediate use of air transportation provide weaker evidence than initially hypothesized as to aviation's role in supporting productivity growth. Both sets of analyses confirm that the importance of air transportation to industry is not uniform and that the government and services sectors appear to benefit from and take advantage of access to aviation more than other industry sectors. In particular, the analyses of business location relative to airports provide evidence that many service and high-value economic sectors are more concentrated near hub airports than are other industry sectors for which air transportation adds less value.



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# TABLE OF CONTENTS

<b>CHAPTER 1: INTRODUCTION .....</b>	<b>13</b>
<b>1.1 Traditional Economic Impacts.....</b>	<b>14</b>
1.1.1 Direct Impacts.....	14
1.1.2 Indirect Impacts.....	15
1.1.3 Induced Impacts .....	15
<b>1.2 Enabling Impacts.....</b>	<b>16</b>
<b>1.3 Stakeholder Identification.....</b>	<b>18</b>
<b>1.4 Thesis Organization .....</b>	<b>19</b>
<b>CHAPTER 2: PRODUCTIVITY-IMPROVING MECHANISMS.....</b>	<b>21</b>
<b>2.1 Productivity Definitions .....</b>	<b>22</b>
<b>2.2 Productivity Mechanisms .....</b>	<b>23</b>
2.2.1 Comparative Advantage.....	24
2.2.2 Economies of Scale.....	24
2.2.3 Logistics Improvements.....	24
2.2.4 Location Choice .....	25
2.2.5 Face-to-Face Communication.....	25
<b>2.3 Air Transportation in Production.....</b>	<b>26</b>
<b>CHAPTER 3: ANALYSIS OF INTERMEDIATE USE OF AIR TRANSPORTATION ..</b>	<b>31</b>
<b>3.1 NAICS and I-O Correspondence .....</b>	<b>31</b>
<b>3.2 Air Transportation Use and Economic Trends.....</b>	<b>32</b>
<b>3.3 Intermediate Use Trends.....</b>	<b>33</b>
3.3.1 Intermediate Use Ranking by Value.....	34
3.3.2 Intermediate Use Ranking by Normalized Value.....	35
3.3.3 Intermediate Use Top User Trends.....	36
3.3.4 Intermediate Use Top User Trends.....	37
<b>3.4 Intermediate Use and Labor Productivity .....</b>	<b>38</b>
<b>3.5 Modal Distributions of Intermediate Inputs .....</b>	<b>41</b>
<b>3.6 Summary of Intermediate Use Findings .....</b>	<b>45</b>

<b>CHAPTER 4: ANALYSIS OF THE RELATIONSHIP BETWEEN INDUSTRY LOCATION AND AIRPORT PROXIMITY .....</b>	<b>47</b>
4.1 U.S. Airport Coverage .....	48
4.2 Population Distribution.....	51
4.3 Establishment Distributions .....	56
4.4 Fortune 500 Headquarters Distribution.....	67
4.5 Distributions From Cargo Airports.....	69
4.6 Metropolitan Area Distributions .....	70
4.7 Summary of Industry Location Findings .....	74
 <b>CHAPTER 5: CONCLUSIONS &amp; POLICY IMPLICATIONS.....</b>	 <b>77</b>
5.1 Research Limitations .....	79
5.1.1 Access to Establishment-Level Air Transportation Use Data .....	79
5.1.2 I-O Use Table Data Considerations.....	80
5.1.3 The Limits of Productivity .....	81
5.2 Additional Research Opportunities .....	81
5.2.1 Reconciliation of SIC and NAICS Air Transportation Use Data.....	81
5.2.2 Time Series Analysis of Industry Location Relative to Hub Airports.....	82
5.2.3 International Distributions of Industry Locations From Airports.....	82
5.2.4 Market Access Connectivity Index .....	83
 <b>APPENDIX A .....</b>	 <b>85</b>
 <b>APPENDIX B.....</b>	 <b>89</b>
 <b>APPENDIX C .....</b>	 <b>91</b>
 <b>APPENDIX D.....</b>	 <b>101</b>
 <b>APPENDIX E .....</b>	 <b>105</b>
 <b>APPENDIX F.....</b>	 <b>107</b>
 <b>REFERENCES .....</b>	 <b>109</b>

# LIST OF FIGURES

Figure 1-1: Feedback-based model of air transportation in the economy (adapted from Ishutkina & Hansman, 2009, p. 29).....	16
Figure 2-1: Example definitions of productivity .....	23
Figure 2-2: Primary uses of air transportation.....	28
Figure 2-3: Model of air transportation in the production process.....	29
Figure 3-1: Industry and air transportation indexed output, 1998-2010 .....	33
Figure 3-2: I-O use trends for air transportation.....	34
Figure 3-3: Top 10 intermediate users of air transportation .....	35
Figure 3-4: Air transportation use relative to total commodity intermediate use.....	36
Figure 3-5: Trend of top intermediate users of air transportation.....	37
Figure 3-6: Federal government air transportation outlays, 1998-2011 .....	37
Figure 3-7: Air transportation use relative to all commodity intermediate use.....	38
Figure 3-8: Example of positive correlation between air transportation use and labor productivity, Publishing Industries (except Internet) .....	39
Figure 3-9: Example of negative correlation between air transportation use and labor productivity, Computer and Electronic Product Manufacturing.....	40
Figure 3-10: Correlations of air transportation use and labor productivity.....	40
Figure 3-11: Transportation of production inputs (purchased-services) by mode .....	42
Figure 3-12: Modal share of purchased-services, Computer Systems Design and Related Services .....	43
Figure 3-13: Modal share of purchased-services, Retail Trade.....	44
Figure 4-1: U.S. hub and Commercial Service Airports.....	50
Figure 4-2: Distribution of total enplanements by number of airports.....	51
Figure 4-3: 5 mile buffers around Chicago hub airports with selected census tracts.....	53
Figure 4-4: 10 mile buffer around Chicago hub Airports with selected census tracts.....	54
Figure 4-5: 50 mile buffers around select U.S. hub airports.....	55
Figure 4-6: Distribution of population from hub airports .....	55
Figure 4-7: Sensitivity of population distribution to airport category .....	56
Figure 4-8: U.S. ZIP Code points.....	58
Figure 4-9: Distribution of establishments from hub airports.....	59
Figure 4-10: Distribution of population and establishments from hub airports .....	59
Figure 4-11: All NAICS and U.S. population distributions.....	61
Figure 4-12: Indexed gross output by major industry group (Source data: BEA, 2012b).....	66
Figure 4-13: Fortune 500 headquarters (2012) and U.S. hub airports .....	68
Figure 4-14: Fortune 500 headquarters distribution from hub airports .....	69
Figure 4-15: Comparison of all establishment distributions from hub and cargo airports .....	70
Figure 4-16: 40 mile buffer example for Louisville International Airport .....	72
Figure 4-17: Distribution of establishments from Memphis International Airport.....	73
Figure 4-18: Distribution of establishments from Louisville International Airport.....	74
Figure A-1: Intermediate use of air transportation for all I-O industry sectors.....	85
Figure A-2: Normalized intermediate use of air transportation for all I-O industry sectors .....	86
Figure A-3: Federal government air transportation outlays as percent of all transportation outlays .....	87
Figure A-4: Federal government air transportation outlays as percent of all outlays .....	87

Figure C-1: Modal share of purchased-services for Federal Reserve Banks, Credit Intermediation, and Related Activities sector.....	91
Figure C-2: Modal share of purchased-services for Information and Data Processing Services sector....	92
Figure C-3: Modal share of purchased-services for Administrative and Support Services sector.....	92
Figure C-4: Modal share of purchased-services for Ambulatory Health Care Services sector.....	93
Figure C-5: Modal share of purchased-services for Real Estate sector.....	93
Figure C-6: Modal share of purchased-services for Securities, Commodity Contracts, and Investments sector.....	94
Figure C-7: Modal share of purchased-services for Publishing Industries sector.....	94
Figure C-8: Modal share of purchased-services for Federal Government Enterprises sector.....	95
Figure C-9: Modal share of purchased-services for Food Services and Drinking Places sector.....	95
Figure C-10: Modal share of purchased-services for Broadcasting and Telecommunications sector.....	96
Figure C-11: Modal share of purchased-services for Other Services, Except Government sector.....	96
Figure C-12: Modal share of purchased-services for Miscellaneous Professional, Scientific, and Technical Services sector.....	97
Figure C-13: Modal share of purchased-services for Other Transportation and Support Activities sector.....	97
Figure C-14: Modal share of purchased-services for Wholesale Trade sector.....	98
Figure C-15: Modal share of purchased-services for Federal General Government sector.....	98
Figure C-16: Modal share of purchased-services for State and Local General Government sector.....	99
Figure C-17: Modal share of purchased-services for Truck Transportation sector.....	99
Figure C-18: Modal share of purchased-services for Oil and Gas Extraction sector.....	100
Figure E-1: Fortune 500 headquarters by Metropolitan Statistical Area (MSA).....	105
Figure F-1: Distributions of New Orleans establishments from Louis Armstrong New Orleans International Airport.....	107
Figure F-2: Distributions of Oklahoma City establishments from Will Rogers World Airport.....	108
Figure F-3: Distributions of Richmond establishments from Richmond International Airport.....	108

# LIST OF TABLES

Table 4-1: Demographically-similar U.S. metropolitan areas .....	71
Table B-1: North American Industry Classification System (NAICS) 2-digit sectors .....	89
Table D-1: U.S. large hub airports matched to Metropolitan Statistical Area (MSA) .....	101
Table D-2: U.S. medium hub airports matched to Metropolitan Statistical Area (MSA).....	102
Table D-3: U.S. small hub airports matched to Metropolitan Statistical Area (MSA), part 1 .....	103
Table D-4: U.S. small hub airports matched to Metropolitan Statistical Area (MSA), part 2 .....	104



# CHAPTER 1

## INTRODUCTION

Understanding the economic impacts of air transportation has long been a priority of policy makers, airlines, aviation authorities, economists, urban planners, and businesses. Since the dawn of the jet age in the late 1950s, aviation has transformed the economics of the United States by providing a faster and safer mode of transportation than anything that had previously existed.

This thesis presents research that continues recent efforts to quantify aviation's significance to the U.S. economy. In 2011, the Federal Aviation Administration (FAA) released an updated version of *The Economic Impact of Civil Aviation on the U.S. Economy* with an accompanying compendium of state-level economic snapshots titled, *The Economic Impact of Civil Aviation by State Map*. The 2011 FAA publications used updated statistics and a revised version of the Regional Input-Output Modeling System (RIMS II) to summarize national economic impacts of civil aviation. The reports placed particular emphasis on the more traditional economic impacts of air transportation—direct, indirect, and induced. Importantly; however, this report also introduced work by Ishutkina and Hansman on the broader, enabling impacts of air transportation (2009).

This thesis is concerned primarily with continuing to investigate these enabling impacts. As a derived demand, air transportation is heavily dependent on the rest of the economy. The question then remains, what parts of the economy are heavily dependent on air transportation? It is this central question around which this thesis is structured. In subsequent chapters, the mechanisms by which air transportation is hypothesized to impact economic productivity are explored, a detailed analysis of industry use of air transportation is conducted, and industry distributions from hub airports are examined. These analyses provide new insight into both the demand and supply sides of the enabling impact feedback loop.

In seeking an answer to this central question, there are several questions of importance to be addressed:

- What are the mechanisms by which air transportation can affect economic productivity?
- What empirical evidence is available for quantitatively analyzing these mechanisms?
- What does the data suggest about the size of these impacts?
- Who (industries, individual consumers, government, etc.) appears to have more to gain or lose due to the presence or absence of a well-functioning air transportation system?
- What are the policy implications of these research findings?

## 1.1 TRADITIONAL ECONOMIC IMPACTS

Before delving into the core of this thesis and a discussion of enabled impacts, it is important to review the more traditional economic impacts which are presented in the FAA's 2011 report. The analysis of economic impacts attributable to the investment in and management of transportation systems has long been essential for such supervisory organizations, whether governmental or otherwise. Economic impacts provide a means of communicating the effect of a program or a system to the broader public, and serve as evidence that such programs or systems are providing value to both their intended users and other stakeholders. In the case of programs which are privately funded, in whole or in part, shareholders might be interested in understanding economic impacts in order to ensure their investments are providing the intended returns.

### 1.1.1 DIRECT IMPACTS

The direct impacts of air transportation refer to changes in employment, payroll, and output made possible by aerospace manufacturing and aviation activities. Direct impacts are created by airlines (both passenger and cargo), airports, aircraft and air cargo service providers, general aviation operators, and aviation-related manufacturing (Federal Aviation Administration [FAA], 2011b, p. 19). Jobs created when an airline establishes a new hub location or adds routes requiring the employment of more flight crew and gate agents are examples of direct impacts. Likewise, direct impacts occur as the result of an airport expansion due to the need for more facilities staff, security personnel and air traffic controllers.

### 1.1.2 INDIRECT IMPACTS

Indirect impacts of air transportation stem primarily from the spending of passengers en route or upon having reached a destination via air travel. Passenger expenditures result in employment, payroll, and sales effects for numerous industries, hence the indirect nature of these impacts. Industries that experience indirect impacts of air transportation include accommodations, food and drinking establishments, arts and entertainment venues, sightseeing services, ground transportation providers, and other concessions (FAA, 2011b, p. 19). More widespread than direct impacts, indirect impacts of air transportation are generated by tourists on vacation, as well as business travelers. The accommodations industry benefits indirectly from an executive's overnight stay in a hotel on a cross-country business trip, just as the food and drinking establishments of a Super Bowl host city benefit from out-of-town visiting fans. A recent study by Mihai (2013) estimates that approximately 60% of visitors to the city of New Orleans, Louisiana for the 2013 National Football League Super Bowl arrived by air (p. 3). Given that total economic impacts of the single day event are estimated at \$480 million, the indirect impacts of air transportation as the result of this event are substantial (p. 5).

### 1.1.3 INDUCED IMPACTS

Also termed secondary impacts, induced impacts are created downstream via spending on the part of industries responsible for direct or indirect impacts. Spending by employees of these industries also is counted in induced impacts. In the FAA's 2011 economic report, secondary impacts of air transportation were estimated using the RIMS II model; direct and indirect impacts of aviation serve as the primary inputs to the model. Because spending by airlines and travelers trickles down throughout the economy and encourages other economic activities, the secondary impacts of aviation are much greater than the direct or indirect impacts. In 2009, airlines contributed \$296.6 billion in output to the economy (FAA, 2011b, p. 22). Traveler spending generated \$597 billion in output. In terms of value added, air transportation-related expenditures contributed \$728.2 billion to Gross Domestic Product (GDP), or 5.2% of the nation's GDP (p. 25).

# 1.2 ENABLING IMPACTS

Beyond the more traditional direct, indirect, and induced impacts, enabling impacts of air transportation refer to the benefits and opportunities gained from access to markets, people, capital, and services afforded by aviation. Enabling impacts are the focus of this thesis. As depicted in Figure 1-1, enabling impacts drive greater economic activity, creating the potential for productivity and quality of life improvements. With enhanced economic activity comes an increased need for transportation of goods and people. This demand impact subsequently stimulates the supply of more air transportation and drives additional enabling impacts.

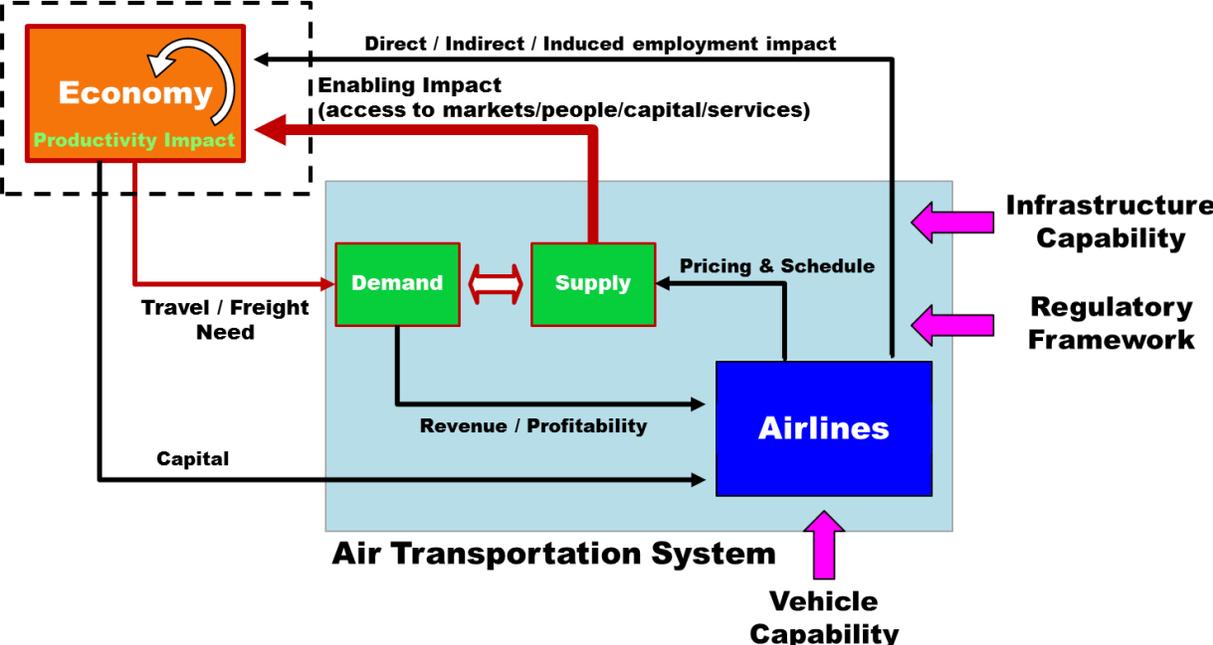


Figure 1-1: Feedback-based model of air transportation in the economy (adapted from Ishutkina & Hansman, 2009, p. 29)

The enabling impacts of air transportation give rise to various changes within the economy, primarily the result of improved access to markets, people, capital, and services. Air transportation has expanded trade and created new global supply chains by allowing companies to ship parts halfway around the world in a matter of hours rather than days. The presence of a robust U.S. aviation system has also greatly influenced the rise of e-commerce and just-in-time manufacturing. While there exist many other examples of economic activity enabled by air

transportation, in this thesis, three particular indicators of these enabling impacts are considered:

- Productivity improvements
  - Historically, there has been much interest in understanding how investments in infrastructure might lead to underlying improvements in the efficiency and productivity of the economy. Productivity improvements can be gained from the creation of a new transportation system or improvements to an existing one due to resulting adjustments to material sourcing, economies of scale, labor matching, and other production factors by industry.
- Use of air transportation by industry
  - Air transportation use by industries for production is, in and of itself, another enabled impact of the aviation system. As an intermediate component of production (that is, one which is accounted for as an input to production), air transportation is used by nearly all industries to some extent. Its combination of speed, safety, and reliability help determine its usefulness to industry and results in variable demand for air transportation depending on a particular industry sector's inputs, production processes, and outputs.
- Industry location relative to airports
  - All things being equal, one might expect the distribution of business establishments from airports to be similar for all industry sectors and relatively uniform across the entire country. In fact, there is considerable evidence to suggest that such distributions are not random and might vary depending upon the particular industry under consideration. Frequent anecdotal accounts of businesses relocating to cities with good air service or otherwise locating near airports suggest that the spatial orientation of businesses within metropolitan areas and across the country is at least due in part to the availability of air transportation.

## 1.3 STAKEHOLDER IDENTIFICATION

It is difficult to identify a significant segment of the U.S. that does not have some stake in a healthy aviation system. As a mature transportation network, the U.S. air transportation system has numerous stakeholder groups. Airlines have much at stake as the primary commercial suppliers of air transportation. The deregulation of the industry in 1978 has led to an extremely competitive environment that has seen the rise and fall of various commercial carriers, a number of mergers, and, within the past decade, bankruptcies for many of the major U.S. airlines. Airlines are reliant on an efficiently managed infrastructure in the form of air traffic control and airport operations. They are also dependent on aircraft manufacturers to produce the aircraft they use to serve travel demand. Airlines for America (A4A) is the leading airline trade association in the U.S. and has recently been advocating for a comprehensive national airline policy that would help ensure the continued health and safety of the country's aviation system.

Aircraft manufacturers rely on a well-functioning aviation system in order to continue to be able to supply new products to operators. While manufacturers serve a worldwide demand for aircraft, they remain extremely receptive to the needs of American carriers since the U.S. is one of the largest markets for aviation in the world. A strong U.S. aviation system helps ensure there will be future demand for new aircraft.

Industry as a whole also has great interest in a strong air transportation system. For those businesses that rely on frequent employee travel, the time savings made possible by air travel are of the utmost importance since travel time savings translate to more time available for other critical work. For those manufacturers and services that source perishable goods, fashions, or other high obsolescence technologies, such as computers or mobile phones, from overseas, air travel can make the difference between having a product in stores the next day or the next month.

For the general public, the ability to fly has opened up a range of travel opportunities that once would have been prohibitively time or cost intensive. Families located far apart can now connect with one another more easily than ever before. Travel and tourism to all corners of the world is now a distinct possibility for much of the nation. Air transportation allows those with serious health problems the option to receive treatment at the very best health care facilities in the world. Consumer goods that would have once been hard to find or expensive to

source can now be ordered online with the click of a button and delivered to one's door in as little as one day.

## 1.4 THESIS ORGANIZATION

The original motivation behind this research effort was to understand how and the degree to which air transportation impacts economic productivity. As discussed already, the particular economic effects explored here pertain more to enabled activity rather than direct or indirect spending and output.

Chapter 2 of this thesis explores the hypothesized mechanisms by which air transportation could impact productivity. A number of mechanisms are introduced and considered from the perspective of how they might improve productivity through the presence of air transportation. A simple production model is developed as a template for exploring how air transportation is consumed both as an input or intermediate to production, and as a final service for transporting goods and people.

Chapter 3 focuses on the intermediate use of air transportation by industry in order to characterize the underlying demand for aviation. Input-output (I-O) data from the Bureau of Economic Analysis (BEA) is used to explore trends in use and identify important users of aviation. Correlations of air transportation use and labor productivity are analyzed across industries in order to identify cases where growth in air transportation appears to be coupled with rising productivity. Finally, modal distributions of service-related intermediate inputs are presented in order to highlight those industries which especially rely on air transportation relative to other modes of transportation. As this research on intermediate uses of air transportation continued to evolve, it became apparent that the impacts of air transportation on productivity were perhaps smaller and less certain than had originally been hypothesized. Focusing on productivity impacts alone failed to capture the degree to which the economy relies on aviation. These findings were nonetheless informative in their own right and helped guide much of the research presented in the latter part of this thesis.

In Chapter 4, distributions of business establishments from airports are constructed in order to test how air service availability impacts business location. Using a set of FAA-designated hub airports as a collection of reference points, population and establishment data from the U.S. Census Bureau are mapped by Census Tract and ZIP Code, respectively.

Distributions of Fortune 500 headquarters from hub airports are also considered. Cargo airports are also tested as an alternative reference set. Finally, several regional distributions are created by mapping establishments within metropolitan areas to their major local airport.

Chapter 5 concludes the thesis by drawing some connections between the demand and supply observations of Chapters 3 and 4, summarizing the main findings of this research, and discussing the policy implications of the results. Limitations of the methods and data employed in this thesis are also explained. The chapter concludes with suggestions of additional areas of study for better understanding how air transportation contributes to the U.S. and global economies.

# CHAPTER 2

## PRODUCTIVITY-IMPROVING MECHANISMS

The rise of the jet age in the late 1950s to early 1960s transformed the economic landscape of the U.S. Jet-engine aircraft cut the time of coast-to-coast domestic flights in half and eventual improvements to engine and aircraft design enabled greater connectivity between cities and faster access to people, capital, and markets. Today, aviation has become an integral part of the economy, primarily due to its speed advantage over alternative modes of transportation. Air transportation's ability to connect new markets is due in large part to this speed. In one study conducted by the International Civil Aeronautics Organisation (ICAO), "70% of businesses report that serving a bigger market is a key benefit of using air services" (Air Transport Action Group, 2005, p. 10). With the ability to travel faster and farther than ever before came the promise of linking new markets, expanding access to capital and labor, and restructuring businesses to take advantage of the increased speed provided by air transportation.

As described by Michael Porter, productivity is the "prime determinant in the long run of a nation's standard of living, for it is the root cause of national per capita income" (1998, p. 6). On the basis that productivity gains derive from competition, Porter has proposed a framework in which four key pillars are responsible for competitive advantage: incentives, information, competitive pressures, and supporting firms, institutions, infrastructure, and knowledge centers (p. xi). Since it is the ability to freely access supporting firms, institutions, infrastructure, and knowledge centers that affects competition, and since competition itself is the key driver of productivity, the role of air transportation in facilitating this access appears to be one of critical importance in sustaining a productive economy. Throughout the rest of this chapter, the mechanisms by which air transportation might be able to influence economic productivity are explored.

Before discussing these productivity impacts; however, it bears mentioning the areas in which this research has not been primarily concerned. Namely, this work has not focused on changes in productivity throughout the air transportation sector itself. This is an important distinction. This thesis concerns how the use of air transportation by other industries impacts the productivity of the U.S. economy, not how the productivity of the aviation sector impacts

the economy (although this is an equally valid and important research topic). The productivity of the air transportation sector has been covered in depth in other research. Notably, Robert Gordon (1993) found declining productivity growth in the air transportation sector following the deregulation of the industry in 1978. Gordon observed similar results for the trucking industry. He suggests that the invention of air transportation itself and the time savings made possible by the first aircraft and subsequent improvements in engine and aircraft technology during the early stages of the industry have been far more influential in impacting productivity than have regulatory and operational changes made by the industry in more recent times.

## 2.1 PRODUCTIVITY DEFINITIONS

Fundamentally, productivity is a measure of production efficiency and can be defined as a ratio of output to input. Higher productivity can be achieved by producing the same amount of output while using less input, by producing more output while using the same input, or (more likely) via changes to both output and input such that the ratio of output to input increases. Productivity is commonly measured at both micro- and macro-economic levels. Inputs have historically been classified as capital (K), labor (L), energy (E), materials (M), or services (S). The denominator of the productivity ratio may consist either of a single type of input (for example, labor) or multiple types (for example, capital and labor). The former is termed single factor productivity, while the latter is called multifactor productivity. Thus, there are four common measures available to economists or researchers interested in assessing productivity:

- Microeconomic single factor productivity
  - At the firm level, the most common measure of single factor productivity is labor productivity, commonly cited as the ratio of revenues per number of employee hours worked.
- Macroeconomic single factor productivity
  - Likewise, at the economy-wide level, labor productivity is also the most commonly reported measure of single factor productivity and is most often recorded as the ration of real GDP to aggregate payroll hours.

- Microeconomic multifactor productivity
  - At the firm level, multifactor productivity might be expressed as the ratio of revenue per an index of capital, labor, materials, energy, materials, and services.
- Macroeconomic multifactor productivity
  - At the economy-wide level, real GDP per an index of capital and labor is one common measure of productivity.

<b>Single Factor Productivity</b>	
<b>Micro</b>	<b>Macro</b>
$\frac{\text{Revenues}}{\text{Employee Hours}}$	$\frac{\text{Real GDP}}{\text{Aggregate Payroll Hours}}$

<b>Multifactor Productivity</b>	
<b>Micro</b>	<b>Macro</b>
$\frac{\text{Revenues}}{\text{KLEMS}}$	$\frac{\text{Real GDP}}{\text{KL}}$

Figure 2-1: Example definitions of productivity

It bears consideration that the example metrics cited here are by no means definitive. For example, real gross domestic income (GDI) could stand in for GDP, or household hours worked could replace payroll hours. In the air transportation sector, revenue passenger miles (RPM) is one measure of this industry’s productivity since it captures the industry’s supply of air transportation relative to available capacity.

## 2.2 PRODUCTIVITY MECHANISMS

To understand how air transportation has the potential to impact productivity, it is necessary to identify the mechanisms by which such impacts might occur. Many of these mechanisms are relevant not only to air transportation, but also to other modes of transportation and even other non-transportation industry sectors. Some are more specific to transportation and air transportation in particular.

### 2.2.1 COMPARATIVE ADVANTAGE

Air transportation can impact productivity by creating interregional connections whereby comparative advantages are achieved. Comparative advantage refers to the theory first advanced by David Ricardo, and subsequently evolved by Eli Heckscher and Bertil Ohlin, that regions that are more efficient at producing certain goods than others will specialize and concentrate resources on making those goods at which they are more efficient. The advantage is comparative in that a region might not be the best at producing a particular good, only that it is comparatively better at producing a good relative to its potential to produce other goods and exchange those goods in the marketplace. Air transportation's role in comparative advantage is that it can allow for concentration of resources in those regions where production is most efficient, thereby generating productivity improvements due to specialization. The speed offered by air transportation also opens up new trading partners and creates new opportunities for gains from trade that might not have existed when the only alternative modes of transportation were much slower. Furthermore, the availability of air transportation to transfer goods eases a region's burden to produce products which, although important, might be inefficient for it to produce.

### 2.2.2 ECONOMIES OF SCALE

Air transportation enables producers to target wider and new markets. By expanding market reach, input costs can be lowered due to larger bulk purchases, marketing advantages are gained due to an expanded customer base, and other costs are lowered due to increasing returns to scale in production. Consumer choice is also improved in cases where air transportation enables greater availability of a wider variety of goods.

### 2.2.3 LOGISTICS IMPROVEMENTS

In terms of logistics, there is a potential for air transportation to lower a firm's total logistics costs in cases where goods are of particularly high value. Since high value goods incur significant holding costs (typically calculated as the value of the good multiplied by its estimated annual depreciation), it can be cheaper overall to ship smaller quantities of such goods at frequent intervals by air transportation. While the shipping costs of using air are

typically higher than for other modes, the savings gained from reducing holding costs can outweigh higher shipping costs. The added reliability of air transportation, largely a result of the mode's speed, also can help shippers reduce inventory buffers that are typically required in order to defray the uncertainty associated with delivery time.

#### 2.2.4 LOCATION CHOICE

The idea that location itself has an inherent value can be traced to the work of von Thünen, who proposed that the value of a place is based on its available access to the marketplace (MacKinnon, Pirie & Gather, 2008, p. 11). This idea has stood up well through time and explains why, in the case of transportation in general, infrastructure improvements can lead to location shifts by industry. For example, reduced transportation costs might compel a multi-establishment company to concentrate its production in fewer locations, relying on more establishment-to-establishment travel, while reducing overall costs due to the economies of scale gained through concentration. Similarly, the presence of new air transportation infrastructure, in the form of new airports, airport improvements, and new air service, can lead to location shifts by businesses that require frequent employee travel. Especially for professional service industries that rely extensively on client meetings and managerial oversight, locating near an airport that offers extensive nonstop flight options can save crucial time and increased potential for delays that come with having to change planes en route. Location choice is explored in depth in Chapter 5 where I consider the distribution of industries from hub airports.

#### 2.2.5 FACE-TO-FACE COMMUNICATION

The importance of face-to-face communication has been widely recognized as a critical component of many industries, particularly in the services sector. On the whole, the need for face-to-face time is positively correlated with increasing knowledge complexity. In this case, firms could benefit from locating in order to maximize the opportunity to consume face-to-face meetings, while minimizing travel costs. One way to do so is to locate near good air service, especially where there are many destinations reachable by non-stop flights. Access to non-stop flights is particularly important since this reduces average travel time and minimizes the potential for delays incurred from en route stopovers.

The rise of virtual communication technologies might suggest that the need for frequent business travel could soon be replaced by home office video conferencing. In the 1950s and 1960s it was believed that up to 66% of face-to-face time would eventually be replaced by virtual communication (Beaverstock, Derudder, Faulconbridge & Witlox, 2010, p. 226). By the end of the 1980s; however, it was noticed that virtual communications had not significantly impinged on business travel. During the 1990s there was even more revision to the belief that virtual technologies would eventually replace business travel. Saffo (1993) has proposed that while virtual communication would be used, such use would only encourage more face-to-face encounters rather than fewer. Indeed, a 1997 study of nine European countries showed positive correlations between demand for air transportation and telecommunications in all cases, supporting the notion that an increase in virtual communication might actually increase the need for travel (Beaverstock et al., 2010, p. 227). Recent research suggests the need for face-to-face communication is as strong as ever today. A Harvard Business Review survey of over 2,300 businesses found that for 95% of respondents, “in-person meetings are both key to successful long-term relationships and to building strong relationships” (2009, p. 6). Furthermore, 89% of those surveyed said that face-to-face meetings are “essential for ‘sealing the deal,’” while 81% agreed that “travelling to meet in person offers value beyond the meeting” (p. 8). According to one executive, “travel is an investment, and you can communicate to a client that you are willing to invest time and money to be with them. In the current environment it is doubly important to be there to close new business quickly” (p. 8). The Harvard Business Review study concludes that despite the increasing prevalence of alternative meeting technologies, the benefits of face-to-face communication cannot be replaced by such alternatives. Efficient use of time is another factor cited in the Harvard study in favor of face-to-face communication. Kobayashi et al. (1998) have gone as far as to show that face-to-face meetings are actually under-consumed, resulting in a net deadweight loss to society.

## 2.3 AIR TRANSPORTATION IN PRODUCTION

BEA I-O accounts serve as a starting point around which to structure the analysis of how air transportation factors into the production process. In particular, this analysis uses I-O use tables, commonly referred to as “recipe” matrices since they show how much of each

commodity an industry uses in order to produce its output (Horowitz & Planting, 2009, p. 1-2). The use tables separate use into intermediate and final use.

Intermediate uses of air transportation are those involving the movement of either materials or people for fulfilling an overall business need. The use of air transportation to move electronics components for a computer manufacturer is one example of an intermediate use of air transportation. Another example of an intermediate use is the transportation of scientific consultants to a client while performing consulting services. By analyzing the intermediate use of air transportation across industries, one can begin to understand air transportation's importance to each industry.

Final use of air transportation constitutes the other side of the production picture. Final use is comprised primarily of personal consumption expenditures—passenger flights taken by private individuals—in addition to exports, imports, and private fixed investment. In 2010, final use of air transportation constituted 70% of total air transportation expenditures and has shown steady growth over the past 10 years.

In subsequent analyses, it became apparent that intermediate use of air transportation suggested a natural split between those industries which are primarily goods-producing and those which are primarily services-producing. In particular, goods-producing industries tend to use air transportation more for moving materials and other freight, while services-producing industries primarily use air transportation for moving people. Among final uses of air transportation, personal consumption accounts for the vast majority of use. Figure 2-2 depicts the fundamental breakdown of air transportation uses as reported in the I-O use tables and the segmentation of intermediate use by goods- and services-producing industries that emerged from later analysis.

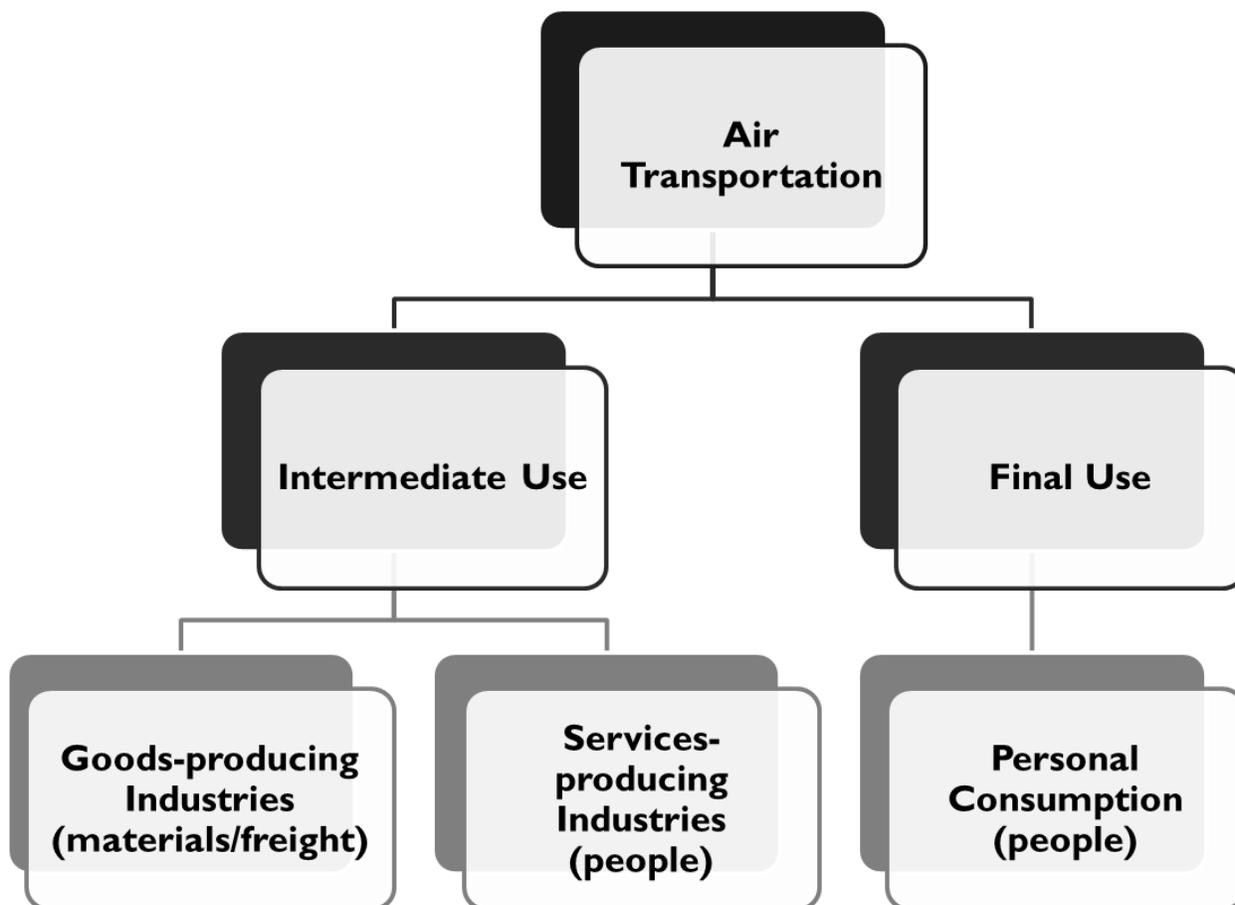


Figure 2-2: Primary uses of air transportation

In tandem with the identification of intermediate and final uses of air transportation, a notional model of economic production that incorporates air transportation was constructed (Figure 2-3). On the left side of the model, inputs to production include capital, labor, energy, materials, and services. Air transportation itself is generally classified as a service input, though one can also think of air transportation as enabling the movement of capital, labor, materials, or services into production. In general, inputs are utilized by industries to create output that is then either transported to market as a finished good, or sent on as another input to a different industry's production processes.

Since many goods do not pass directly from the factory to the consumer, transportation also plays a key role as a final use in moving products from production through wholesale and retail trade channels. Finally, a consumer might purchase a good that is then shipped by air to him or her. The cost of shipping by air in this case is accounted as final use of air transportation. The following examples illustrate how one can think of air transportation as both an intermediate and final use:

- Producer A purchases materials and pays to have them air shipped to its factory. Air transportation is an intermediate input used by Producer A's industry.
- Producer B purchases consulting services provided by Producer C. Producer C uses air transportation to perform these consulting services (for example, travelling to Producer B's headquarters). Air transportation is an intermediate use accounted under Producer C's industry.
- A consumer purchases an airline ticket for personal travel. Air transportation use in this case is a final use, treated as personal consumption expenditures.
- A consumer purchases an electronic device and has it shipped by air to her home. Air transportation is a transport cost included in the consumer's purchase price of computer and electronic products and is accounted as final use.

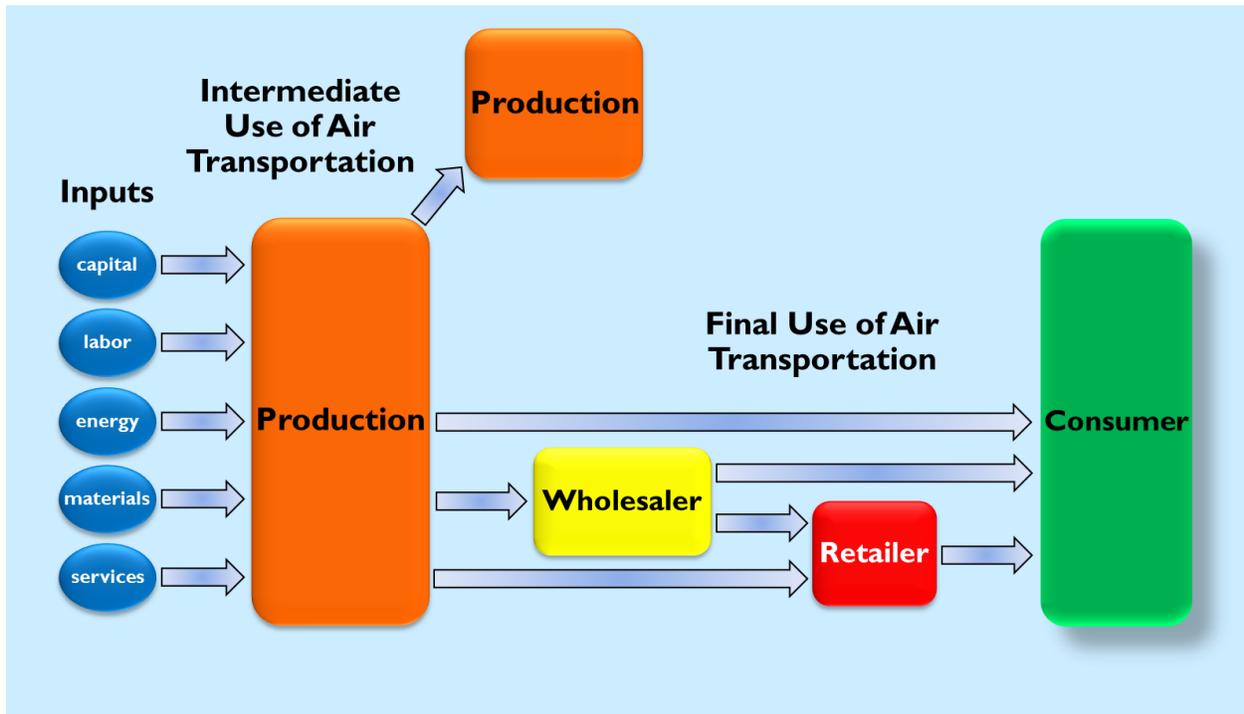


Figure 2-3: Model of air transportation in the production process

Because economic productivity is more closely tied to activities involving air transportation as an intermediate use, this thesis focuses on the left side of the production model. The next chapter contains a detailed examination of intermediate use and draws some conclusions about air transportation's role in affecting productivity.



# CHAPTER 3

## ANALYSIS OF INTERMEDIATE USE OF AIR TRANSPORTATION

In order to understand how well the hypothesized mechanisms of air transportation's impact on economic productivity correspond to reality, a data-driven approach has been applied. While there are many anecdotes available to illustrate how air transportation affects the economics of single companies, drawing broader conclusions from such examples can be challenging given the typical wide range of variables involved in such cases. For the most part, data on air transportation use by companies is difficult to obtain. The competitive advantages offered by air transportation as compared to other modes can make it proprietary knowledge in many sectors. When information on travel or transportation spending is available, it is usually presented as an aggregate figure for all modes of transportation used. One exception is the annual *Business Travel News* "Corporate Travel 100," a ranking of the 100 companies that use the most air transportation for U.S. travel. Not surprisingly, this ranking reveals that the very largest users are also typically the very largest companies, primarily in the financial, consulting, and technology sectors. However, such a ranking of large companies says little else about how important aviation is to a particular company, how much air travel a company is using relative to the average user, and how much a company is spending on air travel compared to other expenses. Furthermore, such a list neglects the other millions of establishments also using air transportation. In order to approach the issue of how air transportation is used, government statistics provided by the BEA, Bureau of Transportation Statistics (BTS), and Bureau of Labor Statistics (BLS) have been employed.

### 3.1 NAICS AND I-O CORRESPONDENCE

The current BEA I-O accounts define industries based on the North American Industry Classification System (NAICS), the official U.S. industry classification system developed along with Canada and Mexico under the North American Free Trade Agreement (NAFTA). NAICS categorizes industries by way of 6-digit codes and was established in 1997 as a replacement for the older Standard Industrial Classification (SIC) system. SIC had maintained a focus on manufacturing industries in particular, and had become outdated with the rise of many more

services industries in the latter stages of the twentieth century. In addition to expanding the range of classified service industries, NAICS has reorganized its classification scheme around production methods. In total, NAICS classifies 1,179 individual industries and 20 major industry sectors which are classified by 2-digit codes (Horowitz & Planting, 2009, p. 4-2).<sup>1</sup>

While it is the general case for I-O industry codes to correspond with NAICS codes, the I-O tables analyzed throughout the rest of this chapter include several other industries, as well as government industries, that are not included in NAICS.

## 3.2 AIR TRANSPORTATION USE AND ECONOMIC TRENDS

In order to study industry use of aviation, trends of air transportation output were first compared to several broader measures of economic output in order to establish a sense of how growth in the air transportation sector itself has compared to overall economic activity in recent years. For this and most subsequent analyses, available data was limited to the period of 1998 through 2010 due to the data reporting practices of the BEA. Figure 3-1 shows the trend in air transportation output compared to several broader measures of economic output: GDP, the output of all industries, and the output of the transportation and warehousing sector (of which air transportation is one part). Output has been indexed to 100 for the year 1998. What is most notable is the effect of September 11 on air transportation output in particular. While aggregate economic growth slowed somewhat during the period of 2001-2002, it remained positive, in contrast to the air transportation sector's decline in output. Besides this particular shock; however, growth in air transportation output throughout the rest of the decade was comparable to the rest of the economy. Unlike for September 11, the effects of the 2009-2010 recession can be observed across all sectors.

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<sup>1</sup> See Appendix B for descriptions of NAICS major 2-digit industry sectors.

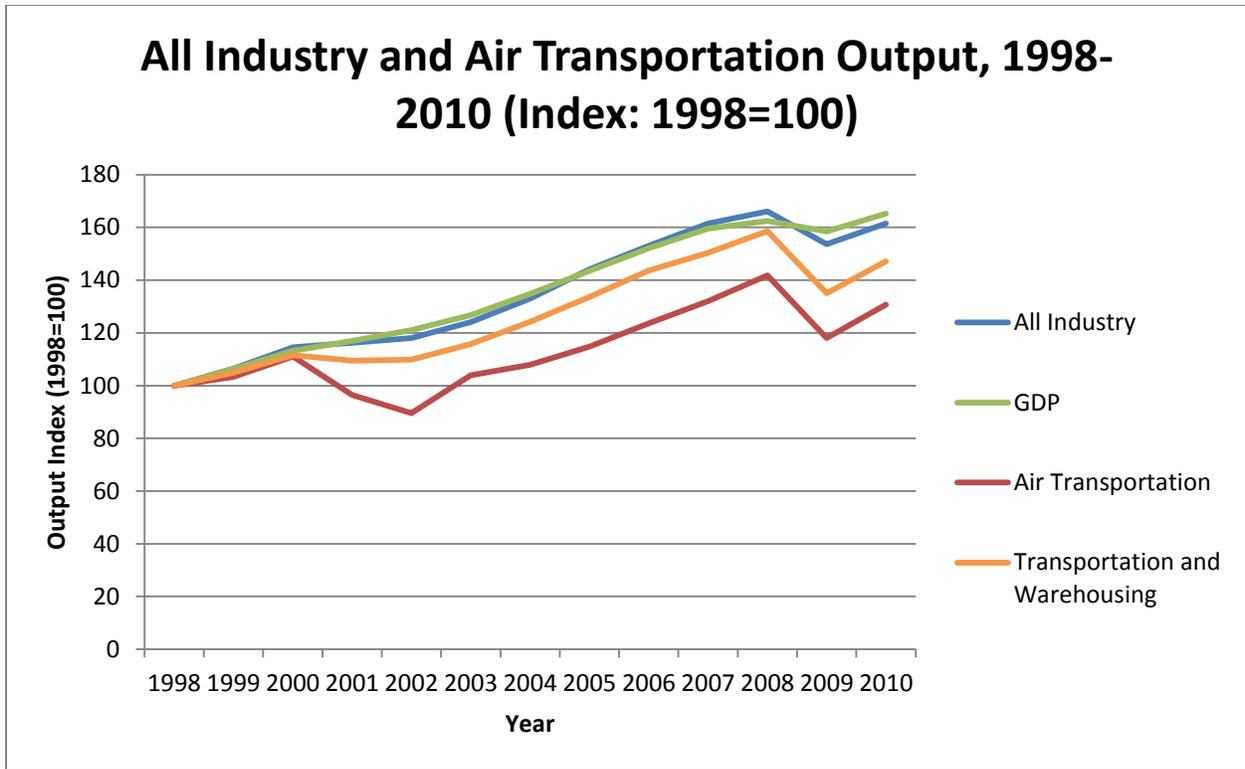


Figure 3-1: Industry and air transportation indexed output, 1998-2010

### 3.3 INTERMEDIATE USE TRENDS

One of the primary roles of the BEA is the preparation of economic accounts data. National, international, and regional databases are all publically available and provide a broad, but thorough description of U.S. economic activity. For this research, the BEA’s annual I-O accounts serve as the primary source of information regarding industry use of air transportation. The I-O use tables are of particular importance, as they describe the uses of commodities by industries for both intermediate and final uses. As a first step towards understanding recent air transportation use, trends of intermediate use, final use, and total air transportation output were prepared. Figure 3-2 shows these trends. The effects of September 11 and the recent recession are clearly visible from 2001-2002 and from 2008-2009, respectively. The figure also indicates that nearly all growth in the total output of air transportation is due to increases in final use, most of which is personal consumption. That intermediate use of air transportation over this period is relatively flat is surprising given the hypothesis that air transportation helps to facilitate production and other business functions. Intermediate use has actually declined slightly over the period of study, from \$45.0 billion in

1998 to \$41.8 billion in 2010. To better understand this recent trend, the next step is to examine the use statistics at the sector level in order to identify which industries appear to be particularly important in supporting air transportation.

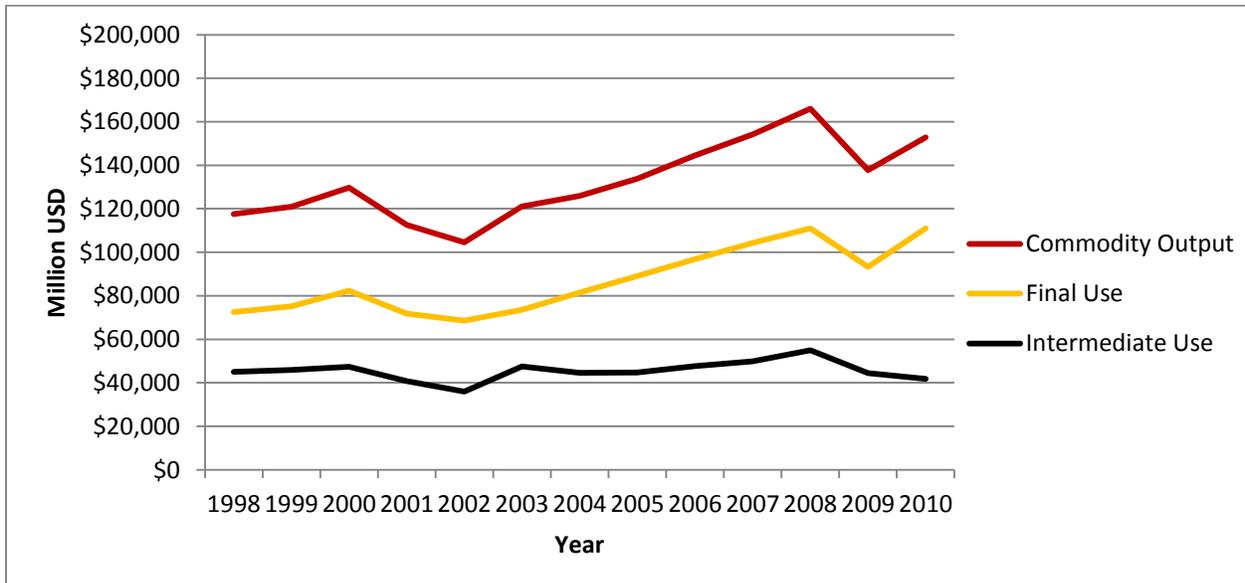


Figure 3-2: I-O use trends for air transportation

### 3.3.1 INTERMEDIATE USE RANKING BY VALUE

One way of attempting to measure the importance of aviation is through aggregate use. Figure 3-3 shows the top users of air transportation during 2010.<sup>2</sup> These data provide a high level overview of who are the major users of air. The Federal General Government sector is the largest user of air transportation, having spent approximately \$6.8 billion in 2010. The Federal Reserve Banks and Related Services sector is the second largest user group, having spent over \$3.2 billion. Other large users include the Wholesale and Retail Trade sectors, several services sectors, the Publishing Industries (including Software) sector,<sup>3</sup> and state and local governments. Not surprisingly, every industry sector accounts for some air transportation spending. While these data show who is using aviation and how much is being used, they do not really indicate how important air transportation is to a given sector. For example, it is reasonable to assume that larger sectors would use more air transportation, just as smaller sectors would use less.

<sup>2</sup> Data for all industry sectors is included in Appendix A.

<sup>3</sup> For the I-O accounts, Publishing Industries include software; in the NAICS definitions, the publishing industries subsector excludes Internet-related products.

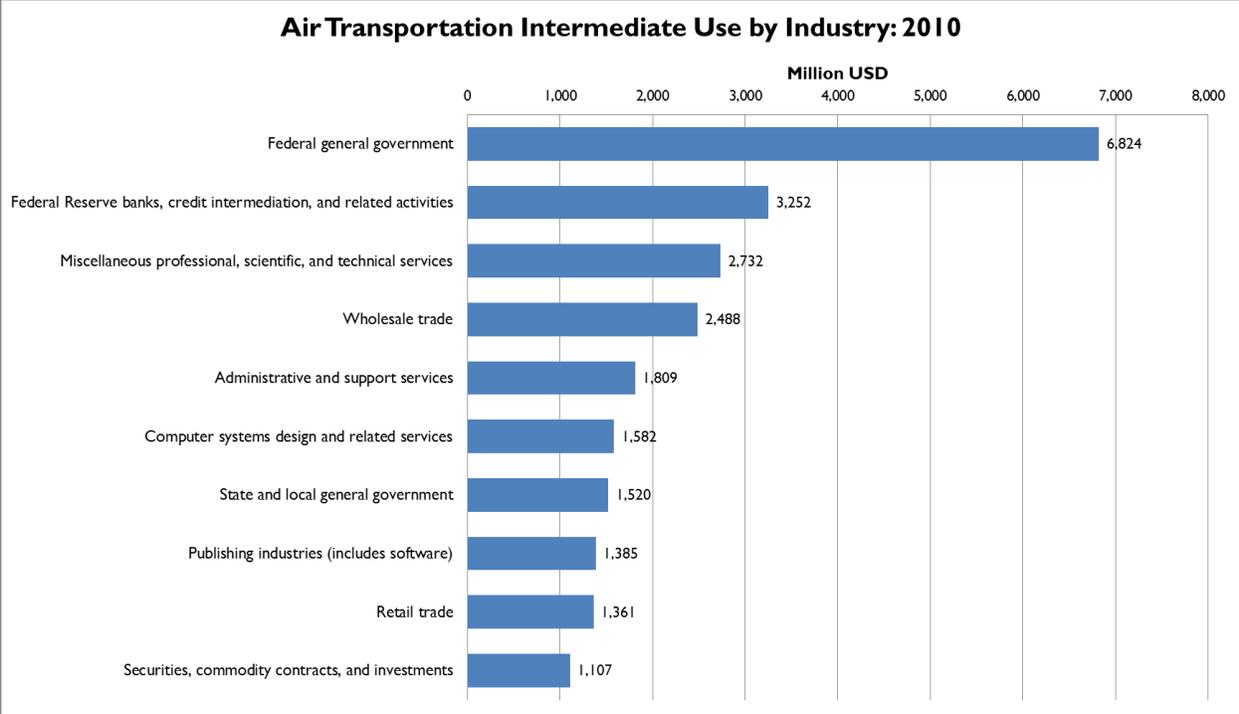


Figure 3-3: Top 10 intermediate users of air transportation

### 3.3.2 INTERMEDIATE USE RANKING BY NORMALIZED VALUE

In order to get a better sense of the criticality of aviation to industry, the next step is to normalize intermediate air transportation use by dividing by total intermediate use. Figure 3-4 shows these normalized values, where air transportation use is reported as a percentage of all intermediate use. Normalized use provides a better sense of how important a commodity is to an industry since it describes the percentage of total resources an industry is willing to devote to a particular commodity. Overall, average normalized use of air transportation in 2010 was 0.4% of all intermediate uses. Just as for absolute use, the Federal General Government leads the way in normalized use, devoting the largest percentage of all intermediate consumption to air transportation. At 3.5%, the Federal General Government devotes ten times more of its resources to air transportation than the economy-wide average. Other top users include numerous services industries, the Publishing Industries (including Software) sector, and several transportation sectors, all of which devote between 1.75-3.5 times more resources on air transportation than the economy-wide average.

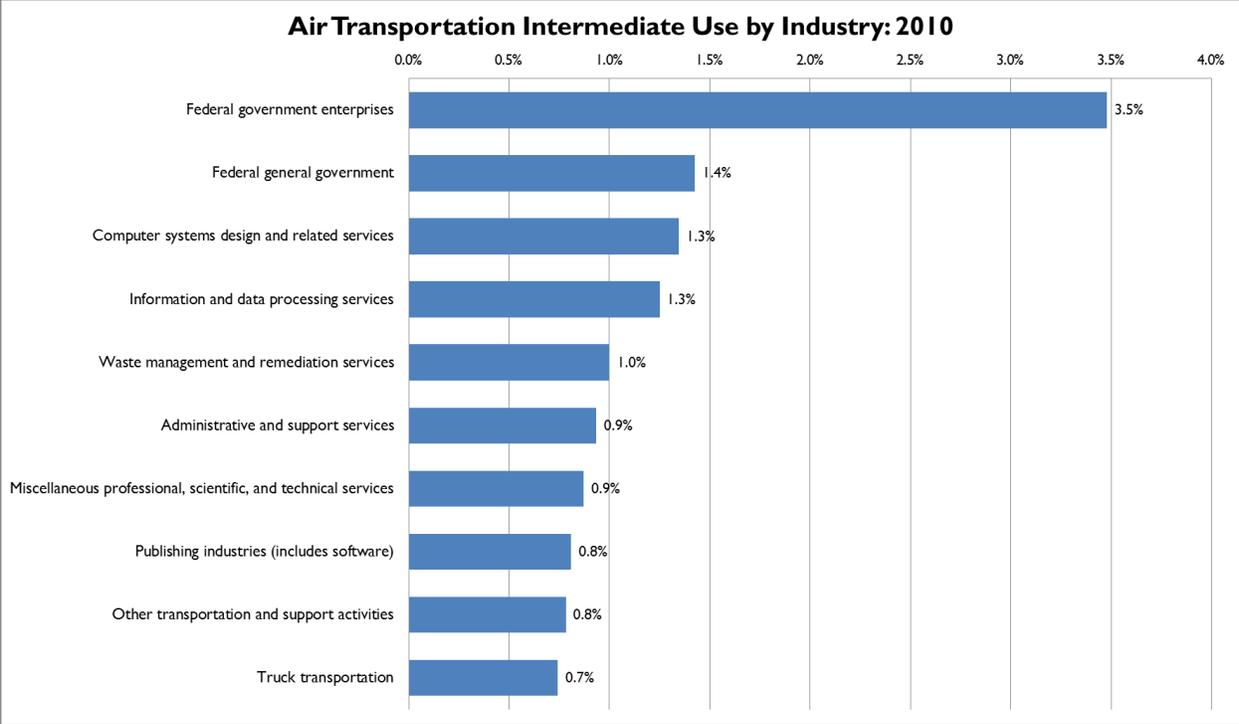


Figure 3-4: Air transportation use relative to total commodity intermediate use

### 3.3.3 INTERMEDIATE USE TOP USER TRENDS

After identifying the users who appear to devote the greatest percentage share of resources to air transportation, the next step is to consider the recent trend in aggregate use for these particular top users. Figure 3-5 shows the trends in intermediate use of air transportation for the largest users. Among the top intermediate users of air transportation by normalized use, most have exhibited usage patterns that follow the average trend in intermediate use over the past 12 years—namely, slowly increasing to stagnant overall changes in use. The notable exceptions to this trend have been the Federal General Government and the Federal Reserve Banks, Credit Intermediation, and Related Activities sectors. The Federal General Government experienced a sharp increase in use of air transportation between 2002 and 2003, largely the result of the Iraq war. Figure 3-6 displays federal budget data on air transportation outlays that confirm the sharp peak in use observed in the BEA I-O data (U.S. Office of Management and Budget [OMB], 2013).

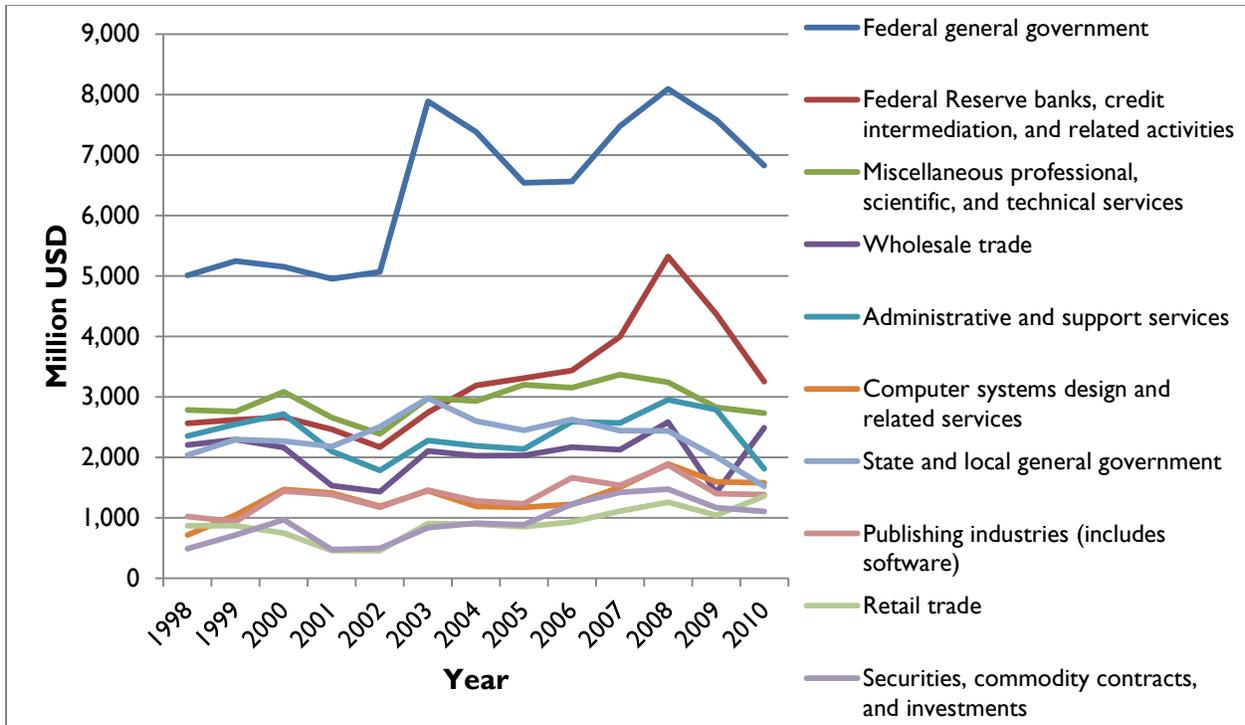


Figure 3-5: Trend of top intermediate users of air transportation

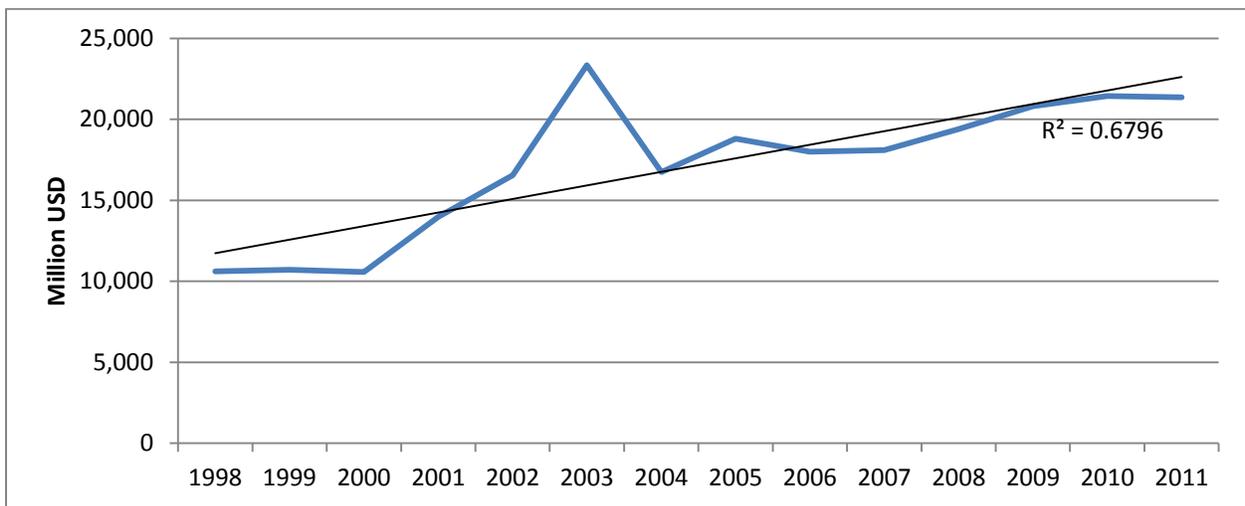


Figure 3-6: Federal government air transportation outlays, 1998-2011

### 3.3.4 INTERMEDIATE USE TOP USER TRENDS

Just as for the rankings of 2010 intermediate use, the trend of normalized use from 1998-2010 has also been considered. In general, the amount of resources devoted to air transportation declined over this period. Figure 3-7 shows these trends for the top users of air transportation. As noted previously, the top users are either government or services sectors.

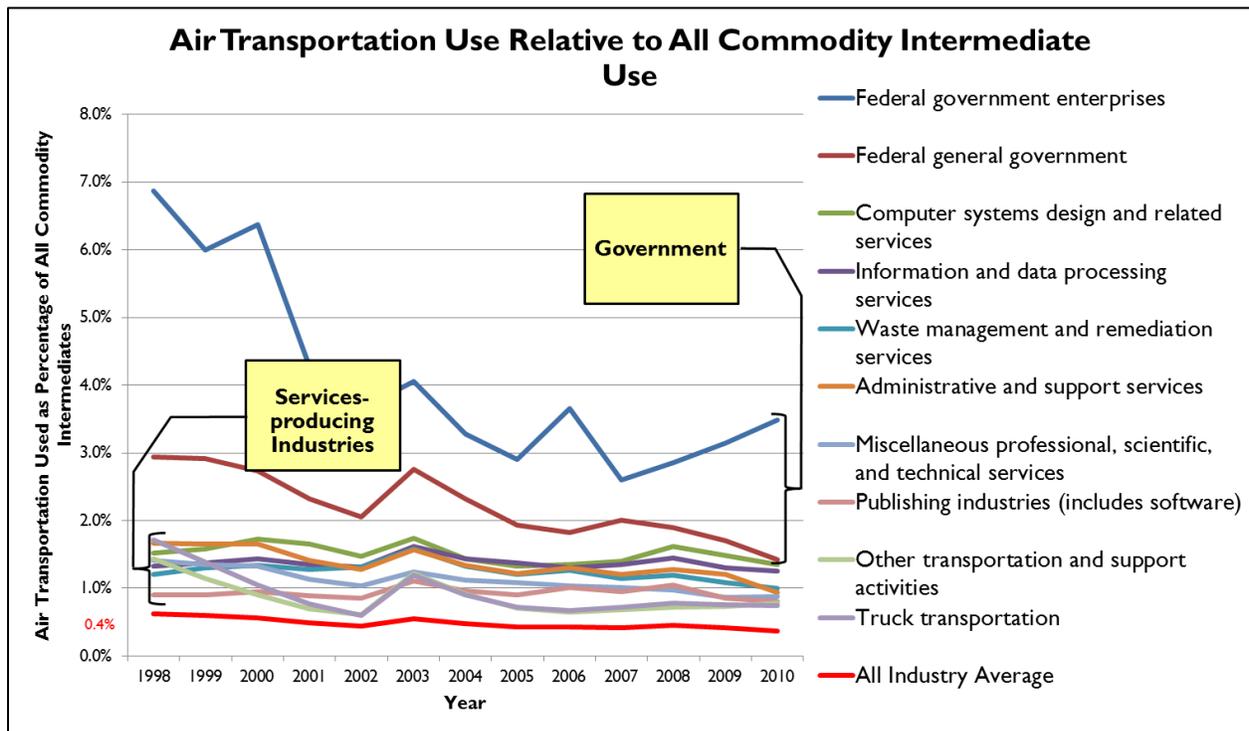


Figure 3-7: Air transportation use relative to all commodity intermediate use

### 3.4 INTERMEDIATE USE AND LABOR PRODUCTIVITY

Having examined the composition of the economy’s use of air transportation, the next stage of intermediate use analysis draws upon BLS productivity data and compares air transportation intermediate use to labor productivity for 26 different industry sectors.<sup>4</sup> For each sector, air transportation intermediate use, labor productivity, and indices of sector output and labor consumption have been plotted. In addition, correlations between air transportation use and labor productivity have been calculated. Overall, some positive correlations of these two variables are observed, primarily for services-producing industries, while a number of negative correlations, primarily for goods-producing industries, are also observed. Correlation coefficients between 0.3 and 1.0 were considered moderate to strong positive correlation, coefficients between -0.3 and 0.3 were considered small to no correlation, and coefficients between -1.0 and -0.3 were considered moderate to strong negative correlation.<sup>5</sup>

<sup>4</sup> The number of industries available for comparison is limited in this case due to different data reporting by the BLS as compared to the BEA.

<sup>5</sup> Coefficient break points based on Cohen (1998).

The Publishing Industries (except Internet) sector exhibited the strongest positive correlation between air transportation use and labor productivity. Figure 3-8 shows that increasing use of air transportation has been accompanied by steady productivity growth in this sector. Despite this correlation, a decline in labor hours over the same period of productivity growth makes it difficult to draw any conclusions about the degree to which increasing air transportation use was responsible for productivity gains in the Publishing Industries (except Internet) sector.

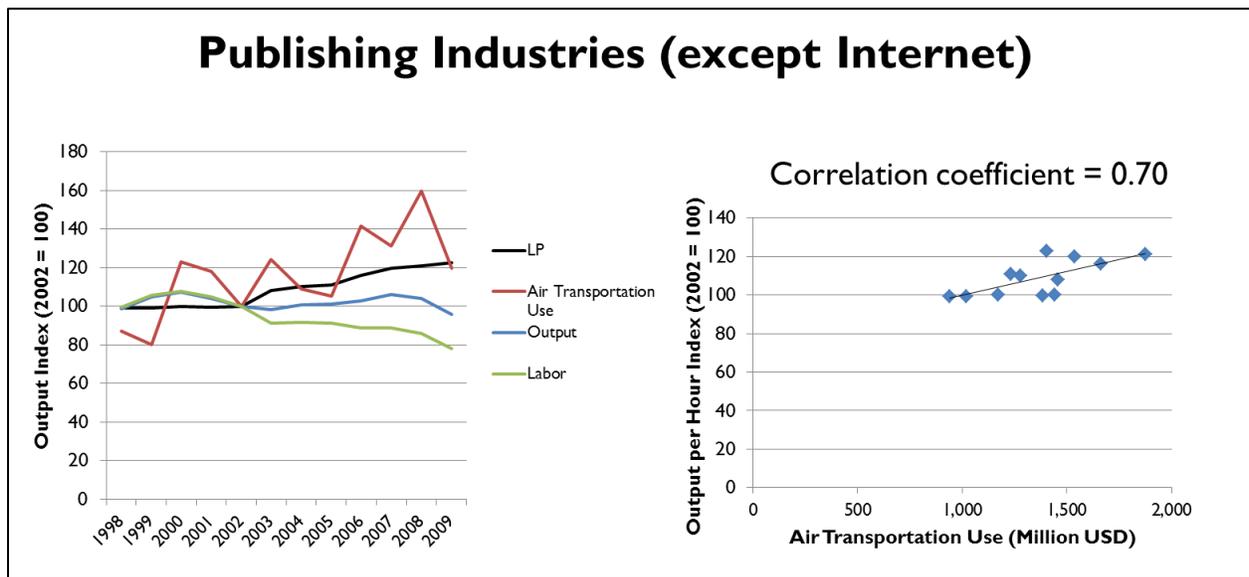


Figure 3-8: Example of positive correlation between air transportation use and labor productivity, Publishing Industries (except Internet)

On the other hand, the Computer and Electronic Product Manufacturing sector exhibited the strongest negative correlation between air transportation use and labor productivity (Figure 3-9). Air transportation use in this sector sharply declined as the result of increased cargo restrictions following the events of September 11 and continued to decline thereafter. Although labor hours also have declined in this industry, labor productivity has soared, in part due to increased output.

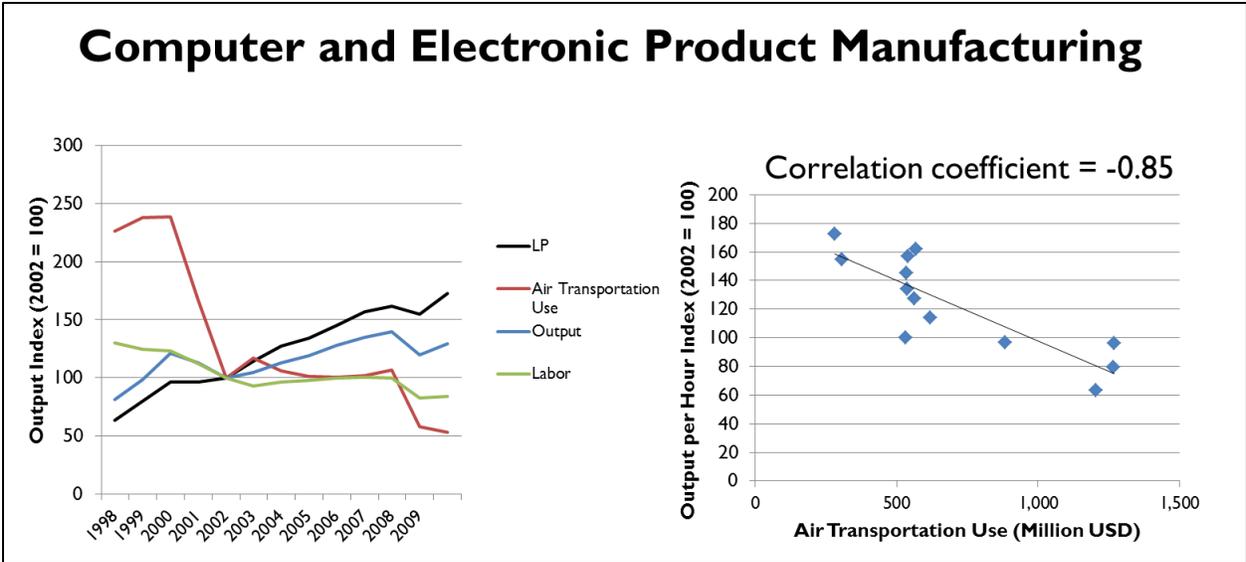


Figure 3-9: Example of negative correlation between air transportation use and labor productivity, Computer and Electronic Product Manufacturing

Figure 3-10 summarizes the positive and negative correlations observed between air transportation use and labor productivity from 1998-2010.

Positive Correlations	Negative Correlations
Publishing industries (except Internet)	Computer and electronic product manufacturing
Retail trade	Paper manufacturing
Nonmetallic mineral manufacturing	Electrical equipment, appliance, and component manufacturing
Food services and drinking places	Petroleum and coal products manufacturing
Accommodation	Line-haul railroads
Support activities for mining	Plastics and rubber products manufacturing
Warehousing and storage	Miscellaneous manufacturing
	Chemical manufacturing
	Oil and gas extraction
	Wood product manufacturing

Primarily Services-producing Industries

Primarily Goods-producing Industries

Figure 3-10: Correlations of air transportation use and labor productivity

Overall, correlations of air transportation use with labor productivity provide a mixed message. On the one hand, a number of services-producing sectors exhibit positive correlations. On the other hand, many sectors (the majority of which are goods-producing) demonstrate negative correlations. While the preponderance of negative correlations does not inspire confidence in the hypothesis that air transportation is a significant enabler of productivity, what is more likely is that the productivity impact of using air transportation is confounded by other factors, such as declining labor hours due to increased technology and automation. In this case, negative correlations do not necessarily imply air transportation is unimportant to particular industries, but rather, that confounding factors make it difficult to measure aviation's importance in this particular data.

### 3.5 MODAL DISTRIBUTIONS OF INTERMEDIATE INPUTS

As a derived demand, air transportation is used to fulfill business needs that require the transportation of things or people. For this reason, the final component of the analysis of industry intermediate use of air transportation consists of an examination of the share of each mode of transportation that industry sectors devote to purchased-services. Purchased-services is one of the five inputs (in addition to capital, labor, materials, and energy) captured in the KLEMS production framework and comprises the vast majority of air transportation use as an intermediate commodity.<sup>6</sup> As Figure 3-11 shows, air transportation has comprised between 35 and 45 percent of all transportation-related purchased-services between 1998 and 2010. Air transportation accounts for a modal share comparable to that of truck transportation and more than twice that of transit and ground passenger transportation.

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<sup>6</sup> 88% of air transportation intermediate use in 2010 is classified as purchased-services. The remaining 12% of use is classified as materials (BEA, 2012c).

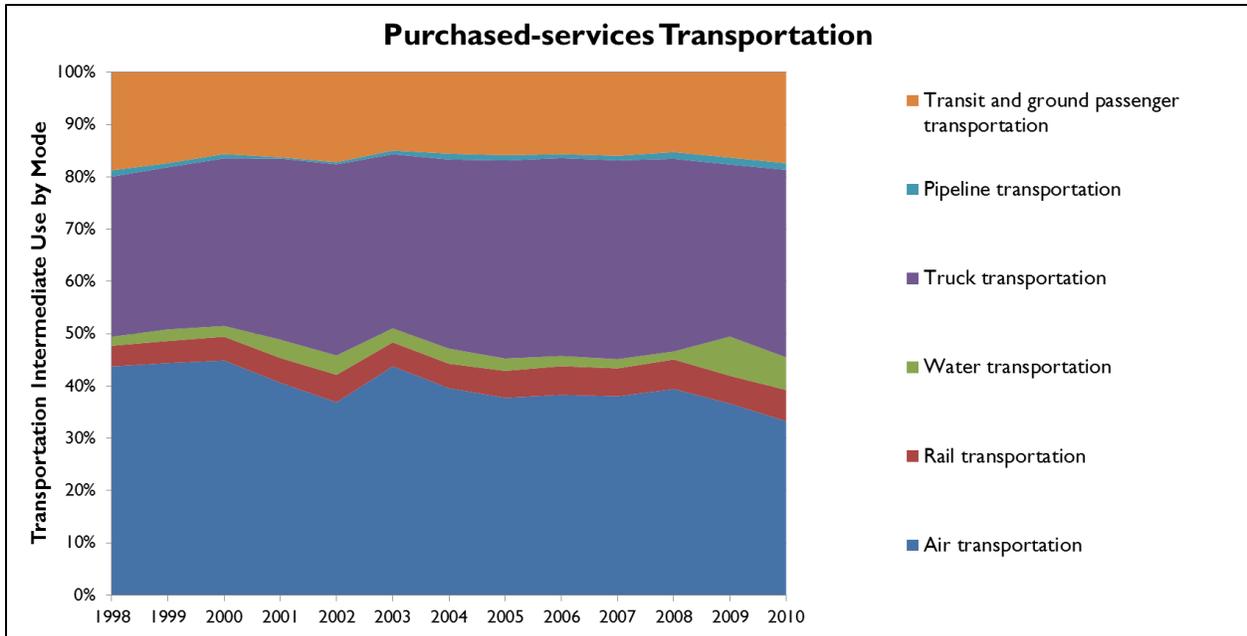


Figure 3-11: Transportation of production inputs (purchased-services) by mode

Next, the modal share of air transportation accounted for as purchased-services was computed across all NAICS sectors. In 2010, the average modal share of air transportation by industry was 33%. Nevertheless, there were some sectors in which air transportation’s modal share was close to twice the economy-wide average, suggesting that air transportation is especially important to these industries or fulfills additional business functions that cannot be met by alternative modes of transportation. In the Computer Systems Design and Related Services sector, for example, air transportation accounted for 66% of all intermediate use of transportation as a purchased-service.

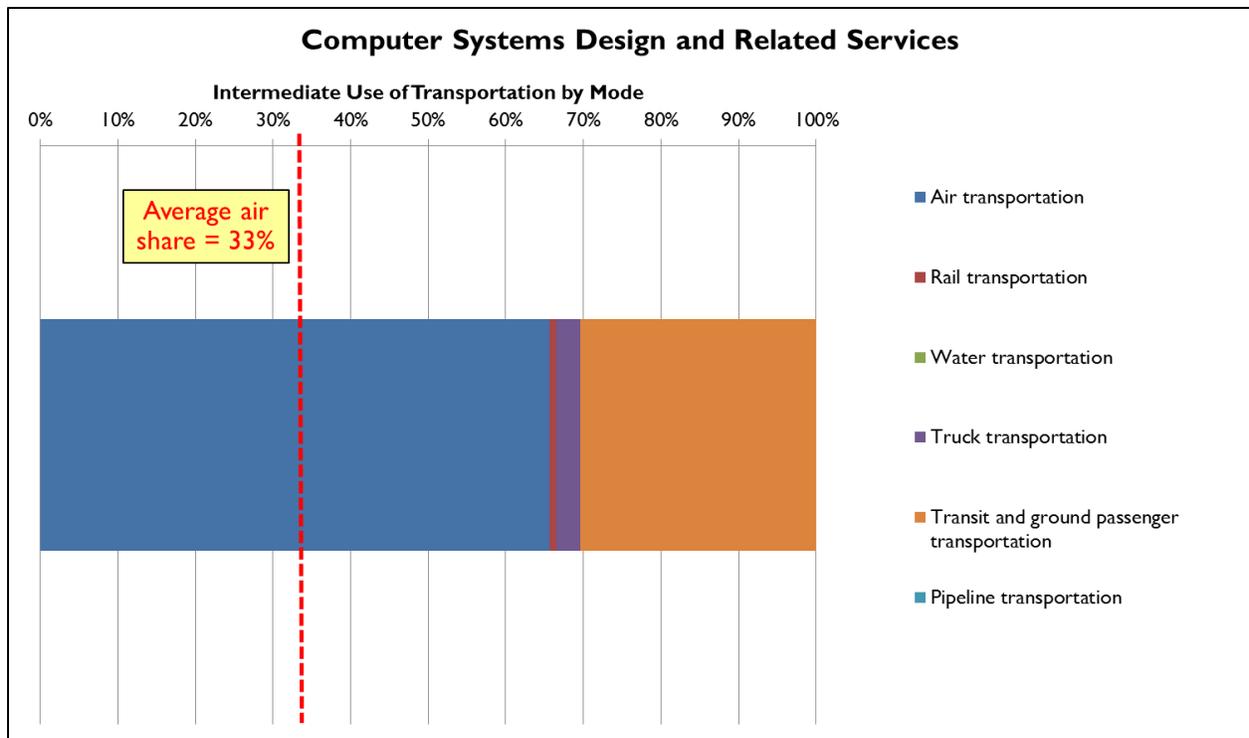


Figure 3-12: Modal share of purchased-services, Computer Systems Design and Related Services

Other industries with a disproportionately high share of air transportation use relative to other modes of transport include:<sup>7</sup>

- Federal Reserve Banks, Credit Intermediation, and Related Activities: 65%
- Information and Data Processing Services: 61%
- Administrative and Support Services: 60%
- Ambulatory Health Care Services: 58%
- Real Estate: 58%
- Securities, Commodity Contracts, and Investments: 58%
- Publishing Industries (includes Software): 57%
- Federal Government Enterprises: 55%
- Food Services and Drinking Places: 54%
- Broadcasting and Telecommunications: 50%
- Other Services, except Government: 48%

<sup>7</sup> Figures of modal shares of purchased-services for all industries can be found in Appendix C.

- Miscellaneous Professional, Scientific, and Technical Services: 43%
- Other Transportation and Support Activities: 41%
- Wholesale Trade: 41%
- Federal General Government: 34%

As observed throughout this chapter, there is an underlying propensity for services-producing sectors to rely on more air transportation as a production intermediate. Use of air transportation is especially high in those sectors that require a high degree of coordination and communication between employees and clients or between employees and management who work in different locales.

By contrast, a sector such as Retail Trade uses a relatively small percentage of air transportation: 13% during 2010 (Figure 3-13). In the case of Retail Trade, the cost effectiveness of truck transportation for moving goods largely explains why this sector does not use more air transportation.

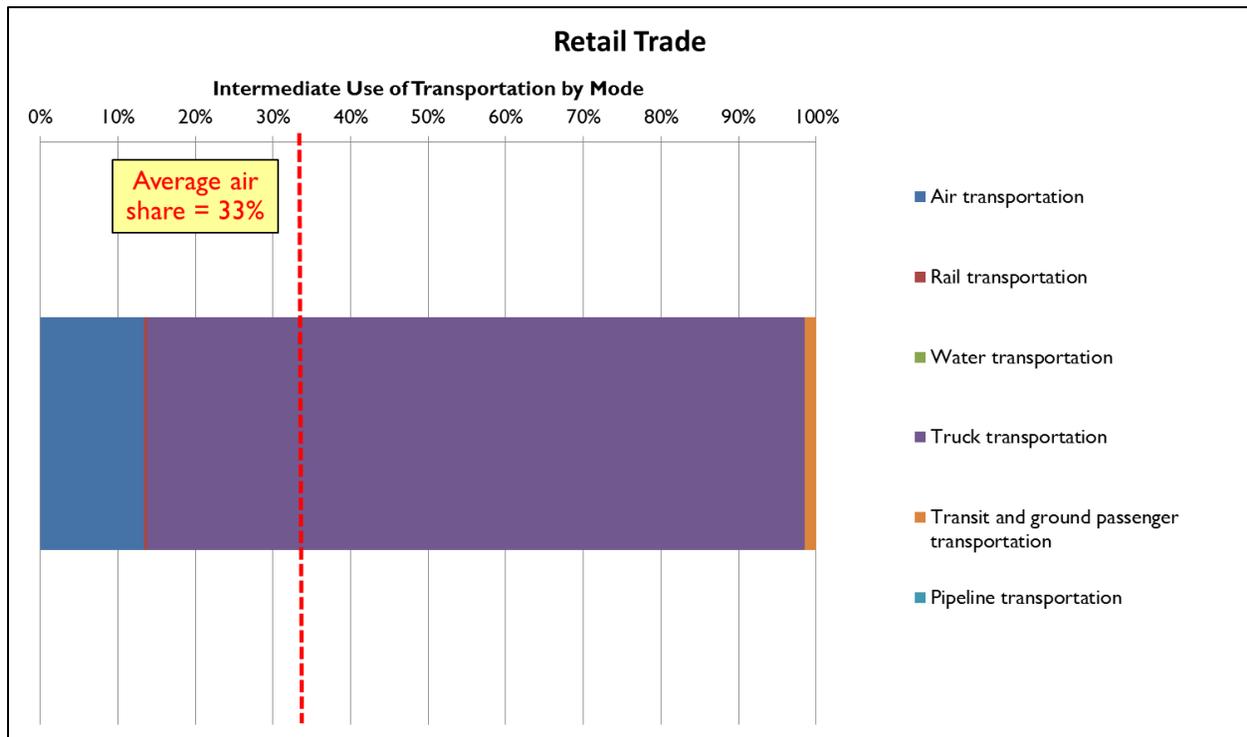


Figure 3-13: Modal share of purchased-services, Retail Trade

### 3.6 SUMMARY OF INTERMEDIATE USE FINDINGS

Analysis of BEA I-O use data from 1998 through 2010 reveals that intermediate use of air transportation has been relatively flat over this period despite rising GDP and overall economic output. Given the overall economic growth over this period, flat intermediate use combined with a wide range of correlations between air transportation use and labor productivity suggest that air transportation's impacts on productivity are smaller than anticipated and perhaps even negligible. While transportation is generally thought to be economically beneficial, the impact on productivity provided by mature systems is potentially smaller than that achievable by the introduction of an entirely new system. There exists some research to date that suggests diminishing marginal benefits of transportation as systems expand (MacKinnon et al., 2008, p. 19). There are several explanations for why this might be the case. In a mature system that already offers a high level of access, businesses are able to structure processes around multiple mode choices that might connect the same locations. Cost is often one of the most important factors in a mode selection and explains why the relatively expensive mode of air transportation is used much less for moving goods than are cheaper truck or rail options. While the speed of air transportation can be critical for businesses that rely on just-in-time supply chains, for many other sectors the speed is not worth the extra cost. In cases where the conveyance of information, whether it be via face-to-face contact or time-sensitive documents, is especially critical; however, transportation costs become less important than the speed of delivery. This observation helps explain in part the other notable result of this analysis: the fact that services-producing sectors consume a higher share of air transportation relative to the rest of the economy.

Initially, it was assumed an I-O analysis of intermediate use might show significant use of aviation by goods-producing industries. Air transportation is well documented in helping expedite the delivery of key supply chain components and aiding just-in-time production. In cases where certain parts are immediately needed in order to avoid production disruptions, air transportation can help replace those parts within a matter of hours. Even under typical procurement conditions, the speed of air transportation can help reduce inventory costs due to shorter lead times. Despite these functions; however, it was in the services-producing sectors, not the goods-producing sectors, where the I-O analysis suggests air transportation is especially critical. A stable to slightly increasing trend in air transportation use combined with

high use overall relative to all intermediate uses and other transportation modes by many services sectors and governments suggest that air transportation plays more of a critical role for those high-value industry sectors that require extensive access to markets, labor, and capital. The analysis in the next chapter continues this services-sector theme when the distributions of business establishments from airports are assessed.

# CHAPTER 4

## ANALYSIS OF THE RELATIONSHIP BETWEEN INDUSTRY LOCATION AND AIRPORT PROXIMITY

Across the U.S., airports play a vital role in ensuring the economic competitiveness of regions, states, and metropolitan areas. One question of particular interest to policymakers at the local and regional levels is how does the connectivity provided by air transportation impact business location? There is considerable anecdotal evidence available that addresses the influence of aviation on business location. Headquarters relocations of large companies are often high profile events that derive considerable media coverage. AT&T moved its headquarters from San Antonio, Texas to nearby Dallas in 2008, among other reasons, to be closer to the better air transportation offered by the city's Dallas/Fort-Worth International Airport and Dallas Love Field. According to AT&T's official press release, "being headquartered near leading air transportation facilities is critical to global companies like AT&T as the airline industry continues to consolidate and reduce hubs and flights amid higher fuel prices and industry economic pressures" (2008). In 2011, Chiquita Brands International announced a move of its global headquarters from Cincinnati, Ohio to Charlotte, North Carolina. While a substantial income tax break offered by North Carolina helped seal the deal, substantially better air transportation options in Charlotte were also instrumental in encouraging the move. Cincinnati's primary airport once served as a hub for Delta Airlines, but has seen significant capacity reductions ever since that airline's merger with Northwest Airlines in 2008.<sup>8</sup> By contrast, Charlotte's Douglas International Airport has become an increasingly important hub for U.S. Airways. Direct flights to Frankfurt, Germany (significant because of Chiquita's major European presence) and San Jose, Costa Rica (the location of one of Chiquita's regional headquarters) are major draws to Chiquita in particular. Most notably, the airport offers nonstop flights to all five of Chiquita's main ports, allowing management to always be one flight away from overseeing critical business activities (Portillo, 2011). In a 2008 survey of Pennsylvania businesses, proximity to a Commercial Service Airport was ranked as the sixth most important factor when considering relocation—more important than access to

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<sup>8</sup> Cincinnati/Northern Kentucky International Airport is the primary airport for the Cincinnati area.

universities or research centers, or the presence of a nearby urban business district (Pennsylvania Department of Transportation, 2011, p. 42). Overall, 78% of businesses indicated that the availability of a Commercial Service Airport is a significant factor to consider when contemplating the establishment or relocation of a business (p. 42).

While such anecdotal accounts of the importance of air transportation to business locations is instructional, it is difficult to comprehensively document all (or even most) major business relocations. To their credit, Strauss-Kahn and Vives have published findings on the factors influencing headquarters relocations by utilizing the extensive Dun & Bradstreet *Who Owns Whom?* database of over 84 million companies worldwide (2008). Using a set of approximately 30,000 U.S. headquarters, Strauss-Kahn and Vives employed a nested logit model coupled with a regression analysis to test how a variety of factors could explain headquarters relocations between 1996 and 2001. They found that the probability of relocating in a metropolitan area increases significantly with the availability of airports. Using odds ratios, they estimated that the probability of relocating in a metropolitan area increases by 40% if the city offers a small hub airport (p. 177). The odds of relocation increase by 90% if the metropolitan area offers a large hub airport. As for whether or not a headquarters is likely to move, Strauss-Kahn and Vives found that an airport was decreasingly likely to move with increasing size of its currently available hub (e.g. all else being equal, headquarters in the New York metro area, home to 3 large hub airports, would be less likely to move than headquarters in the St. Louis metro area, home to just one medium hub airport). Specifically, the probability of relocating decreases 33% if the current area offers a small hub and decreases by 40% if the current area offers a large hub (p. 179).

## 4.1 U.S. AIRPORT COVERAGE

In order to test the relationship between business location and airport proximity, U.S. Census data that map establishments by ZIP Code were utilized. Before examining the distribution of population and business establishments from airports; however, it is helpful to understand the distribution of airports themselves throughout the country. At present, there are nearly 20,000 airport facilities in the United States and its overseas territories. Of these nearly 20,000, the majority are privately-owned facilities which do not handle regularly scheduled commercial service. Because this research has been especially concerned with the

impacts available air service might impart to both personal and business travelers, all subsequent analyses have been performed on a subset of all U.S. aviation facilities—Commercial Service Airports.

As of the end of 2010 (the latest year for which complete data was available), there were 498 Commercial Service Airports in the U.S. These are publicly owned airports that have at least 2,500 passenger enplanements annually while receiving scheduled passenger service (FAA, 2012a). Commercial Service Airports with more than 10,000 annual passenger enplanements are termed Primary, while those with up to 10,000 enplanements are termed Nonprimary. Within the category of Primary Airports, finer distinctions are made. Large hubs are the busiest airports in the U.S., handling 1% or more of annual passenger enplanements for the entire U.S.<sup>9</sup> In 2010, there were 29 large hub airports. Medium hubs handle at least 0.25%, but less than 1% of annual U.S. enplanements. There were 36 medium hubs in 2010. Small hubs handle at least 0.05%, but less than 0.25% of annual U.S. enplanements. In 2010, there were 74 small hubs. Finally, nonhub Primary airports handle more than 10,000 passenger enplanements per year, but less than 0.05% of annual U.S. enplanements. There were 249 nonhub airports in 2010. Figure 4-1 shows the location of all U.S. hub and Commercial Service Airports.

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<sup>9</sup> In 2010, total passenger enplanements totaled 713,776,556 (FAA, 2012b). Large hubs handled over 7,137,766 enplanements. Medium hubs handled between 1,784,441 and 7,137,766 enplanements. Small hubs handled between 356,888 and 1,784,441 enplanements.

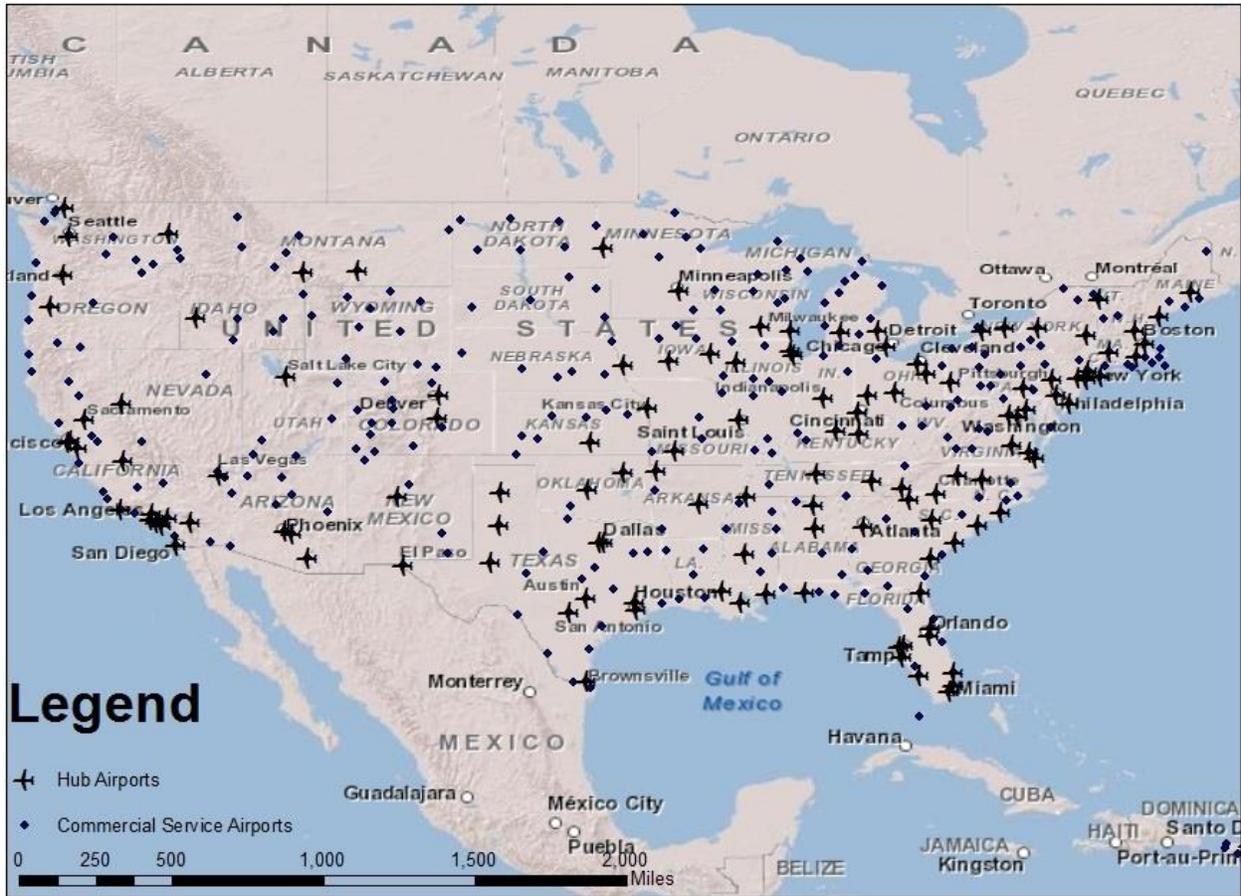


Figure 4-1: U.S. hub and Commercial Service Airports

Figure 4-2 shows the relationship between enplanements and number of airports for the U.S. The figure shows that a small number of airports handle the vast majority of the nation's aviation activity. Out of 1,774 airports with recorded enplanements during 2010, the 16 busiest of those handled 50% of all U.S. enplanements. Large hubs alone (the 29 busiest) handled 70% of total enplanements, while the nation's 139 hub airports (large, medium, and small hubs) handled 96.6% of total enplanements. Because the additional 359 other commercial service airports were only responsible for an additional 3.2% of enplanements, the set of hub airports have been retained as a representative set of U.S. airports for most of the subsequent location distribution analyses. Analyses were also performed for additional sets of airports in order to test the sensitivity of distributions to the set of airports considered. These sensitivities are discussed briefly here and additional results can be found in the appendix.

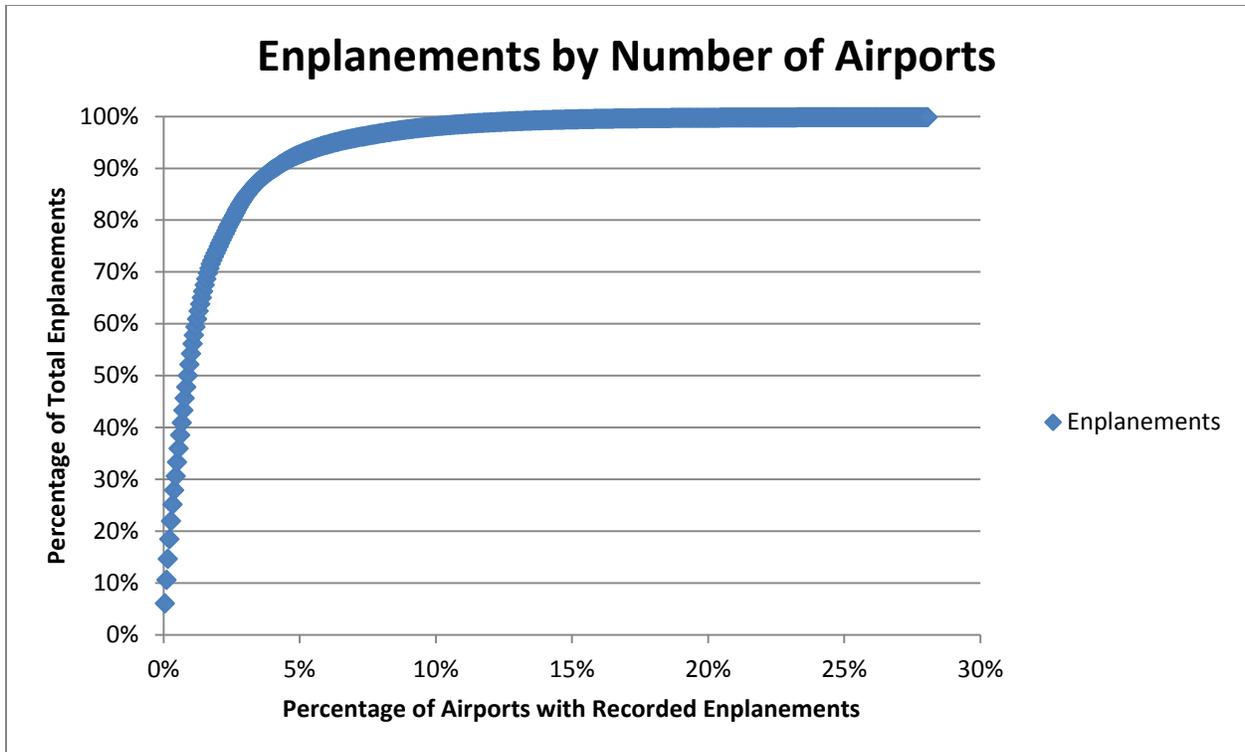


Figure 4-2: Distribution of total enplanements by number of airports

## 4.2 POPULATION DISTRIBUTION

As a first step, the spatial distribution of the U.S. population from hub airports was calculated using a method similar to that previously employed by Bonnefoy and Hansman (2008). For this method, Esri’s geographic information system ArcGIS was used to map population by U.S. Census tract. The U.S. Census Bureau publishes shapefiles which consist of the 2010 Census TIGER/Line Shapefiles merged with the 2010 Census Summary File 1 Demographic Profile (DP1). The 2010 Census TIGER/Line Shapefiles are purely geographic representations, consisting of linear features (such as roads, rivers, legal boundaries), some point features (such as hospitals), and some areal features (such as parks). These geographic features are combined with the demographic data of the 2010 Census to create geographic shapefiles that can be analyzed in an application like ArcGIS.

The units of analysis for the merged shapefiles are census tracts. Census tracts are small statistical subunits of counties. Tracts are drawn by the U.S. Census Bureau to contain a population between 1,200 and 8,000 people, with an optimum tract consisting of 4,000 people (2012b, p. 41). Because tracts are drawn based on population, they vary in size depending on

population density. Urban tracts might encompass only several city blocks, while rural tracts in sparsely populated locations can be several thousand square miles. While census block groups and blocks are even more finely partitioned units, tracts are the most commonly used subdivision since they are sufficiently small in populated areas as to account for local demographic variations, but not overly small as to require excessive data procurement and processing time. Analyses using the smaller census blocks are typically confined to the county or state level. Since the analysis of population distribution relative to airports occurs at a national level, the use of census tracts provides a sufficient level of detail without the considerably greater time demands required for processing block-level data.

In order to compute the distribution of population from hub airports, a series of buffers were constructed around the hub airports. After performing sensitivity tests, buffers in 5 mile increments were used out to 50 miles. Beyond 50 miles from hub airports, buffers in increments of 10 miles were used out to 100 miles. As an example, census tracts whose centroids were contained within a buffer of 5 mile radius were counted as being within 5 miles of a hub airport. Most census tracts are either entirely contained within or entirely excluded from a given buffer. For those buffers that lie on the border of a buffer, when aggregating over all 74,002 census tracts, it is reasonable to assume that approximately half of all split buffers will have centroids that lie within the buffer and the other half will have centroids that lie outside the buffer. Therefore, using the centroid to determine whether a census tract lies within a buffer is a reasonable approximation to use for estimating the number of people within a given radius of a hub airport. Figure 4-3 illustrates how census tracts are selected within a 5 mile buffer in the Chicago metropolitan area.

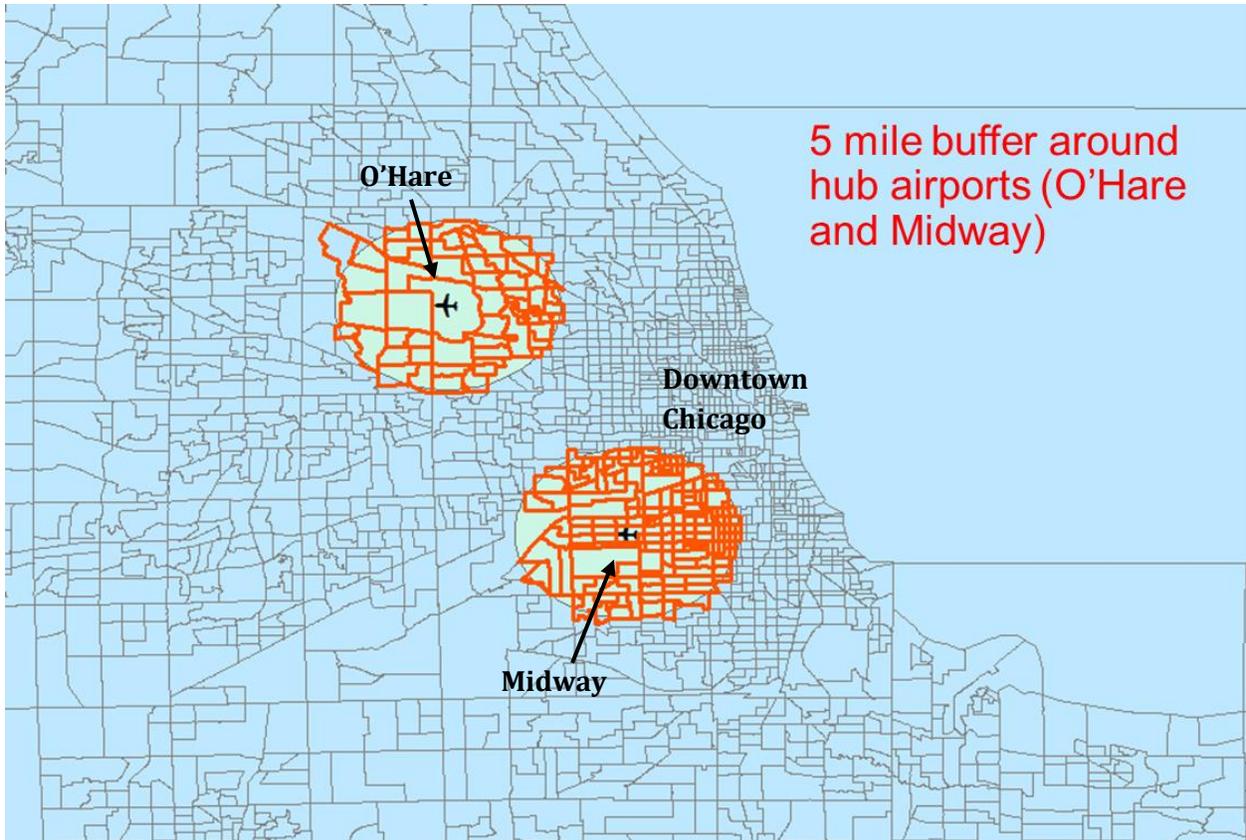


Figure 4-3: 5 mile buffers around Chicago hub airports with selected census tracts

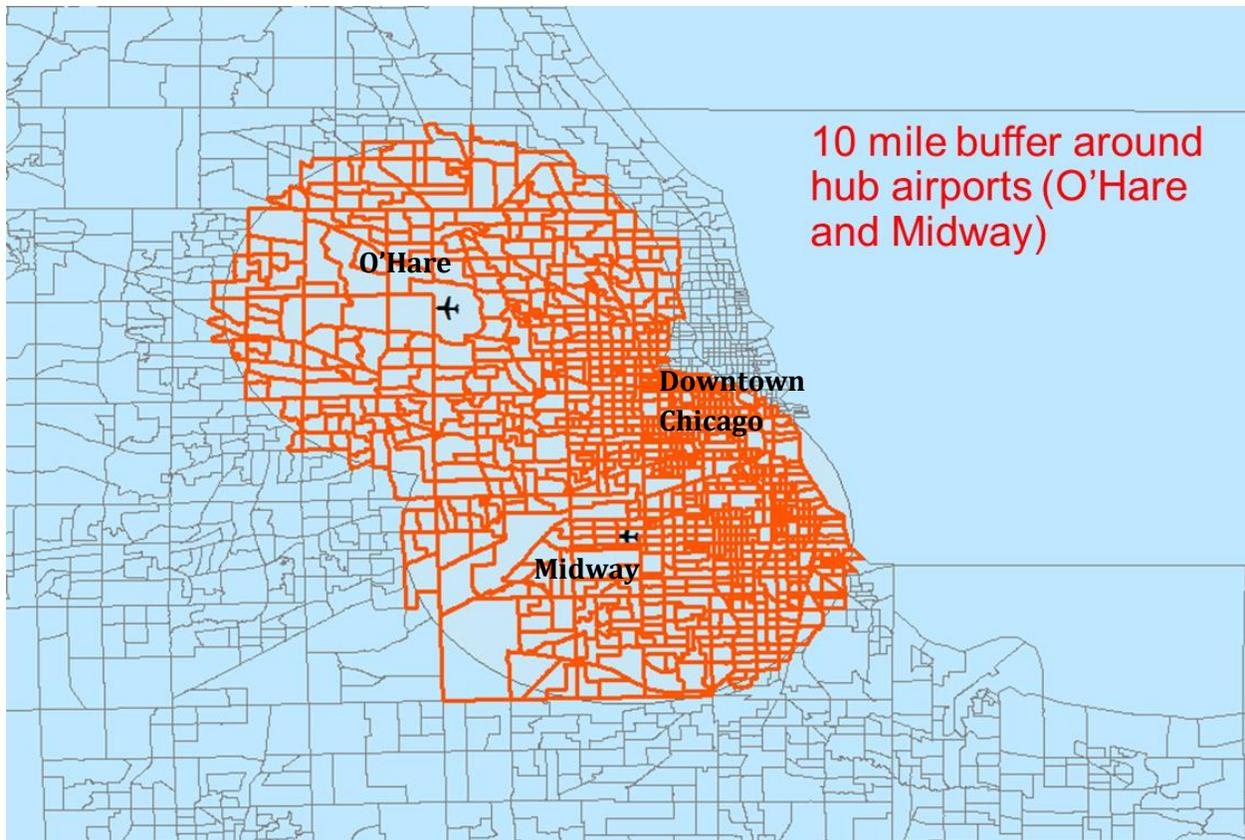


Figure 4-4: 10 mile buffer around Chicago hub Airports with selected census tracts

In cases where neighboring airports have buffers that overlap, buffers are merged in order to avoid double-counting population (see Figure 4-4). For example, in the Chicago metropolitan area, many people live within 10 miles of either of the city's two hub airports.<sup>10</sup> Figure 4-5 depicts the Northeast U.S. and shows numerous merged buffers when selecting census tracts within 50 miles of a hub airport.

<sup>10</sup> These hubs are Chicago O'Hare International Airport and Chicago Midway International Airport.

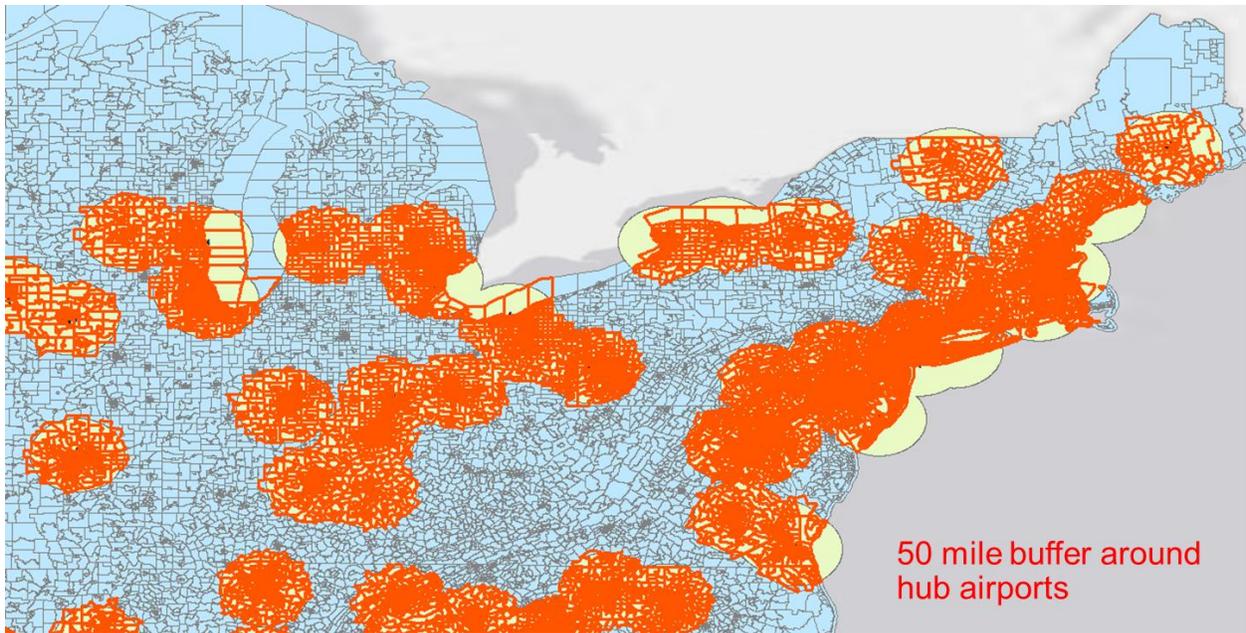


Figure 4-5: 50 mile buffers around select U.S. hub airports

Figure 4-6 shows the resulting distribution of population from U.S. hub airports. For example, based on the selected methodology, 50% of the U.S. population lives within 20 miles of a hub airport, while 77% of the population lives within 50 miles of a hub airport.

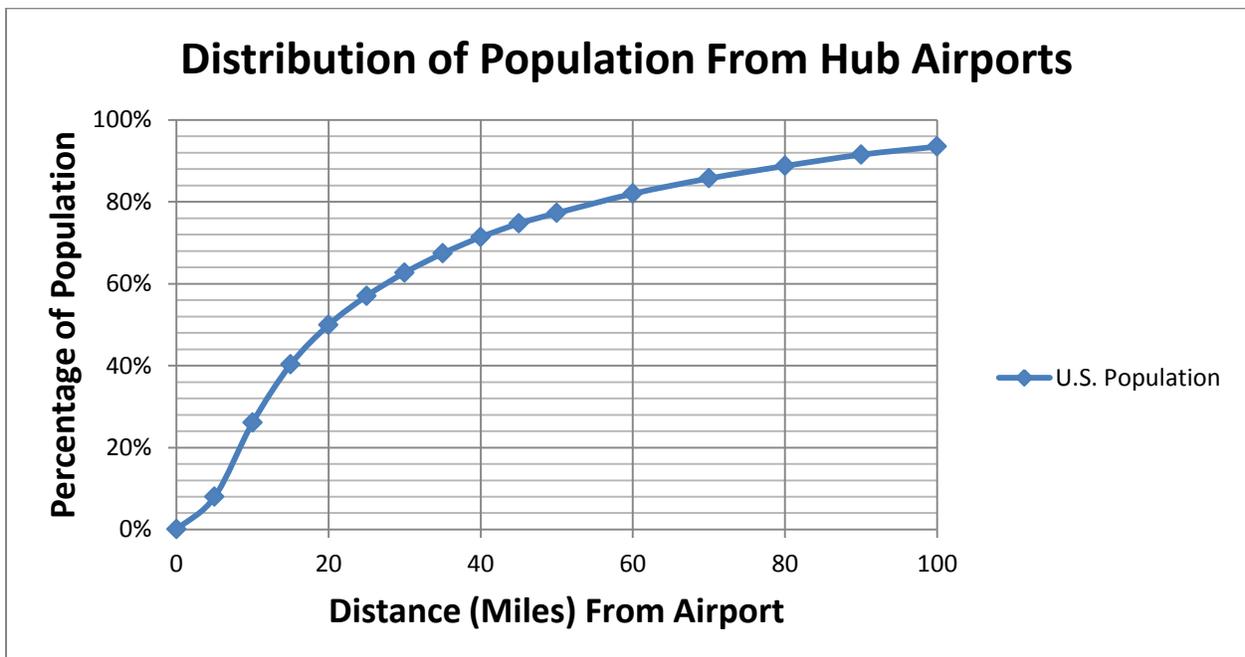


Figure 4-6: Distribution of population from hub airports

By comparison, one can compare the distributions of population from airports for different sets of airports. One would expect to see greater concentration near all hubs, for

example, as compared to just large hubs. Similarly, greater concentration would be expected near all Primary Commercial Service as compared to just hub airports. Figure 4-7 shows the sensitivity of population to airport category. Categories include large hubs, large and medium hubs, all hubs, Primary Commercial Service Airports, and all Commercial Service Airports.

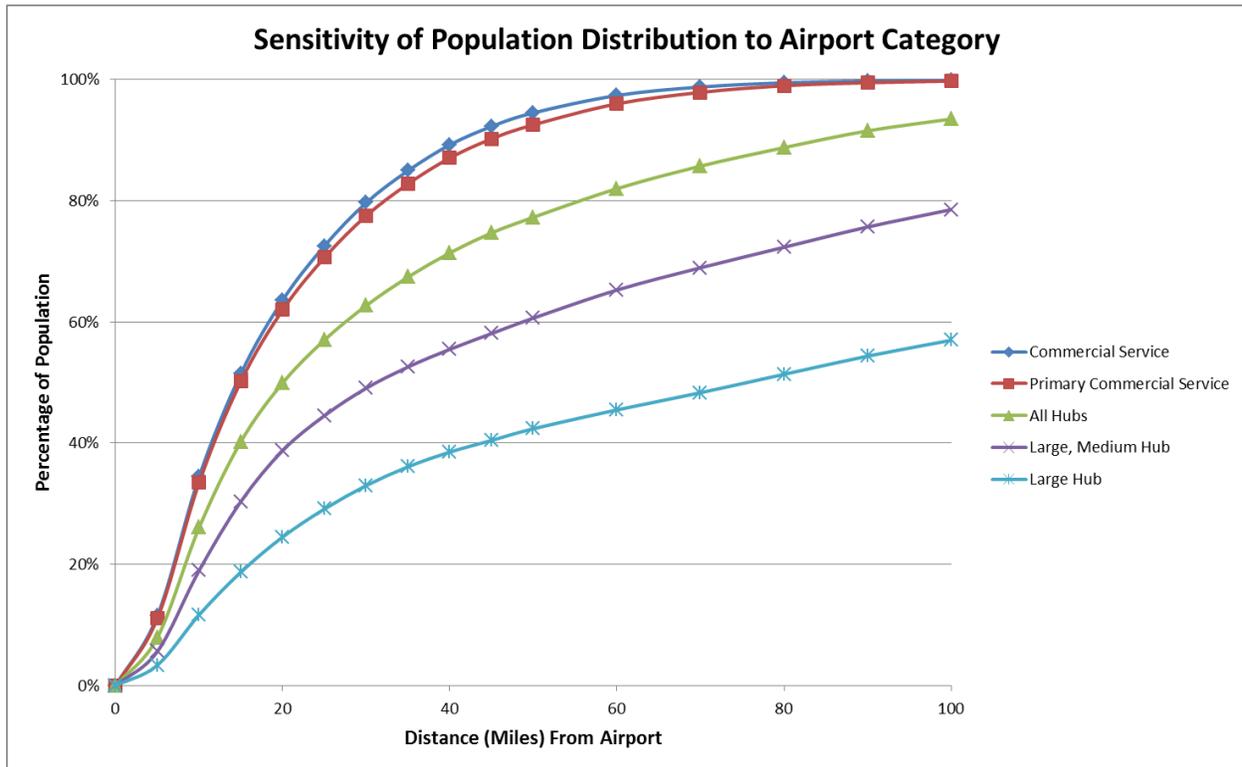


Figure 4-7: Sensitivity of population distribution to airport category

### 4.3 ESTABLISHMENT DISTRIBUTIONS

Having estimated the distribution of U.S. population from hub airports, the next step is to derive similar distributions for U.S. businesses. If access to air transportation is especially critical for businesses, it is hypothesized that such criticality could be revealed by the underlying distributions of businesses from airports. Specifically, one could expect to see greater concentration of businesses near airports than of people.

The data available to track business locations are different from the demographic data available in the 2010 U.S. Census. Instead of using data at the census tract level, this particular analysis uses ZIP Code-level data from the Census Bureau’s County Business Patterns database. County Business Patterns come from the Business Register (BR) database, the

Census' most complete and up-to-date record of single- and multi-establishment employers and include data on number of establishments, employment, and payroll by NAICS sector (U.S. Census Bureau, 2012c). ZIP Code Business Patterns are created from the County Business Patterns and have been used to prepare distributions of establishments from airports since they provide greater detail than the county level data. The challenge of using ZIP Code data is that ZIP Codes themselves do not have polygonal boundaries like states, counties, or census tracts. ZIP Codes are assigned by the U.S. Postal Service for the purposes of mail distribution. While they often follow physical boundaries, such as roads, because they are only assigned according to delivery location, their borders cannot always be easily drawn. While the Census Bureau publishes a set of ZIP Code Tabulation Areas (ZCTAs) that approximate the physical location of ZIP Codes, the ZCTAs combine some adjacent or sparsely populated ZIP Codes in many cases, making it difficult to compare the ZIP Code Business Patterns to the ZCTAs. Instead, this analysis uses a dataset of U.S. Zip Code points prepared by Esri. The Esri dataset assigns a single point for each ZIP Code according to delivery-based centroids. ZIP Codes with few or no street delivery locations get assigned to a single organization that has street delivery. As a result, the Esri set is considerably more comprehensive than the ZCTAs (containing 41,403 unique ZIP Code points as compared to the only 33,120 ZCTAs in the 2010 set of data). Figure 4-8 shows a map of the U.S. covered by the 40,000+ ZIP Code points. Points corresponding to multiple delivery locations are termed "ZIP Code areas," while points representing single delivery locations are "Post Office or large volume customers."

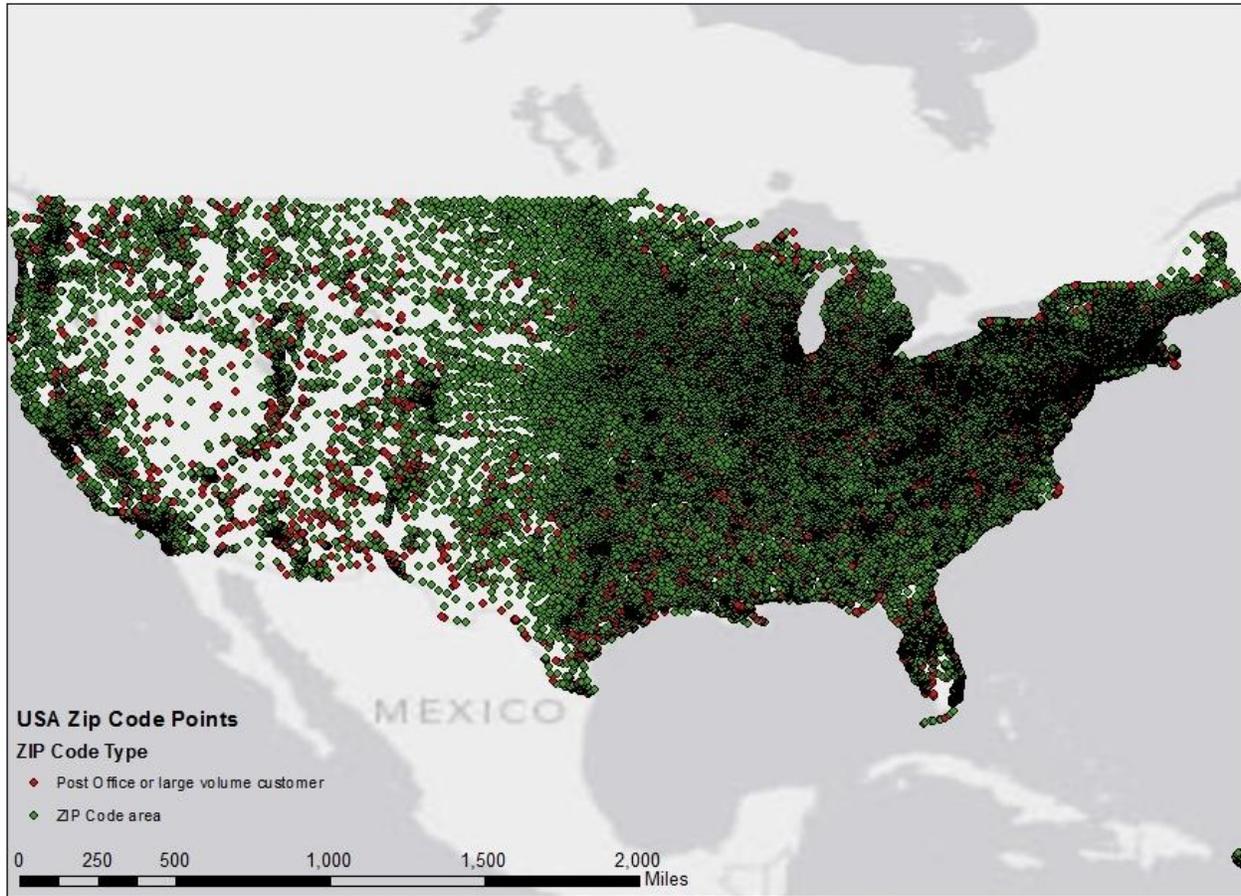


Figure 4-8: U.S. ZIP Code points

After mapping establishment counts for each ZIP Code from the ZIP Code Business Patterns to the Esri points dataset, buffers are constructed around each hub airport just as they are for the population distribution analysis. Since the ZIP Code points are based on the centroids of delivery locations, all ZIP Code points lying within a given buffer are counted, while those lying outside a buffer are excluded for a given count.

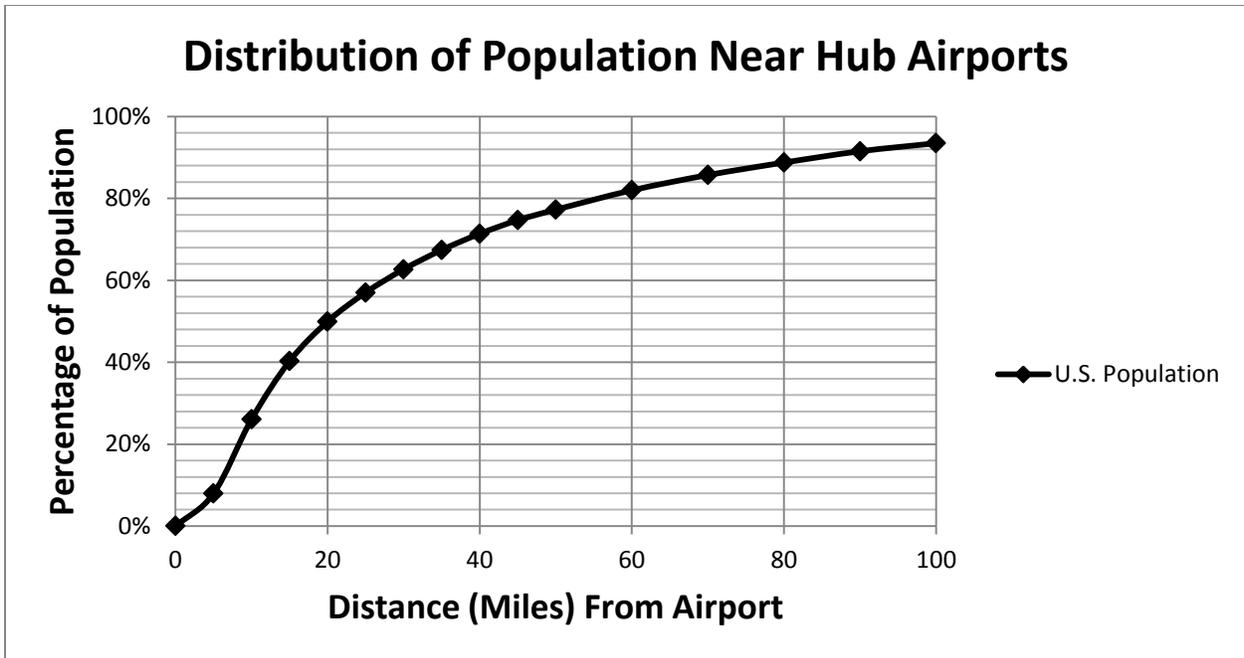


Figure 4-9: Distribution of establishments from hub airports

Figure 4-9 shows the distribution of all business establishments from hub airports. The distribution of all business establishments from hub airports is very similar to the distribution of all population. For comparison, Figure 4-10 shows distributions for both population and business establishments.

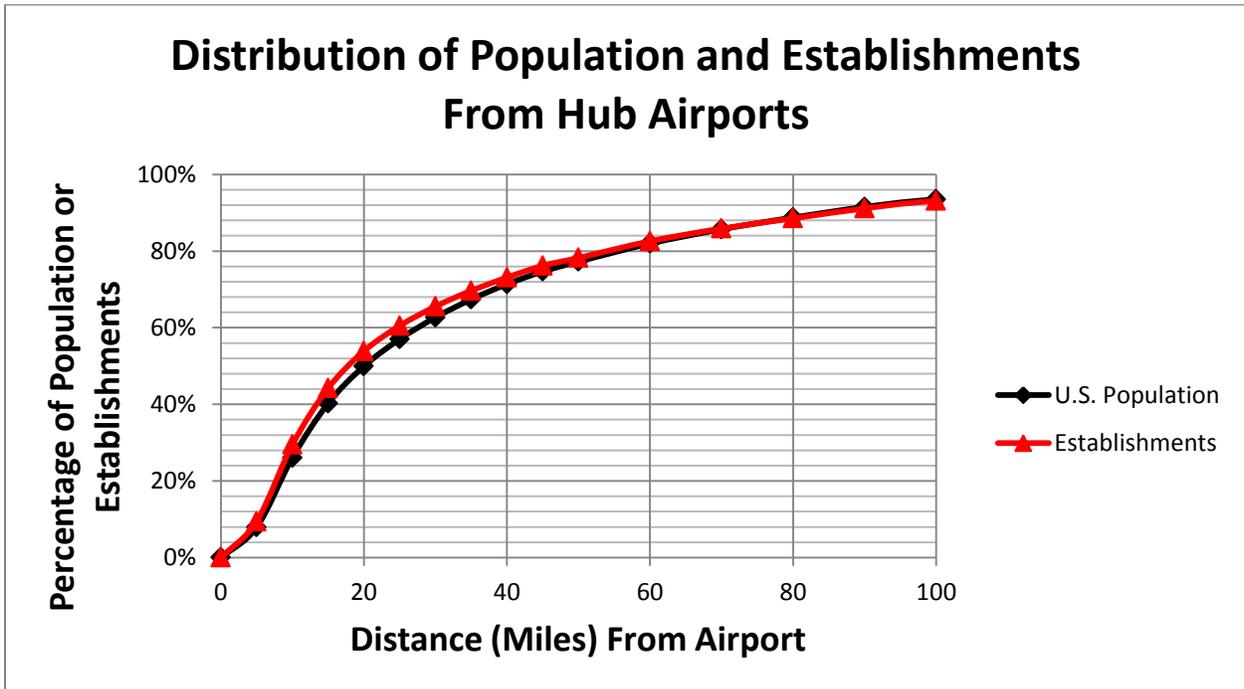


Figure 4-10: Distribution of population and establishments from hub airports

The fact that both distributions are quite similar is perhaps not surprising. When aggregating all people and businesses, it is reasonable that 50% of all people and 50% of all business establishments are located within 20 miles of a hub airport. What is less obvious and more significant for understanding air transportation's role in influencing business location is how such distributions change for only a subset of all businesses. In particular, are there certain industries where pronounced differences in such distributions might suggest that hub airport proximity is a key driver of location?

Again, using the ZIP Code Business Patterns data, establishment counts for each ZIP Code were mapped using ArcGIS. Instead of aggregating all business establishments, businesses were partitioned into one of the 20 2-digit NAICS sectors.<sup>11</sup> All 20 distributions, as well as the distributions for population and all establishments are depicted in Figure 4-11.

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<sup>11</sup> See Appendix B for descriptions of all 2-Digit NAICS sectors

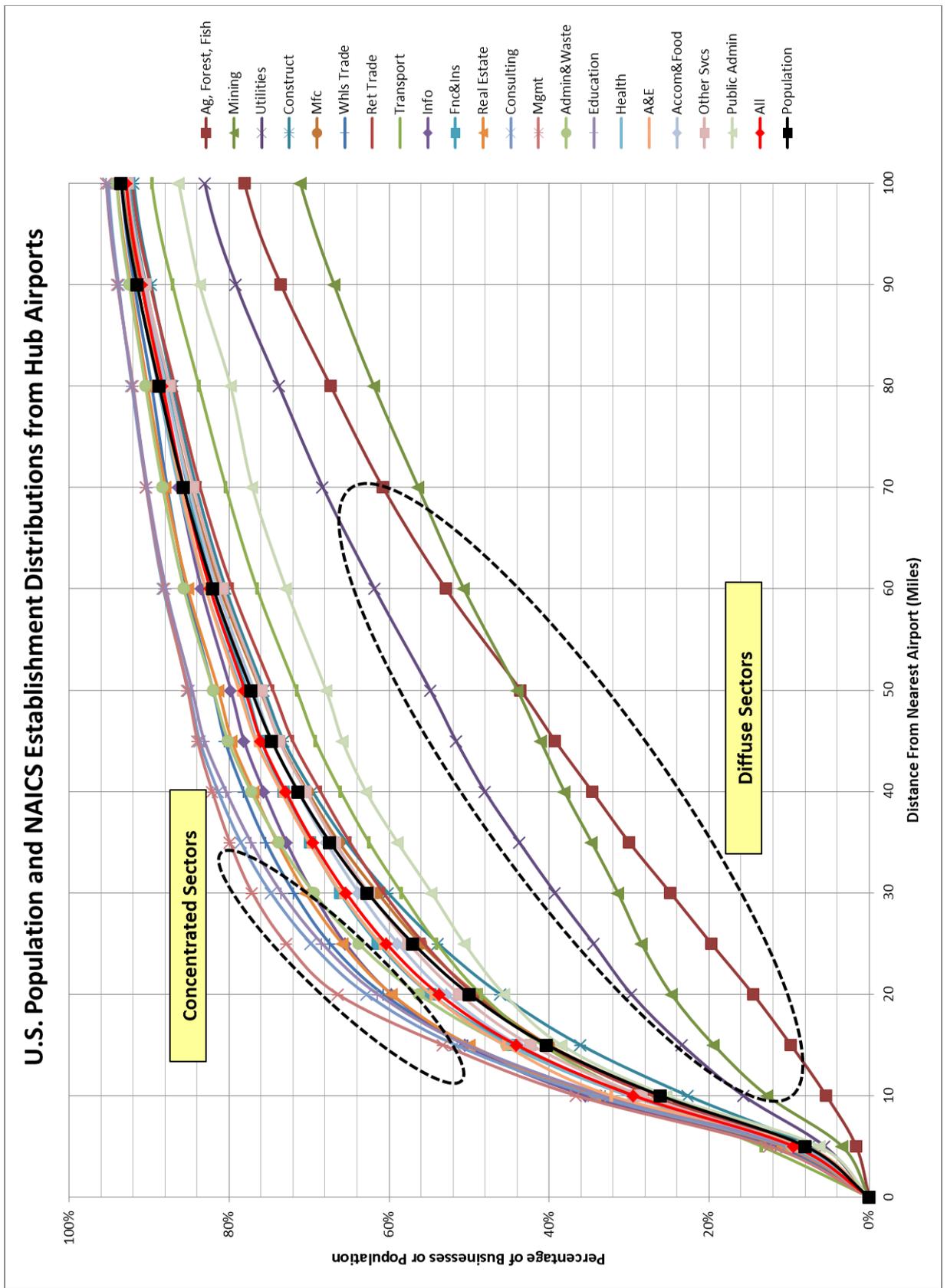


Figure 4-11: All NAICS and U.S. population distributions



These results demonstrate that the distribution of business establishments near hub airports is not uniform across industry sectors. In particular, there are a few key points that are illustrated by the distributions in Figure 4-11. First, certain industries tend to be much more closely distributed from hub airports than all business establishments (depicted as the red curve in Figure 4-11), while other industries are less closely distributed. For example, 66% of establishments in the NAICS 55 sector, Management of Companies and Enterprises, are located within 20 miles of a hub, while only 30% of establishments in the NAICS 22 sector, Utilities, are located within 20 miles of a hub. Second, the hypothesis that the Management of Companies and Enterprises sector (NAICS 55) might be most closely distributed from hub airports due to the need for extensive company oversight, project management, and corporate meetings is confirmed by this analysis. Finally, and perhaps most importantly, most sectors exhibiting greater than average concentration near hubs are services-producing industries, while most sectors exhibiting less than average concentration near hubs are goods-producing industries. More concentrated sectors include:<sup>12</sup>

- Management of Companies and Enterprises (NAICS 55)
  - This sector includes the offices of holding companies that hold the securities of other companies. It also includes corporate, subsidiary, regional, administrative, and head offices. For such offices that are responsible for strategic planning and decisionmaking, nearby access to airports is important in that it allows management to be that much closer to the next flight out to a distant site office or client.
- Professional, Scientific, and Technical Services (NAICS 54)
  - Legal counseling, accounting, architectural and design services, consulting, computer services, research, advertising, and many other technically-oriented services all are comprised within the NAICS 54 sector. For a firm with technical expertise whose services might be in demand across the country, close proximity to the local airport can mean the difference between easily being able to fly out to meet a client or losing out on a project to a competitor.
- Educational Services (NAICS 61)

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<sup>12</sup> More information on specific sector composition and functions can be found in U.S. Census Bureau (2002).

- The sector includes colleges, universities, professional schools, trade schools, computer training, flight training, fine arts instruction, and other training or teaching services. Access to labor and capital is especially important for establishments in the Educational Services sector. For schools that hope to attract talent, the presence of a nearby airport can also help ensure prospective students will visit and current students, faculty, and staff will have flexibility to travel as needed.
- Wholesale Trade (NAICS 42)
  - Wholesalers sell goods or raw materials to other businesses while typically operating out of a warehouse or office. Merchant wholesalers typically own their own warehouses and facilitate the purchase and sale of goods by themselves. Business to business brokers or commission merchants, by contrast, are third parties that arrange for purchase and sale of goods by others and typically do not handle the transacted goods. A medical supplies wholesaler might rely on air transportation to move expensive equipment or materials due to their high value and time-criticality for the hospitals that require them. Likewise, a jewelry merchant wholesaler will frequently use air transportation due to the mode's safety, reliability, and timeliness. Wholesalers are likely to situate warehouses near airports since this minimizes the time required for transferring goods between aircraft and surface transportation.
- Information (NAICS 51)
  - NAICS 51 covers a wide range of functions, including publishing industries, broadcasting services, motion picture and sound recording industries, Internet service providers, telecommunications companies, and many others involved in producing or providing a means for the dissemination of information and data. As for the NAICS 54 sector, the ability to access capital and knowledge bases in is a crucial part of why the Information sector shows a greater than average concentration near hub airports.
- Real Estate and Rental and Leasing (NAICS 53)
  - Includes establishments that deal in renting or leasing real estate, managing real estate for others, and other services such as real estate appraisals. For this

sector, the ability to manage across space might explain why there is a noticeable concentration near hubs.

- Administrative and Support and Waste Management and Remediation Services (NAICS 56)
  - The sectors in NAICS 56 primarily provide day-to-day operational support for other organizations, including tasks such as office administration, personnel hiring, security, and cleaning services. This sector performs duties similar to those of the management establishments in NAICS 55, though ones which typically do not affect upper level management or strategy. For this reason, access to airports appears important for this coordination, but less so than for the NAICS 55 sector.

More diffuse sectors include:

- Mining, Quarrying, and Natural Gas Extraction (NAICS 21)
  - This sector includes establishments that operate mines, quarries, and natural gas or oil wells, as well as those that provide support activities such as exploration, site preparation, and pipeline construction. Because most mining activities occur away from urban areas in fixed locations, access to good air transportation is not as important to this sector as for many of the services sectors. The primary outputs of this sector are materials that due to either their mass (in the case of coal) or physical properties (in the case of oil or gas) are most often transported by rail or pipeline, respectively.
- Agriculture, Forestry, Fishing and Hunting (NAICS 11)
  - Like the NAICS 21 sector, the NAICS 11 sector is heavily tied to the physical resources of a fixed location. Because such locations frequently involve large land areas, establishments in this sector tend to be located in more rural parts of the country. Furthermore, because this sector tends to produce large quantities of output which typically have low value-per-weight, rail, truck, or water transportation tend to be more efficient than air for the transport of such goods to market.
- Utilities (NAICS 22)

- The Utilities sector includes establishments that provide electric power, gas, steam, water, and sewage removal. Establishments in this sector tend to occupy fixed locations over the long term due to the high fixed costs many of these facilities require. Airport access does therefore not appear to be of special importance for coordinating utilities provision.

What these results suggest is that the availability of air transportation has a pronounced effect on industry location. Specifically, greater concentration of a sector near hub airports suggests air transportation is more important to that sector. A key point illustrated by these results is that the sectors most concentrated near airports also happen to be the primary growth sectors of the economy. Figure 4-12 shows gross output for goods-producing, services-producing, and information-communications-technology-producing industries from 1998 through 2010.

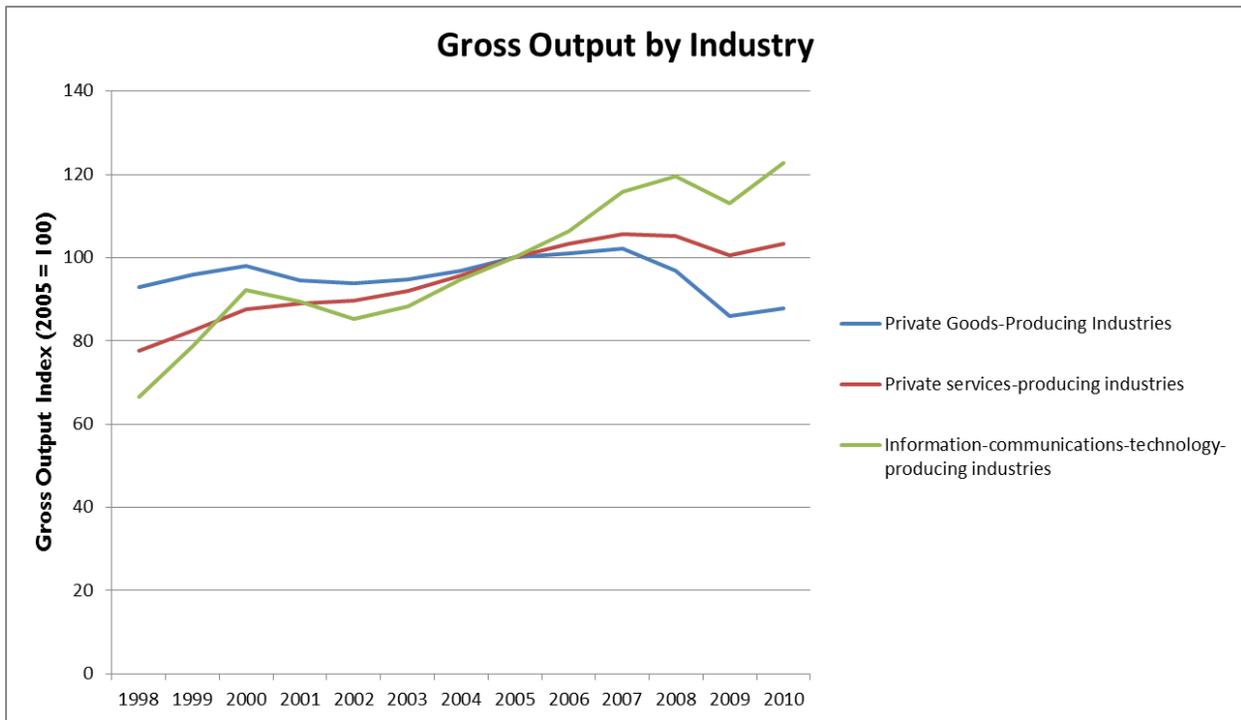


Figure 4-12: Indexed gross output by major industry group<sup>13</sup> (Source data: BEA, 2012b)

<sup>13</sup> Private goods-producing industries include agriculture, forestry, fishing, and hunting, construction, and manufacturing. Private services-producing industries include utilities, wholesale trade, retail trade, transportation and warehousing, information, finance, insurance, real estate, professional business services, educational services, health care, arts and entertainment, accommodation and food services, and other services. Information-communications-technology-producing industries include computer and

As the figure shows, growth in the services-producing and information-communications-technology-producing industries has far outpaced that of the goods-producing industries since 1998. Overall, output in the services-producing and information-communications-technology-producing industries over this period has increased 33% and 85%, respectively, compared to a 5% decline in output for goods-producing industries. The proximity of these high growth sectors to hub airports suggests air transportation has an important role to play in helping sustain this growth.

## 4.4 FORTUNE 500 HEADQUARTERS DISTRIBUTION

To extend the analysis of industry sectors, the distribution of Fortune 500 headquarters from hub airports was also constructed. The addresses of all Fortune 500 headquarters were mapped in ArcGIS and the buffer method of Sections 4.1 and 4.2 was applied once more. Figure 4-13 shows the location of Fortune 500 headquarters in the U.S. relative to hub airports.<sup>14</sup>

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electronic products, publishing industries, information and data processing services, and computer systems design services (BEA, 2012b).

<sup>14</sup> Appendix E summarizes Fortune 500 headquarters by metropolitan area.

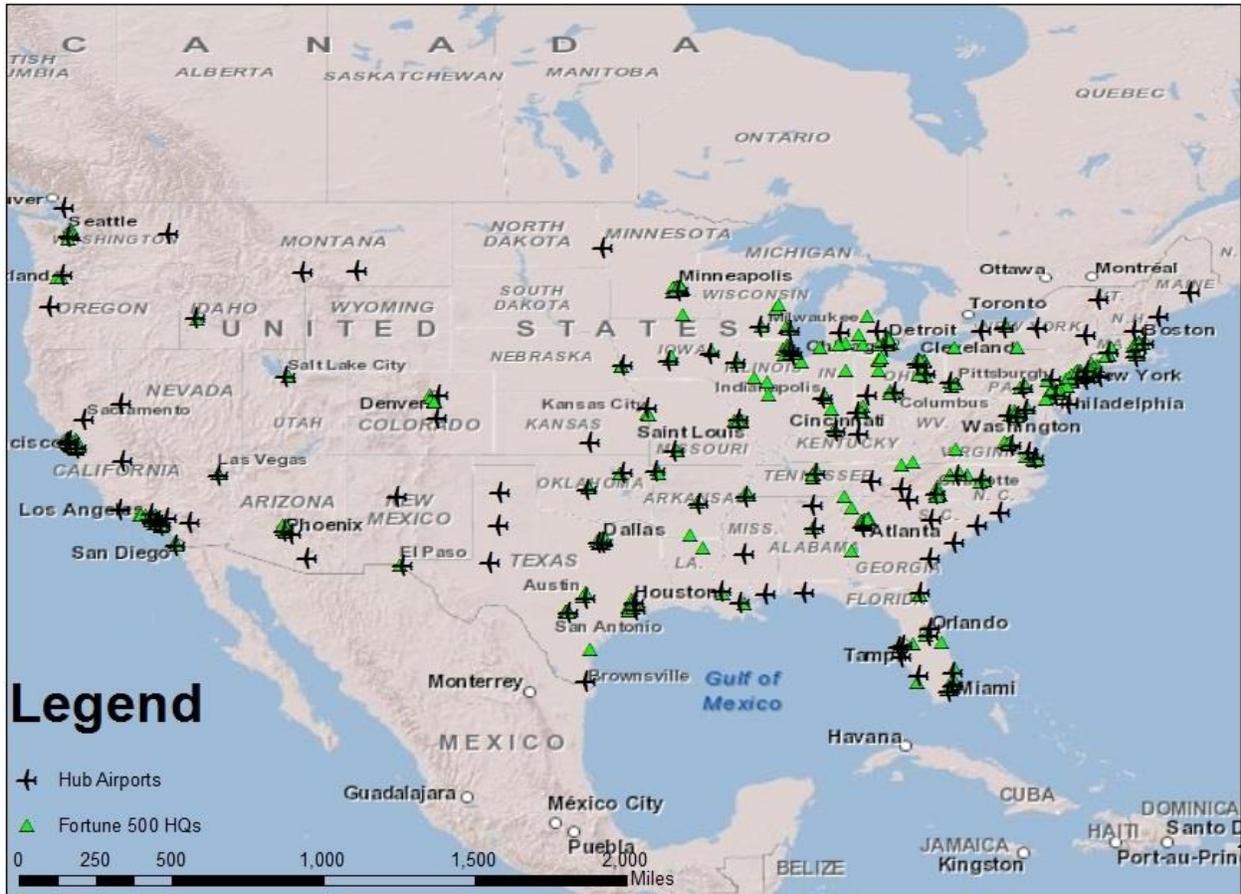


Figure 4-13: Fortune 500 headquarters (2012) and U.S. hub airports

The resulting distribution for Fortune 500 headquarters shows even more concentration near hub airports than for the Management of Companies and Enterprises (NAICS 55) sector (Figure 4-14). Over 50% of Fortune 500 headquarters are located within 10 miles of a hub airport, compared to only 29% of all business establishments that are located within the same distance of a hub. 84% of headquarters are located within just 20 miles.

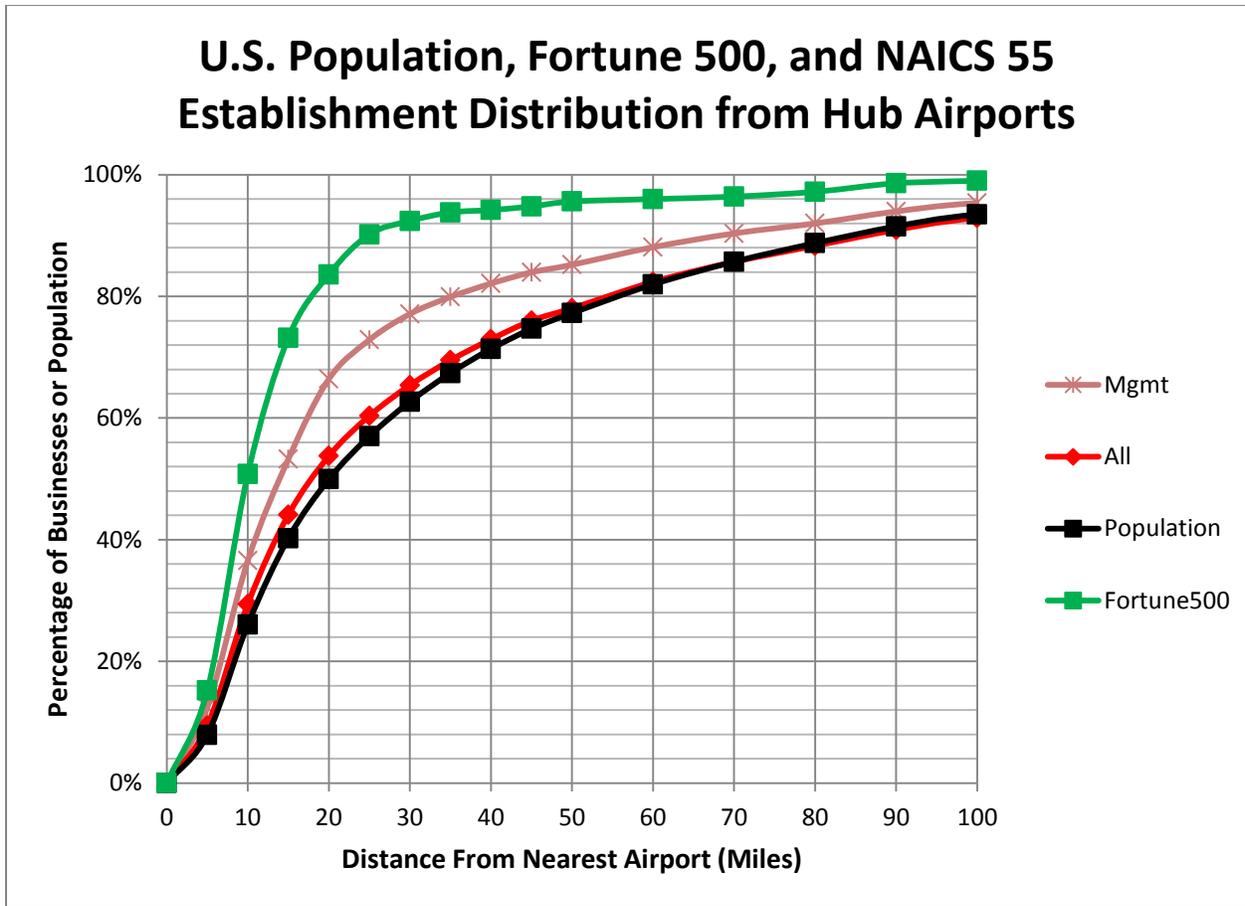


Figure 4-14: Fortune 500 headquarters distribution from hub airports

These results confirm the importance of connectivity for company headquarters and help bolster the findings of studies linking airport access to headquarters location.<sup>15</sup>

## 4.5 DISTRIBUTIONS FROM CARGO AIRPORTS

In addition to examining the distributions of business establishments from hub airports, distributions from a set of airports which report significant cargo flight activity were also created in order to test whether certain industry sectors appear to show stronger concentration near cargo airports as opposed to hub airports. Figure 4-15 shows the distribution of all establishments from both hub and cargo airports. Establishments show a slightly greater

<sup>15</sup> In addition to the Strauss-Kahn and Vives (2008) study, Bel and Fageda (2008) examined the factors affecting the location of firm headquarters in 87 major urban areas throughout Europe. Controlling for other economic factors, they use the availability of direct intercontinental flights as a proxy for an urban area's connectivity to the global economy. They estimate that a 10% increase in intercontinental flights within any area leads to a 4% increase in the number of headquarters that locate in a given area (p. 488).

concentration near hub airports; however, this is likely due to there being a greater number of hub airports than cargo airports.<sup>16</sup> This is confirmed by the distributions of each industry sector from cargo airports. All distributions show slightly greater concentration near hubs with no significant deviations from the distributions observed for hub airports.

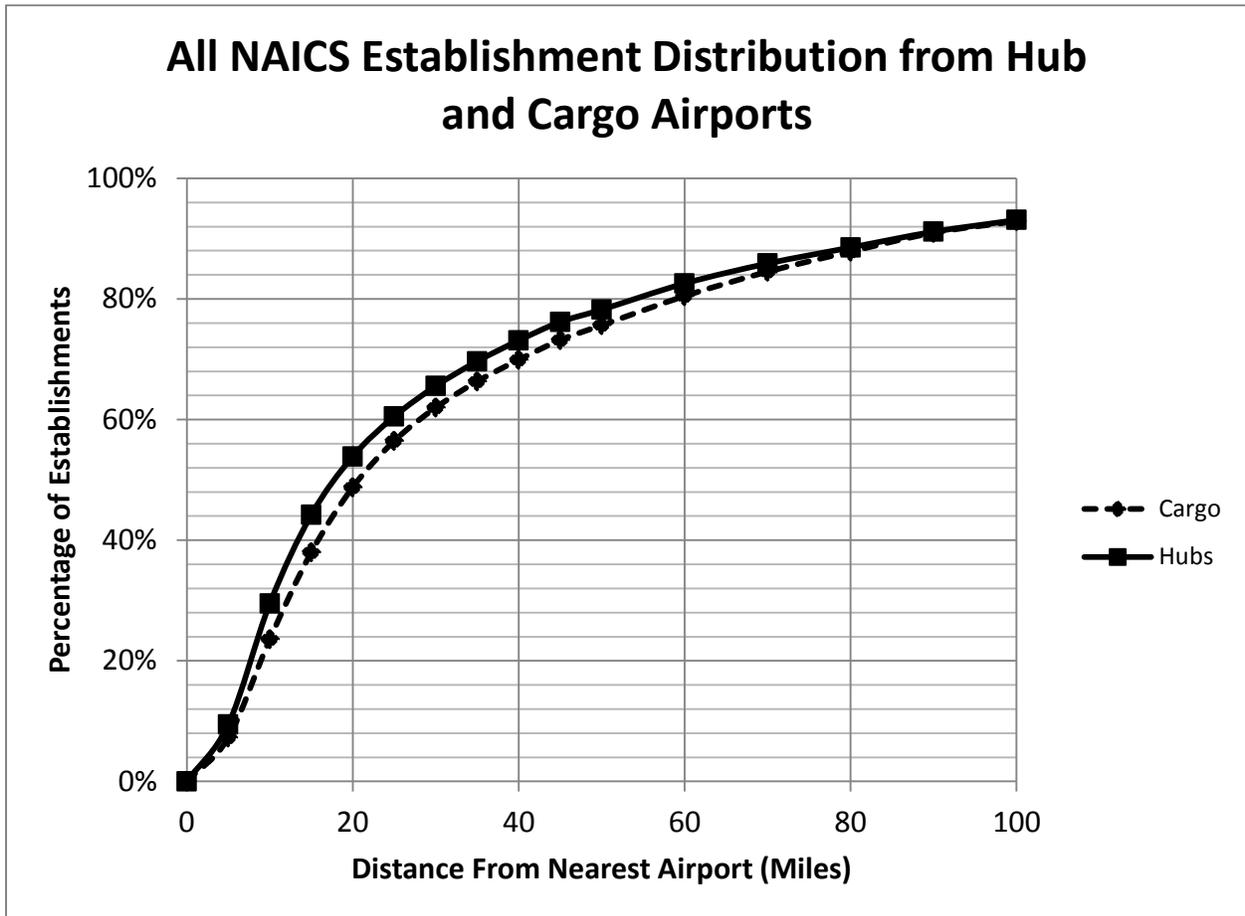


Figure 4-15: Comparison of all establishment distributions from hub and cargo airports

## 4.6 METROPOLITAN AREA DISTRIBUTIONS

In order to examine local differences in industry distributions from airports, the analyses of the previous sections were modified in order to study the distributions of establishments from airports within major U.S. metropolitan areas. As a first exercise, the urban areas of Memphis, Tennessee and Louisville, Kentucky were selected because of their key roles as freight hubs for couriers FedEx and UPS, respectively. In addition to Louisville and

<sup>16</sup> The FAA reports 139 hub airports and 124 cargo airports for 2010 (FAA, 2012b).

Memphis, three other metropolitan areas were selected which are demographically similar to Louisville and Memphis in terms of population, income and population density. Based on these three criteria, the Richmond, Virginia, Oklahoma City, Oklahoma, and New Orleans, Louisiana metropolitan areas were retained for comparison. Table 4-1 displays the demographic data for these five metropolitan areas.

Table 4-1: Demographically-similar U.S. metropolitan areas

METRO AREA	2010 POPULATION	2010 INCOME (MILLION USD)	POPULATION DENSITY (PEOPLE PER SQ KM)
Memphis, TN-MS-AR Metro Area	1,316,100	49,138	111
Louisville/Jefferson County, KY-IN Metro Area	1,283,566	48,093	121
Richmond, VA Metro Area	1,258,251	51,643	85
Oklahoma City, OK Metro Area	1,252,987	47,508	88
New Orleans-Metairie-Kenner, LA Metro Area	1,167,764	49,946	152

To derive metropolitan establishment distributions, a method similar to that used for generating the national distributions has been employed. Because metropolitan boundaries are of limited size and border on neighboring regions, using radial buffers eventually leads to the counting of some establishments that lie outside of the metropolitan area of interest. For each subsequent buffer, establishments are counted and reported as a percentage of the total establishments for a metropolitan area. For small buffers, this means that 100% of establishments counted lie within the metropolitan area of interest. Beyond 30-40 miles, some counted establishments might not lie within the boundaries of the metropolitan area. Figure 4-16 provides an example of a 40 mile buffer centered on Louisville International Airport.

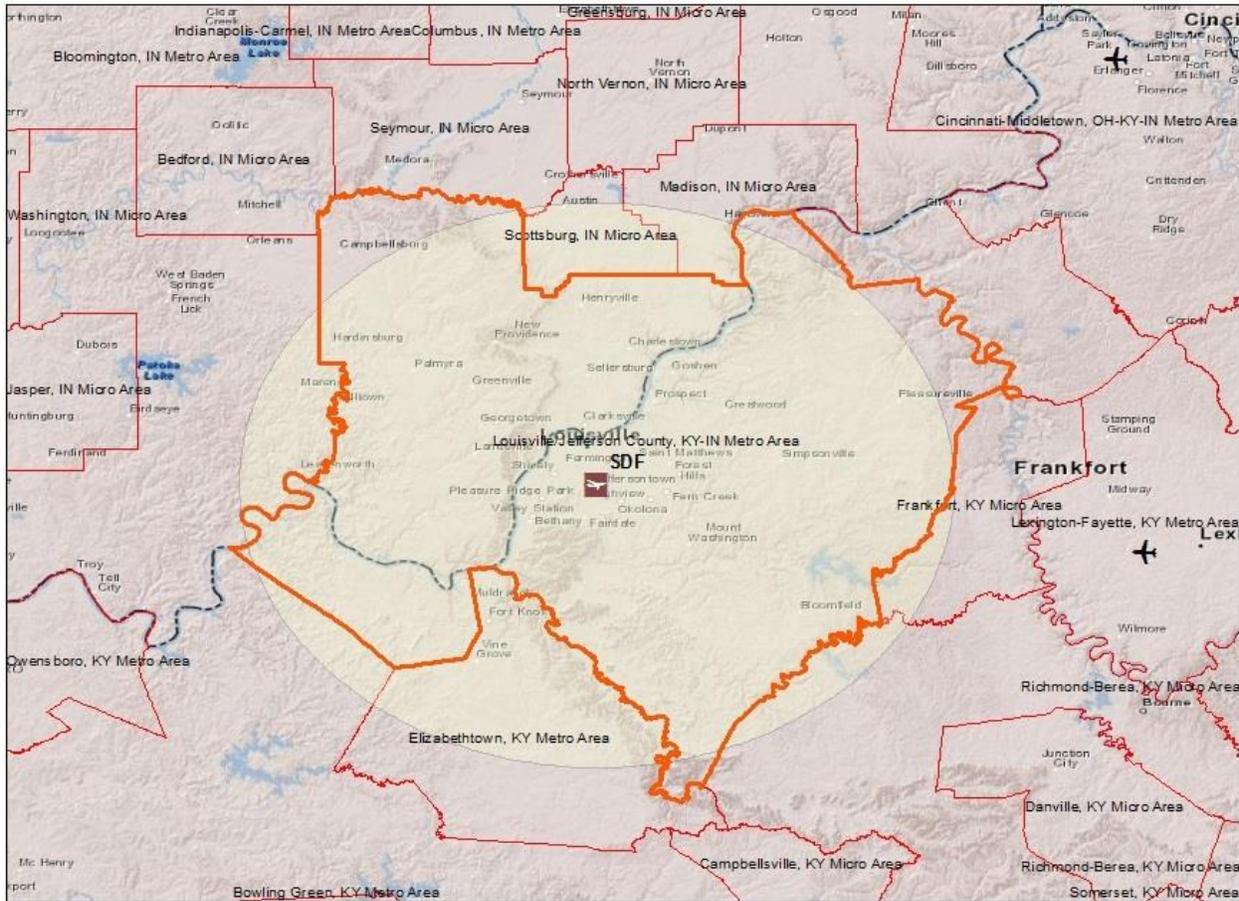


Figure 4-16: 40 mile buffer example for Louisville International Airport

At the edges of a metropolitan area, buffers begin to capture more than 100% of the establishments within a metropolitan area due to establishments that lie in adjacent areas. In Figures 4-17 and 4-18, this is visible for the percentage of establishments located beyond 30 miles. Since the primary purpose of a metropolitan area analysis of industry distributions is to identify industries particularly concentrated near the local airport, this end behavior does not invalidate the analysis. It is also likely the case that some establishments located in neighboring metropolitan areas (especially those near the border) might utilize the airport of an adjacent area, especially if air service at the neighboring airport is of higher quality. For this reason as well, capturing some establishments that lie outside the metropolitan area of interest is acceptable for this particular analysis.

Figures 4-17 displays the distribution of establishments within the Memphis metropolitan area from Memphis International Airport. The effect of FedEx's presence at and near the airport is clearly discernible by the high concentration of the Transportation and Warehousing and Wholesale Trade sectors near the airport. 32% of Transportation and

Warehousing establishments within the entire Memphis metropolitan area are located within only 5 miles of the airport, compared to the only 12% of all establishments located within the same distance of the airport. The presence of FedEx is especially crucial in attracting many establishments within the Wholesale Trade sector to locate near the airport in order to minimize transit and processing times between aircraft and trucks.

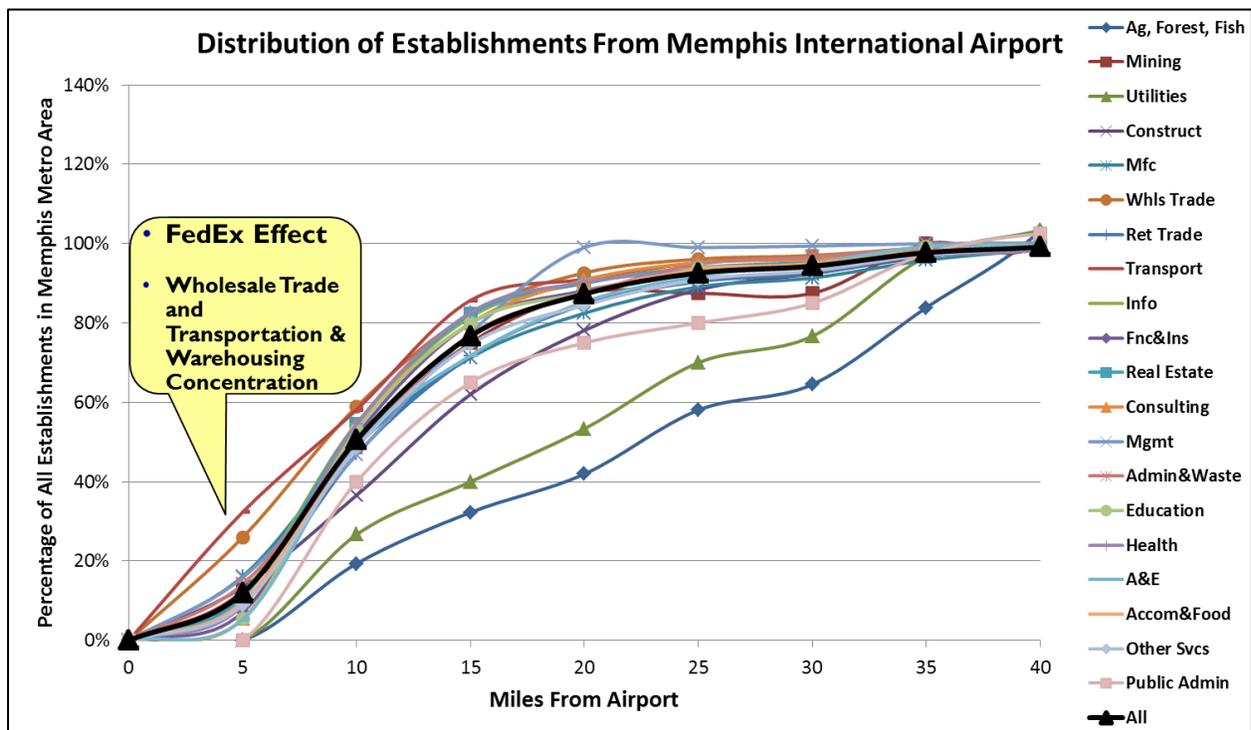


Figure 4-17: Distribution of establishments from Memphis International Airport

There is a similar story to be told for the Louisville metropolitan area, where 31% of all Transportation and Warehousing establishments are located within 5 miles of the Louisville International Airport (compared to the only 19% of all establishments located within the same distance of the airport). The effect of UPS' presence in this area is further evidenced by the above average concentration of Wholesale Trade establishments (Figure 4-18).

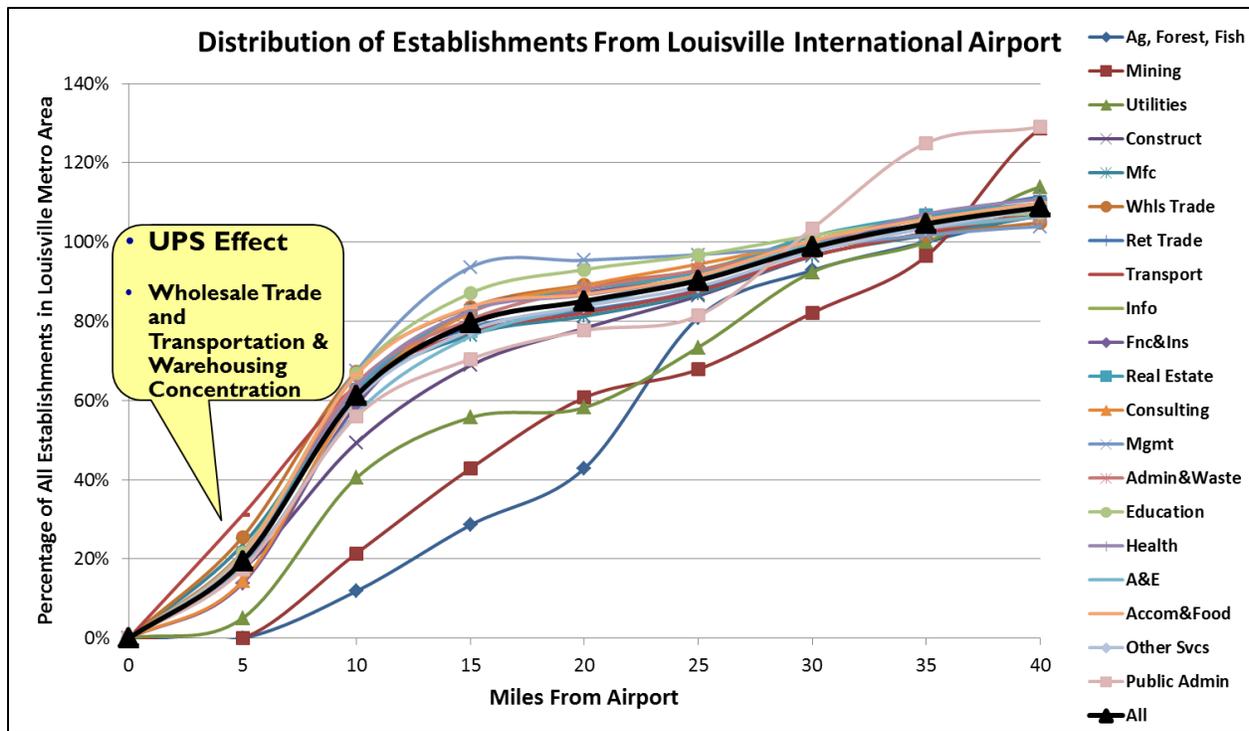


Figure 4-18: Distribution of establishments from Louisville International Airport

## 4.7 SUMMARY OF INDUSTRY LOCATION FINDINGS

Analysis of industry locations relative to nearby airports supports the hypothesis that the importance of air transportation to industry is not uniform. When considered in aggregate, establishments appear to be distributed from airports in a manner similar to population. On a sector-by-sector basis; however, certain industries, especially services-producing sectors, show a revealed preference of locating closer to airports than do industries overall. The analysis also confirmed initial suspicions that industries relying on extensive oversight and face-to-face communication might exhibit the strongest preference for location near airports. Indeed, the Management of Companies and Enterprises (NAICS 55) sector is most closely distributed from hub airports, while Fortune 500 headquarters are even more concentrated near hubs.

The metropolitan area analyses suggests the presence of major couriers in Memphis and Louisville has led to a location shift of some establishments in the Transportation and Warehousing and Wholesale Trade sectors closer to the major airport of each of these urban areas. While it must be acknowledged that establishing causation in these cases, as well as in the other examples cited throughout this chapter, is somewhat confounded by the typical existence of good air service in large metropolitan areas that support sizeable local economies,

the magnitude of the differences in distributions observed between both industry sectors and metropolitan areas suggests air transportation does play a significant part towards influencing industry location.

Overall, the findings of this chapter echo those of Chapter 3, in which data suggested air transportation is especially important to high-value, services sectors that rely on extensive face-to-face communication, management oversight, and market connectivity.



# CHAPTER 5

## CONCLUSIONS & POLICY IMPLICATIONS

This research was conducted in order to better understand the impact of air transportation on the U.S. economy, including potential contributions to productivity and other indicators. As explained at the outset of this thesis, the policy implications of a better understanding of how aviation impacts the economy are wide-ranging and affect an array of stakeholders. Underlying much of this work is the premise that it is important to maintain the country's current aviation infrastructure and to improve those parts of the system that stand to yield the greatest economic benefits. While some other countries have chosen to leave the provision of aviation infrastructure to the private sector, the U.S. has decided the nation's air transportation system warrants government management and oversight, a task assigned to the FAA.

As a first step of this research effort, hypothesized mechanisms by which the use of aviation might elicit a positive contribution to economic productivity were identified, both at the microeconomic and macroeconomic levels. In order to refine these mechanisms and to test the contribution of industry use of air transportation on productivity, I-O use data from the BEA was analyzed for trends, correlations to BLS productivity data, and other relevant information.

This thesis has identified particular sectors of the economy—namely, services sectors—for which air transportation appears to be of particular importance. The data indicate that the federal government and many services-producing sectors rely much more heavily on the use of air transportation, as evidenced by their absolute use, relative use, and proximity to hub airports, than the economy as a whole. What is more, most of these services sectors are moderate to high growth sectors within the economy. In order to ensure the maximum economic potential of these sectors, the government should consider that the most productive sectors of the economy are the ones that stand to benefit the most from a healthy air transportation system.

The link between air transportation use and economic productivity was also investigated as part of this thesis. Based on these analyses, the link between air transportation

use and positive productivity contributions appears to be weak.<sup>17</sup> While all industries use some amount of air transportation, it is difficult to establish causality between such use and changes in productivity over the thirteen year period of analysis. Much of this difficulty is due to the presence of confounding variables, such as the use of new and additional technologies and price fluctuations. While the productivity-enabling effects of air transportation appear weaker than first anticipated; however, other economic impacts seem more pronounced. Both the intermediate use and industry location analyses imply the access to markets, labor, capital, and services provided by air transportation is especially critical to the services-producing sectors.

The finding that certain industries rely more heavily on air transportation than others suggests there is opportunity for the FAA to establish a dialog with particular industry trade groups or representatives in order to maximize potential synergies and align investments. For those industries that do not appear to place a premium on use of air transportation, follow-up work could help identify whether this lack of use is simply due to the particular industry, or due to shortcomings on the part of the country's aviation system.

At the regional level, there also exist opportunities for airport authorities, chambers of commerce, and individual businesses to work together to benefit from aviation. The research suggests there remain opportunities for airports to coordinate with companies to arrange new air service that would improve connectivity and improve regional clout. Likewise, relocation incentives remain a tool to be utilized by regional or local governments when trying to court new businesses. This research defends the anecdotal accounts that good air transportation is one such tool for encouraging company and headquarters relocations.

Finally, the role of hub airports appears to be especially critical. Evidence that Fortune 500 headquarters and other high-growth, high-value services sectors are concentrated near hubs indicates these particular airports play a particularly important role in supporting the nation's economy.

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<sup>17</sup> Though Oxford Economics (2009) notes several studies which suggest an increase in connectivity often leads to increased labor productivity.

## 5.1 RESEARCH LIMITATIONS

As with any investigative undertaking, there are limitations inherent to the present research. While methods and data were selected in order to limit the impact of such limitations, certain choices were made that would not have been required in an ideal world.

### 5.1.1 ACCESS TO ESTABLISHMENT-LEVEL AIR TRANSPORTATION USE DATA

At the outset of this research, a host of activities were considered which might have been able to aid in understanding the contributions of air transportation to a company's productivity (and subsequently, how such company-level productivity gains might translate to the economy as a whole). Annual reports, employee blogs, and media coverage of companies were perused to see what data was available on air transportation use. Aircraft manufacturer Boeing was investigated in order to understand how this company has used air transportation to facilitate the global supply chain that has been responsible for the creation of its new Boeing 787 aircraft. Large retailers (of both the online and brick and mortar varieties) such as Amazon and Walmart were also studied to see how these corporate giants use air transportation to move products across their distribution and retail networks. Two of the largest couriers in the U.S., FedEx and UPS, were also researched for insights on how much of their business involves the use of air transportation. In addition, the 2012 Federal Budget was scanned for information on air transportation use by specific departments and agencies. Beyond these specific sources, numerous anecdotal accounts of air transportation's importance to companies were also documented. In nearly all of these cases; however, there is never information reported on how much and for what purposes air transportation is used within a company. This is not surprising given that such information is generally regarded as proprietary knowledge that could weaken a company's competitive advantage if released to the general public. Nonetheless, it had been hoped that more information regarding specific use of air transportation would have been more widely available. In cases where there was some information about an establishment's use of transportation, such information typically did not specify the mode of transportation used. This was the case for the federal budget, where transportation is listed only as either "travel and transportation of persons," or "transportation of things" (2012).

### 5.1.2 I-O USE TABLE DATA CONSIDERATIONS

While the BEA's I-O use data provided a comprehensive view of how air transportation is used by all sectors of the economy, there are limitations inherent to using this dataset. First, I-O data comes from many sources. The Economic Census is the preferred and most reliable source of data for the I-O accounts; however, these data are only released every five years and exclude some sectors that the I-O accounts include (Horowitz & Planting, 2009, p. 3-1). In order to fill in the data gaps, other U.S. Census Bureau programs collect industry-specific data on an annual basis.<sup>18</sup> While the BEA attempts to reconcile differences in reporting by these various sources, it should be recognized that data contained in the I-O accounts is a composite dataset that intends to provide as representative a description of the U.S. economy as possible given the lack of a single, authoritative source for all economic data.

Second, I-O use accounts report primarily, but not entirely, based on the industry definitions outlined in the NAICS. Since the NAICS has only recently replaced the older SIC, there are only thirteen years of data available for purposes of tracking the use of air transportation by NAICS-defined industries. Older use data exists, based on the SIC definitions; however, due to differences in definitions and the addition of new industries to the NAICS, the BEA strongly recommends against comparing SIC accounts to the NAICS accounts. While there exist correspondence mappings to translate SIC industries to NAICS industries, these particular mappings were found to be incomplete. Given the incompleteness of these mappings and the additional assumptions that would have been necessary to link these datasets, it is not believed that extending these analyses to several earlier years would have added much to the reported findings.

Finally, despite the fact that all I-O data since 1997 has been tied to the NAICS industry definitions, the NAICS industry definitions themselves undergo revisions on a five year basis. While such refinements are typically small in scope, they can result in adjustments to industry classifications that might lead to uncontrolled changes in an industry's reported use of commodities.

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<sup>18</sup> Annual surveys include the Annual Survey of Manufactures (ASM), the Annual Retail Trade Survey, the Service Annual Survey (SAS), County Business Patterns, and Statistics of U.S. Businesses. Other surveys occurring on an annual or five year basis are also used as needed.

### 5.1.3 THE LIMITS OF PRODUCTIVITY

At the outset this research was focused on the contributions of air transportation to economic productivity. Given the array of studies aimed at more traditional economic impacts of air transportation, this might appear to be a reasonable and novel exercise. Porter would likely agree that, due to the central role of productivity gains in impacting a country's standard of living, understanding the impacts of aviation on productivity is a worthwhile exercise that might long be overdue. One should be at least mindful; however, that productivity improvements in and of themselves are only one part of the bigger economic picture. It was Simon Kuznets, the father of modern national production accounting, who first asserted that "the welfare of a nation can scarcely be inferred from a measure of national income" (1934). Kuznets later went on to add that, "distributions must be kept in mind between quantity and quality of growth, between costs and returns, and between the short and long term...goals for 'more' growth should specify more of what and for what" (1962, p. 29). To this end, air transportation's impact on the economy might be considered not only in terms of its productivity-improving capabilities, but also in terms of its influence on quality of life and consumer choice.

## 5.2 ADDITIONAL RESEARCH OPPORTUNITIES

As several of the approaches for examining the economic impacts of air transportation employed in this thesis have received relatively little attention in the past, there remain significant opportunities for extending these and related methods towards future research.

### 5.2.1 RECONCILIATION OF SIC AND NAICS AIR TRANSPORTATION USE DATA

A reconciliation of SIC and NAICS I-O data would allow for analysis of more long term trends in the intermediate and final use of air transportation. I-O use data is currently only known to exist from 1978 (the year of airline deregulation) to the present. Better data on air transportation use during the 1950s, 1960s, and early 1970s could prove especially insightful due to the steady growth in the industry during these decades. Such data might allow one to identify specific industries which incorporated air transportation as a key factor in production. Reconciliation of SIC and NAICS data was outside the scope of this current research, though it

appears unlikely that there even exists data before 1978 at a level of specificity that would allow the estimation of more detailed economic accounts from these earlier periods.

### 5.2.2 TIME SERIES ANALYSIS OF INDUSTRY LOCATION RELATIVE TO HUB AIRPORTS

A time series analysis of industry location relative to hub airports would be a next step towards reaffirming the findings that certain industry sectors tend to cluster more closely near hub airports than others. As is the case for I-O data availability, the ZIP Code Business Patterns data used in this research is only available as far back as 1994. Confounding the data collection exercise in this case is the fact that establishments were reported according to SIC definitions up until the introduction of NAICS in 1998. County Business Patterns statistics exist as far back as 1964; however, the size of many counties would make it difficult to obtain meaningful distributions of the proximity of establishments to airports.

While an analysis of industry location distributions from the mid-1990s might reveal differences in distributions from those observed using 2010 data, a more fundamental issue lies in the fact that there have been only a handful of new airports constructed between 1994 and the present. Denver International Airport is the newest large hub in the U.S., having replaced the now defunct Stapleton International Airport in 1995. Since the opening of the new Denver airport, the only other new airport openings have been those of Northwest Arkansas Regional Airport in 1998, Northwest Florida Beaches International Airport in 2010, and St. George Municipal Airport in 2011. In all cases, these new airports replaced older facilities located nearby.

### 5.2.3 INTERNATIONAL DISTRIBUTIONS OF INDUSTRY LOCATIONS FROM AIRPORTS

While outside the scope of this research's focus on the U.S. economy, a logical extension to the method used in Chapter 4 would be to construct similar distributions for other countries and metropolitan areas. Such analyses might provide valuable insights regarding the importance of aviation to businesses internationally and could yield additional evidence of air transportation's role in enabling market access and interpersonal connectivity for the services sector.

#### 5.2.4 MARKET ACCESS CONNECTIVITY INDEX

One final extension to the location distributions of Chapter 4 would be to explore building a connectivity index based on available air service from a given market and the number of business establishments throughout the country reachable by a nonstop flight from that market. Such indices have been constructed before for population; however, the author is not aware of indices which are partially weighted by establishments (Pearce, 2007). Instead of population, establishments, especially within particular sectors, could provide a more accurate index to the extent that connectivity relies more on the number of businesses within a region rather than population.



# APPENDIX A

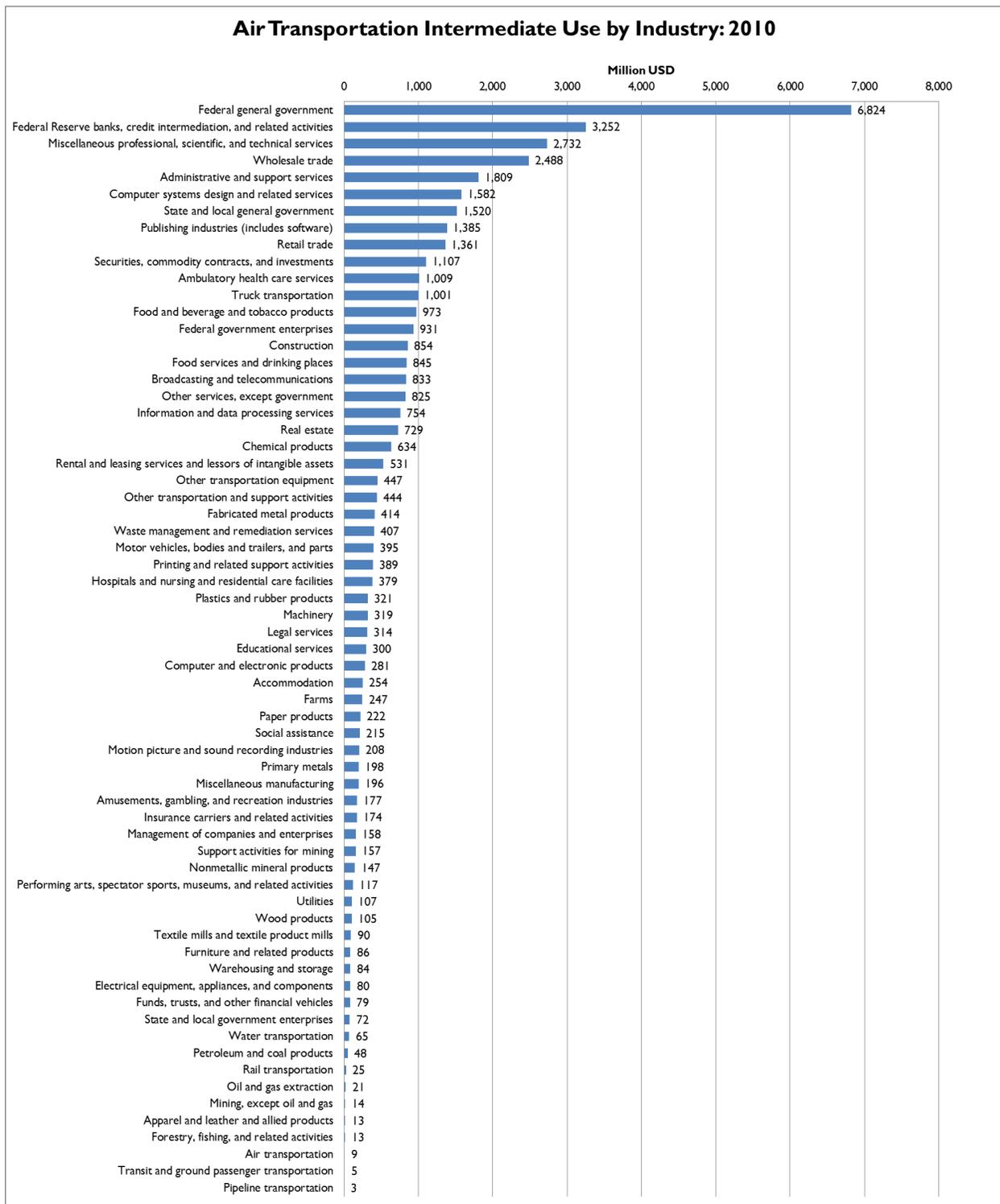


Figure A-1: Intermediate use of air transportation for all I-O industry sectors

### Air Transportation Use Normalized by Total Commodity Intermediate Use: 2010

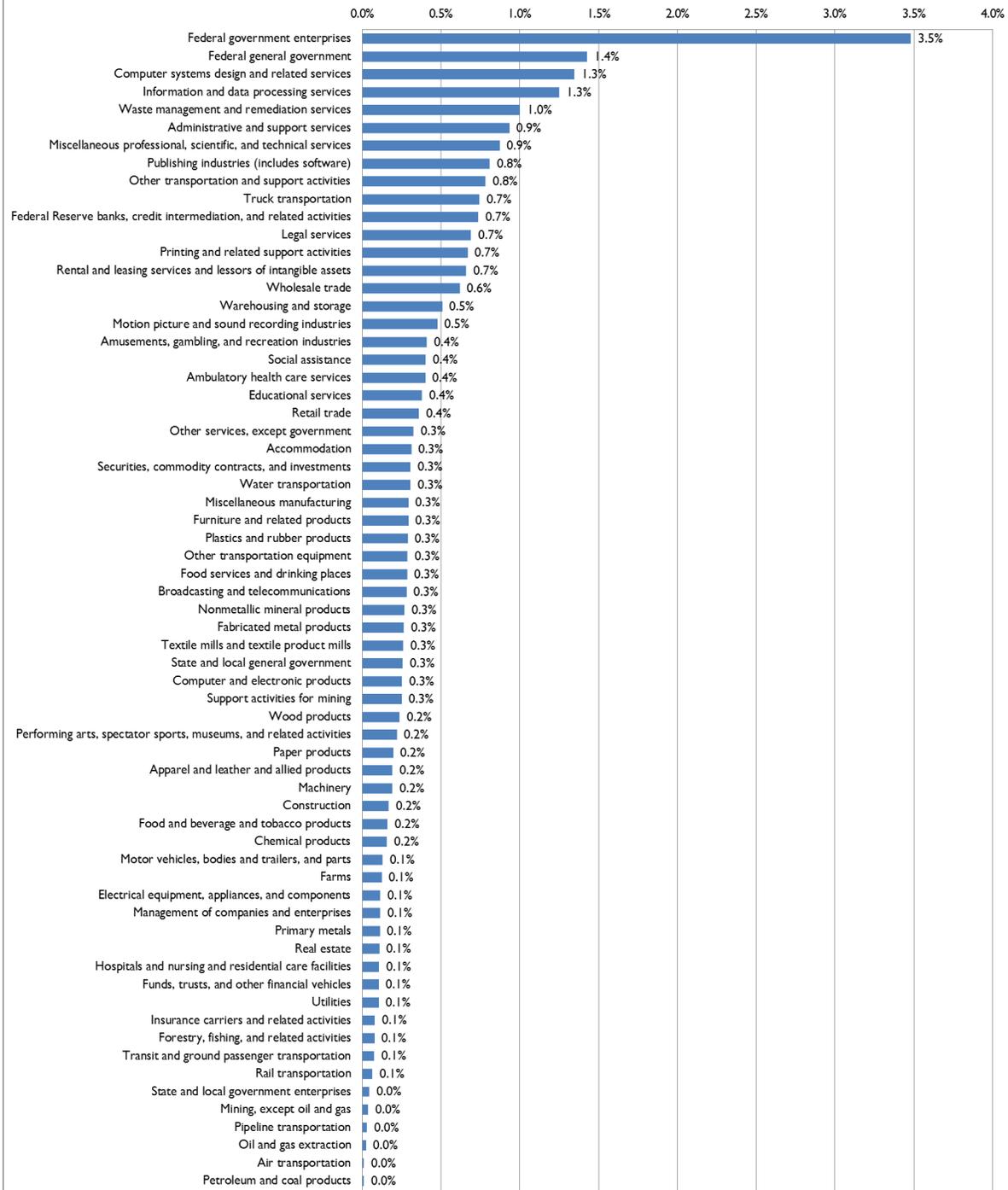


Figure A-2: Normalized intermediate use of air transportation for all I-O industry sectors

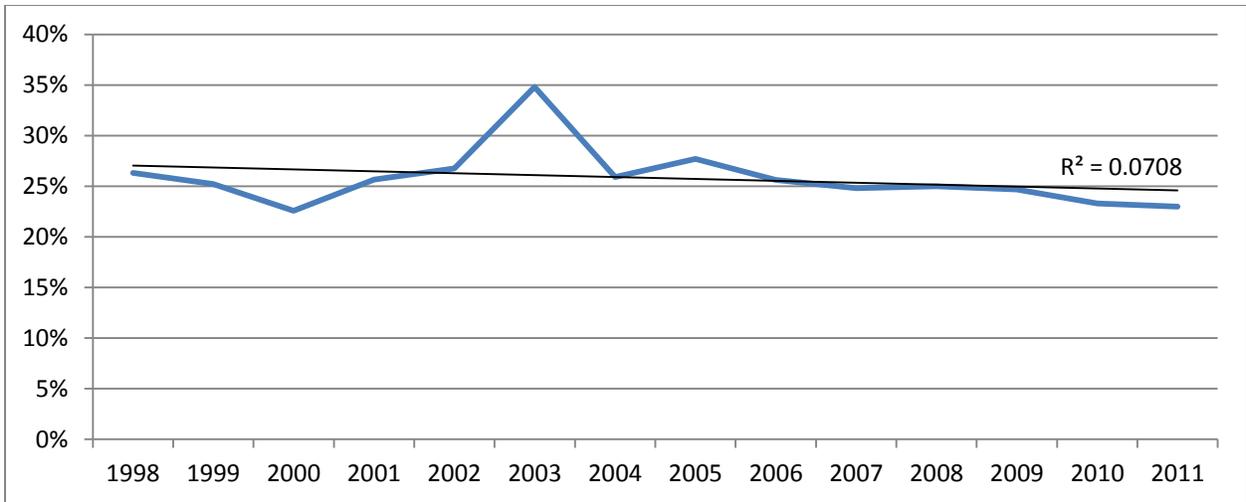


Figure A-3: Federal government air transportation outlays as percent of all transportation outlays

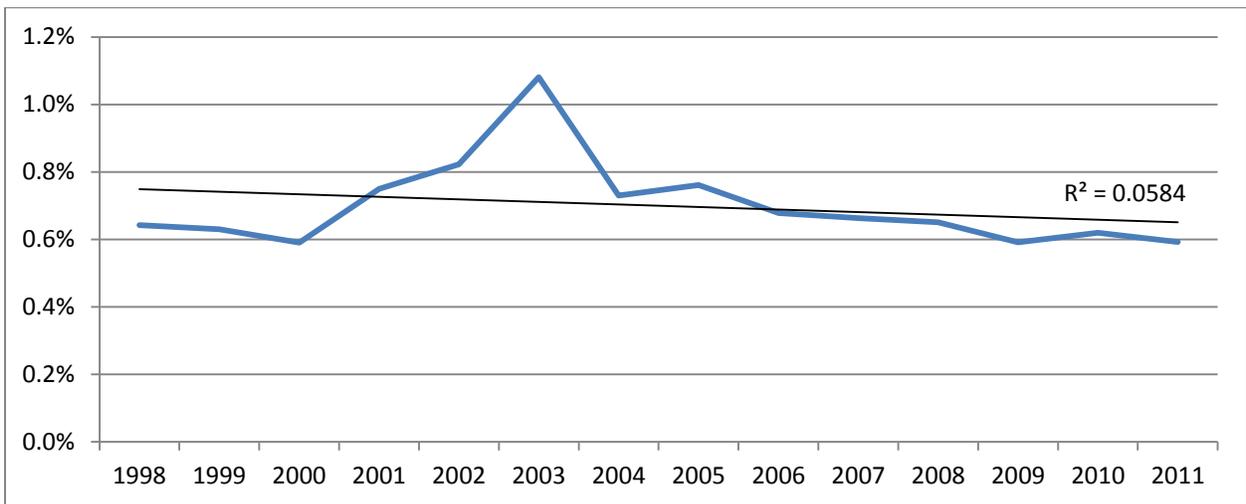


Figure A-4: Federal government air transportation outlays as percent of all outlays



# APPENDIX B

Table B-1: North American Industry Classification System (NAICS) 2-digit sectors

NAICS Code	Definition	NAICS Code	Definition
N11	Agriculture, Forestry, Fishing, Hunting	N53	Real Estate, Rentals & Leasing
N21	Mining	N54	Professional, Scientific, and Technical Services
N22	Utilities	<b>N55</b>	<b>Management of Companies and Enterprises</b>
N23	Construction	N56	Administrative Support, Waste Management
N31	Manufacturing	N61	Education Services
N42	Wholesale Trade	N62	Health Care and Social Assistance
N44	Retail Trade	N71	Arts, Entertainment, and Recreation
N48	Transportation	N72	Accommodation and Food Services
N51	Information	N81	Other Services
N52	Finance and Insurance	N99	Public Administration



# APPENDIX C

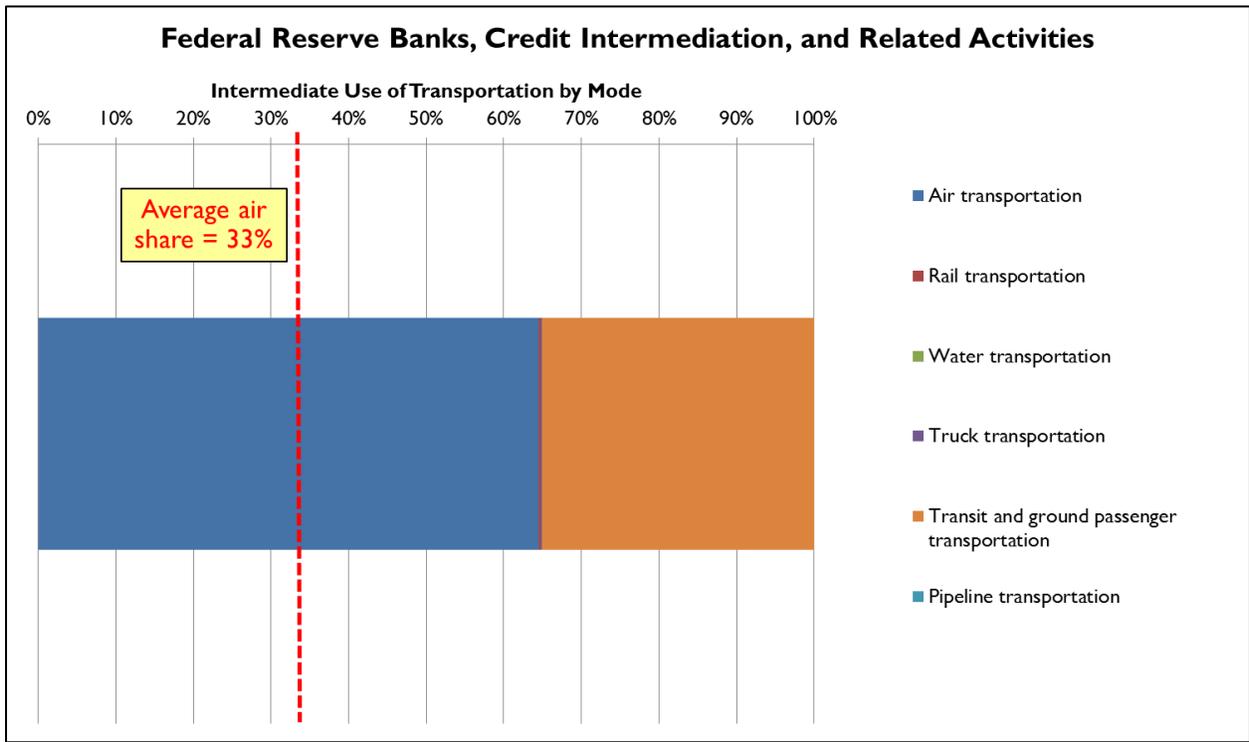


Figure C-1: Modal share of purchased-services for Federal Reserve Banks, Credit Intermediation, and Related Activities sector

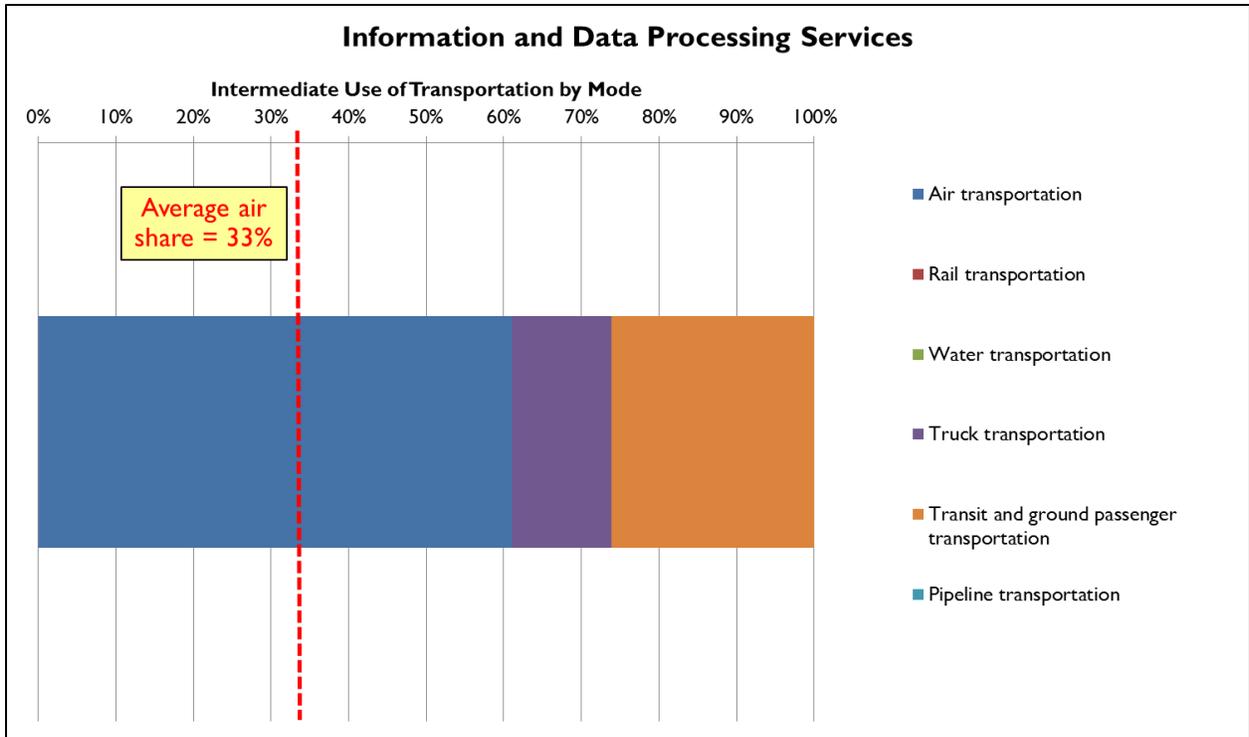


Figure C-2: Modal share of purchased-services for Information and Data Processing Services sector

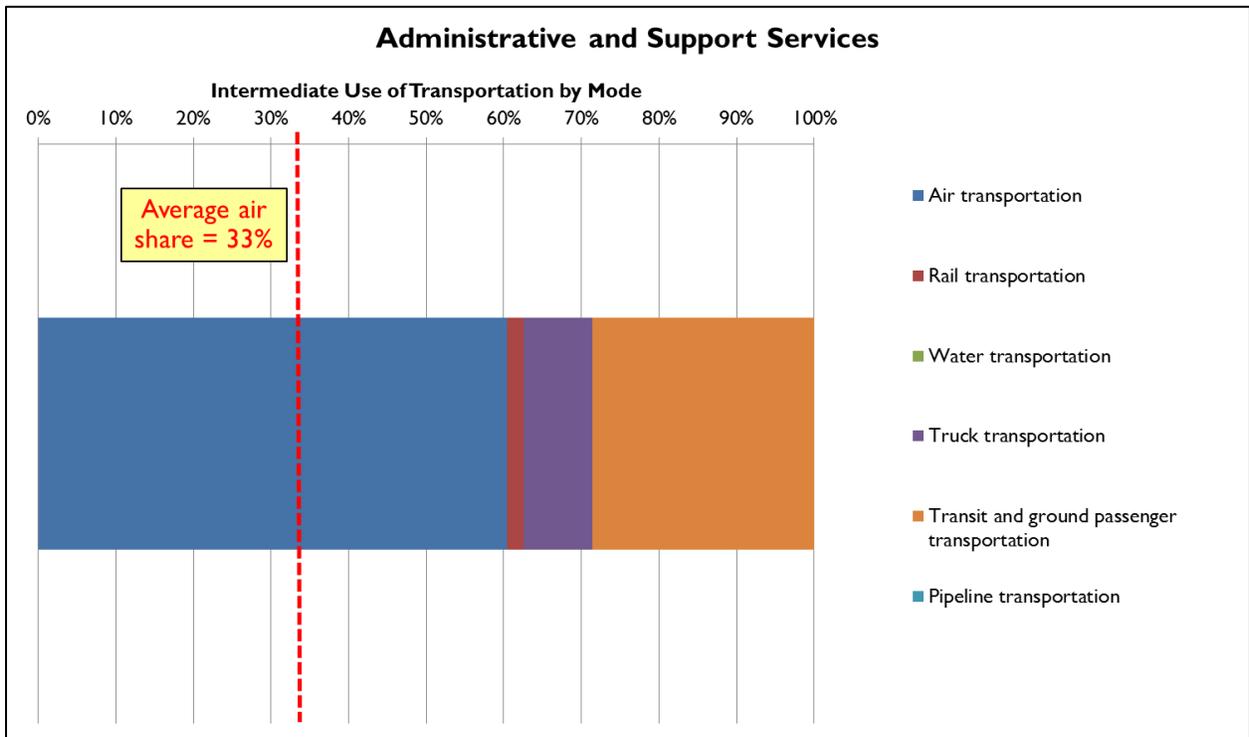


Figure C-3: Modal share of purchased-services for Administrative and Support Services sector

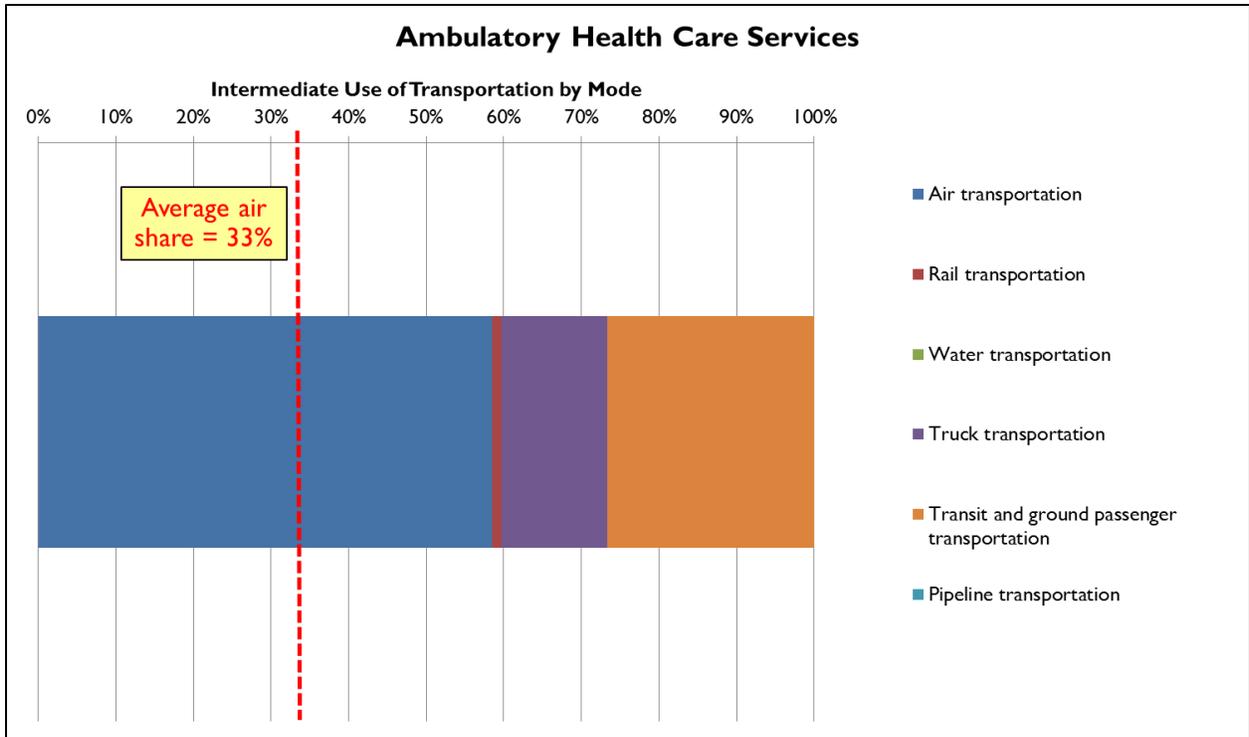


Figure C-4: Modal share of purchased-services for Ambulatory Health Care Services sector

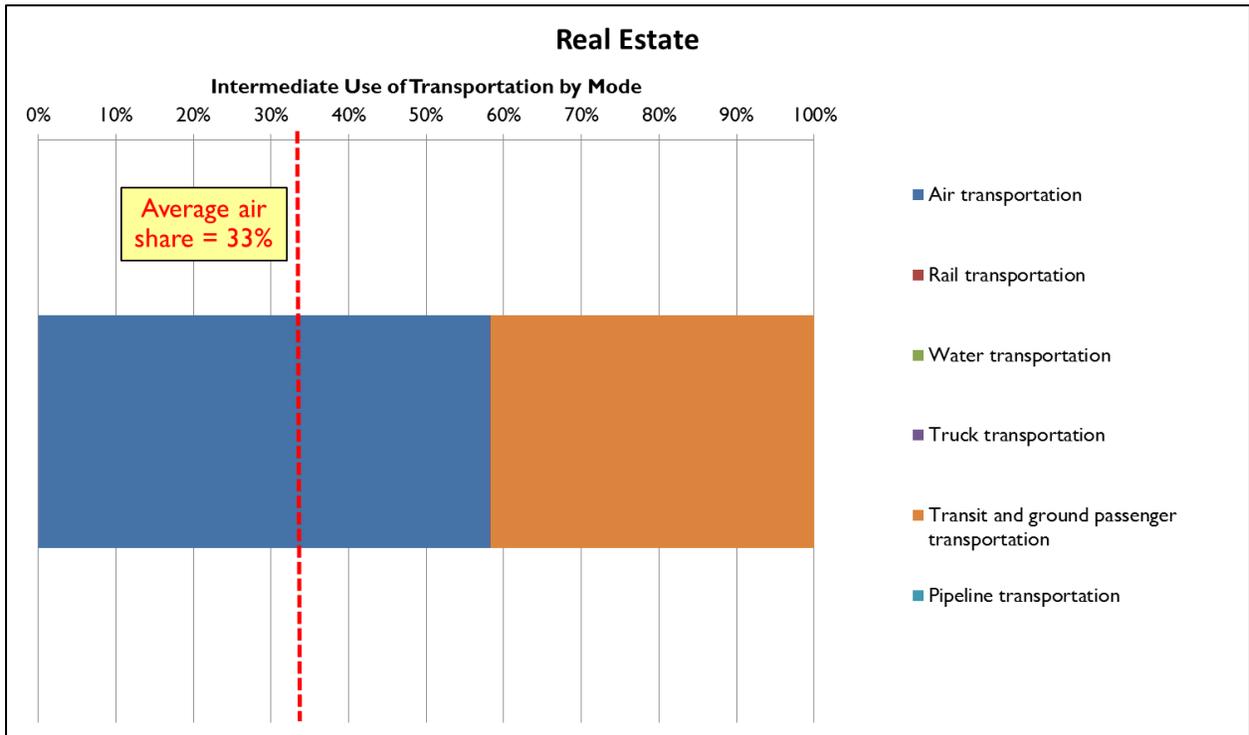


Figure C-5: Modal share of purchased-services for Real Estate sector

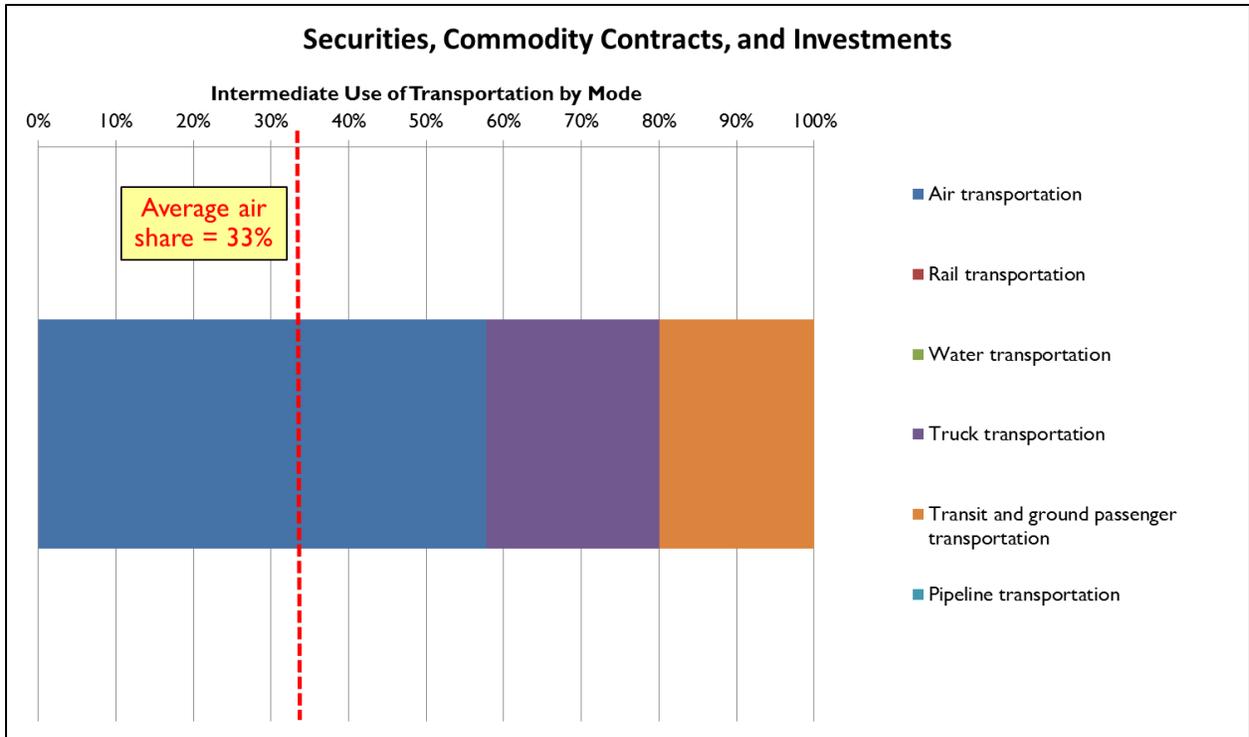


Figure C-6: Modal share of purchased-services for Securities, Commodity Contracts, and Investments sector

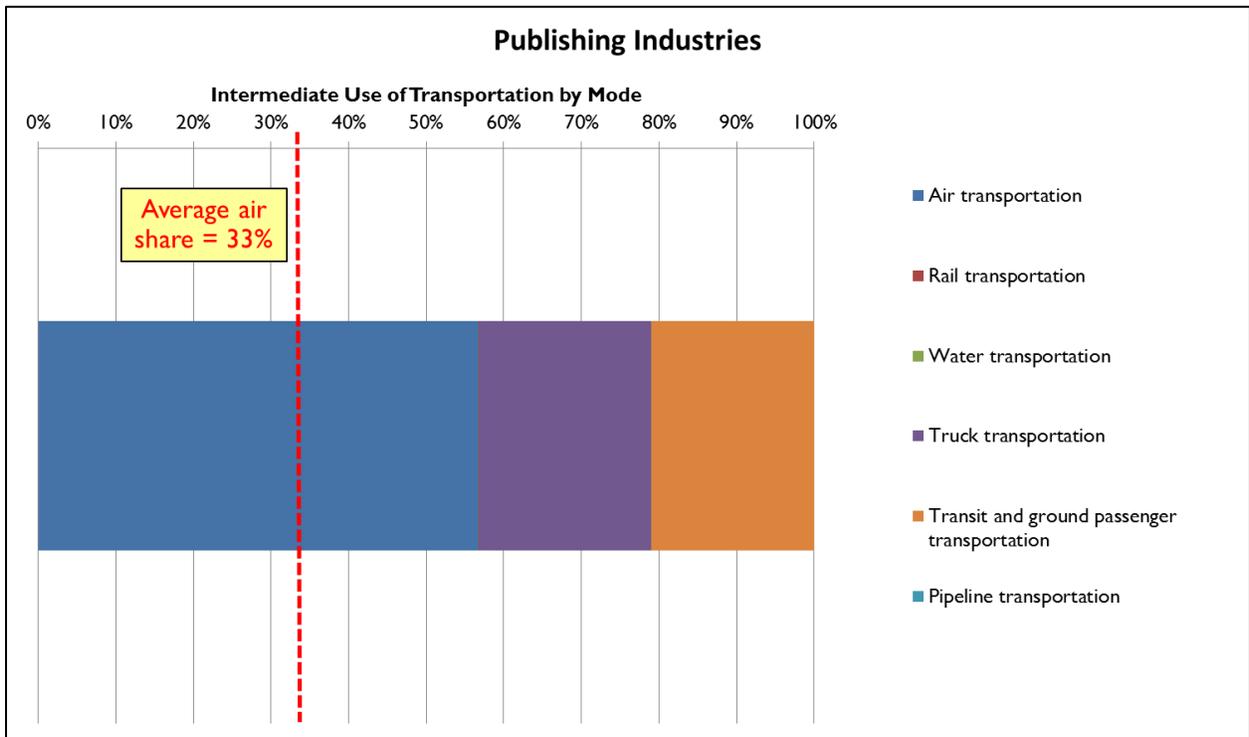


Figure C-7: Modal share of purchased-services for Publishing Industries sector

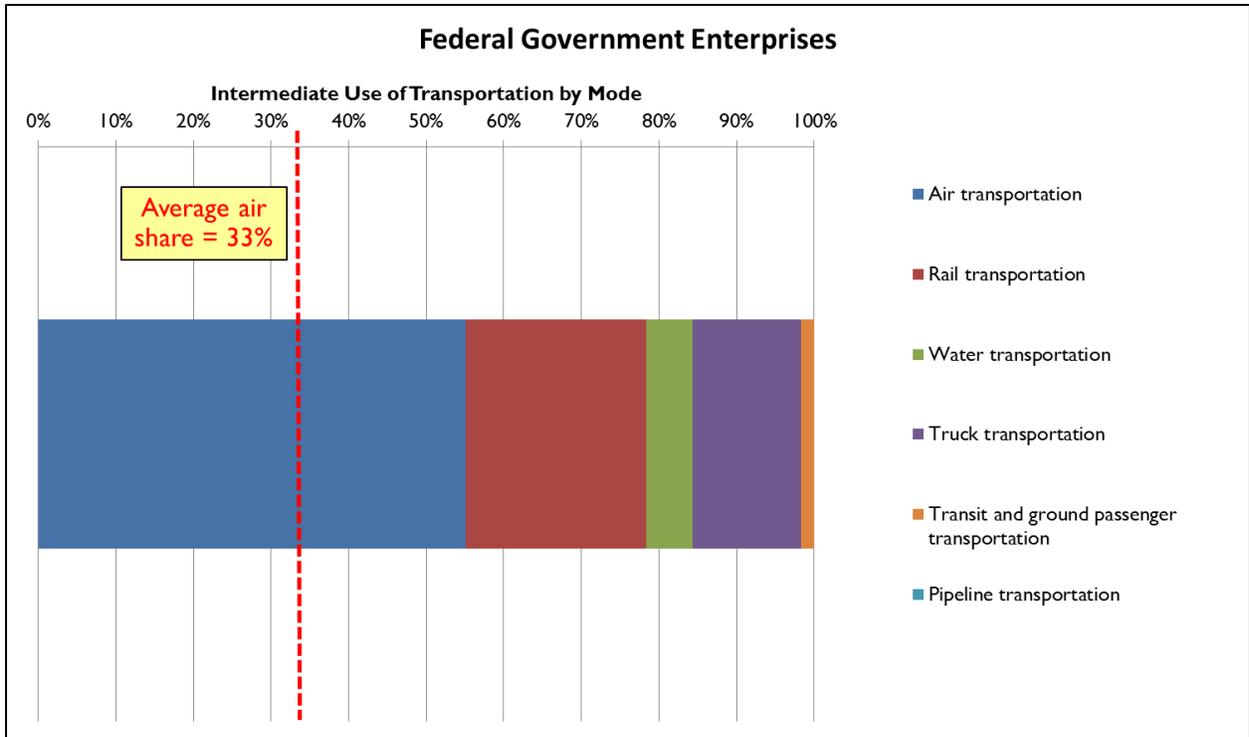


Figure C-8: Modal share of purchased-services for Federal Government Enterprises sector

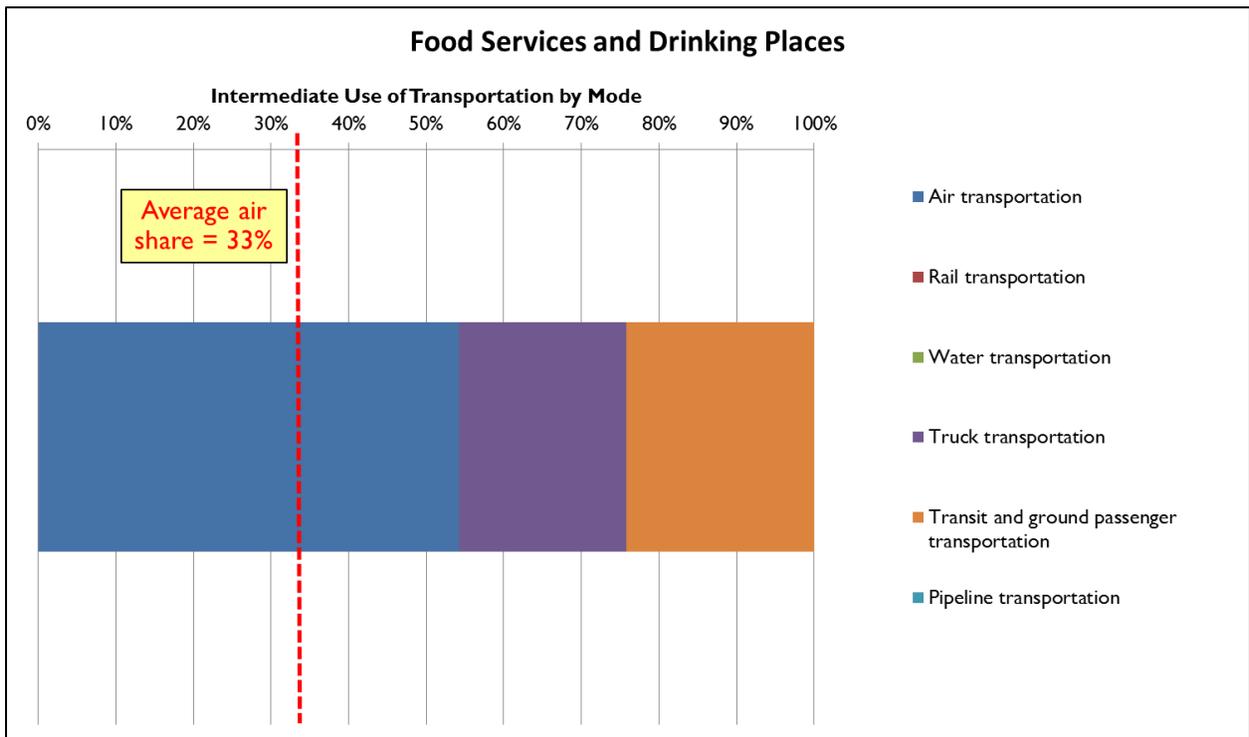


Figure C-9: Modal share of purchased-services for Food Services and Drinking Places sector

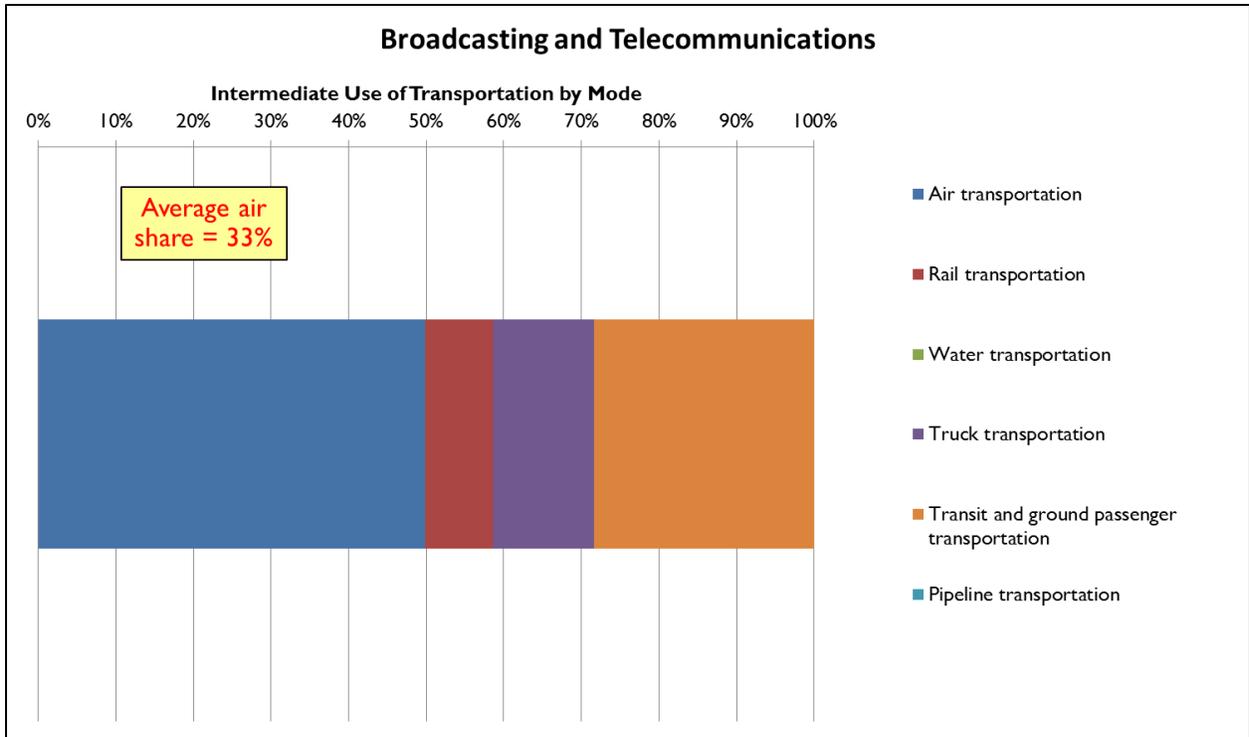


Figure C-10: Modal share of purchased-services for Broadcasting and Telecommunications sector

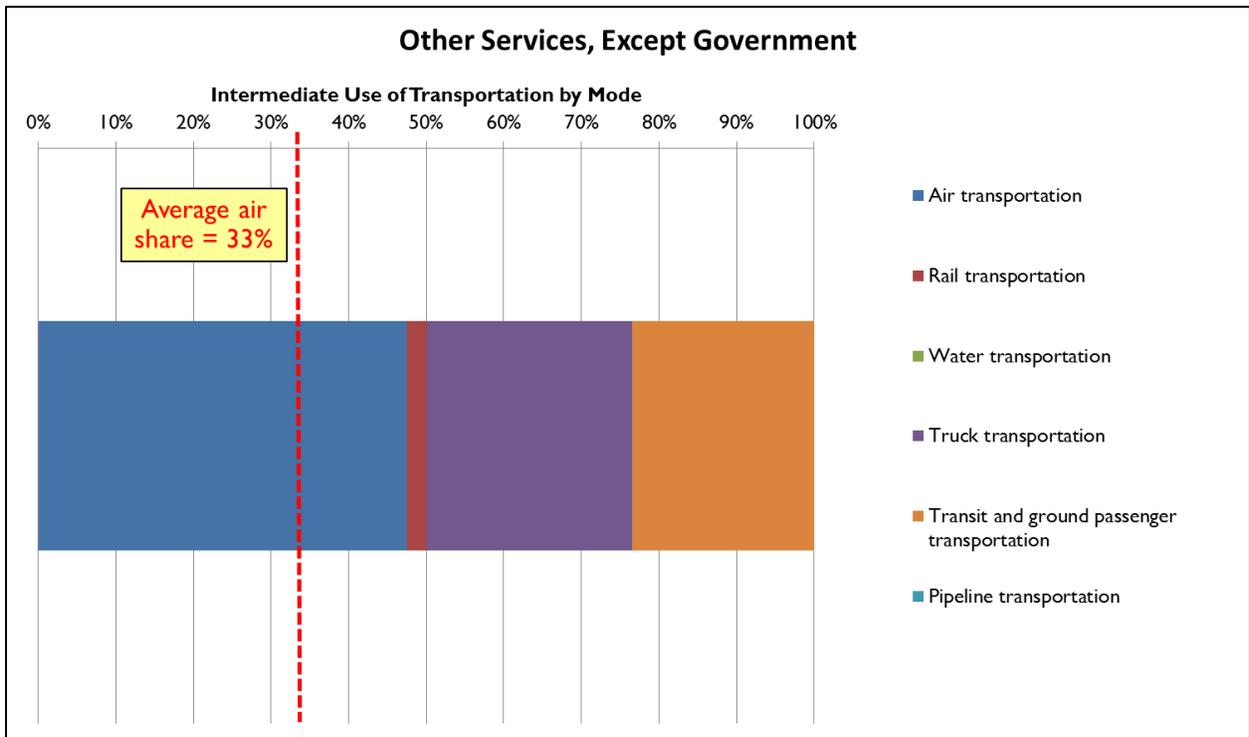


Figure C-11: Modal share of purchased-services for Other Services, Except Government sector

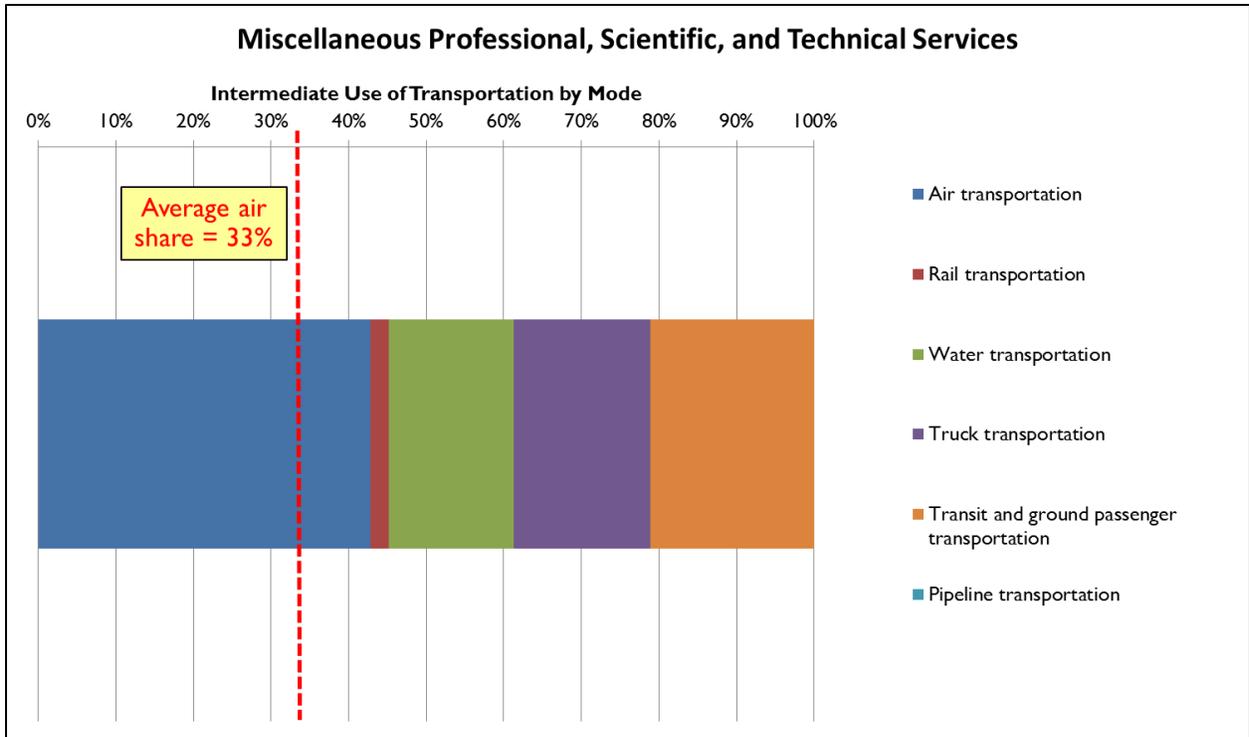


Figure C-12: Modal share of purchased-services for Miscellaneous Professional, Scientific, and Technical Services sector

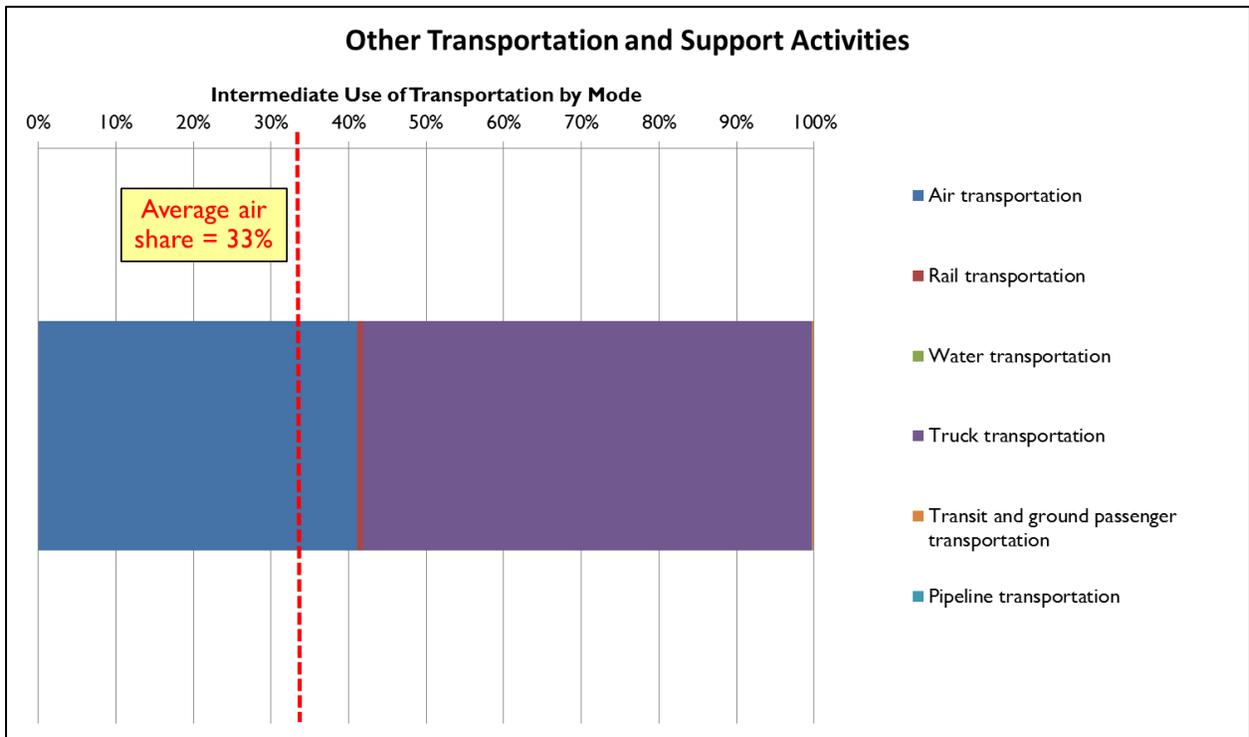


Figure C-13: Modal share of purchased-services for Other Transportation and Support Activities sector

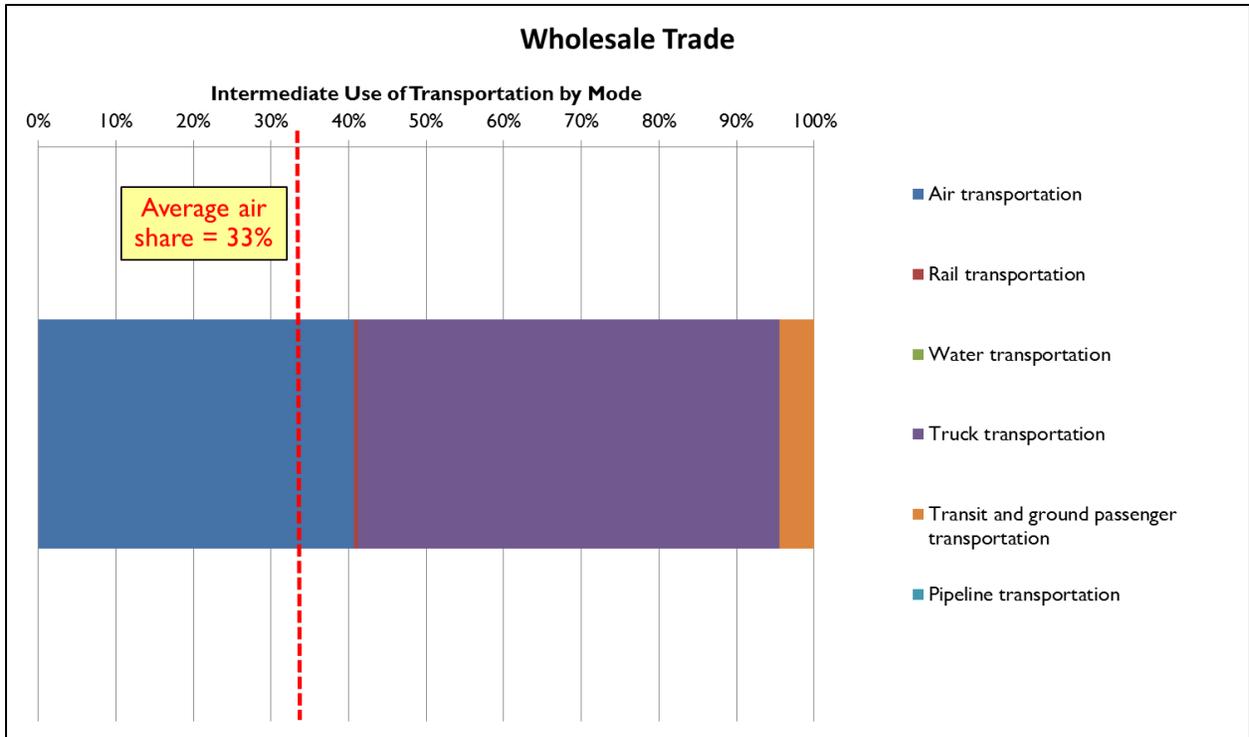


Figure C-14: Modal share of purchased-services for Wholesale Trade sector

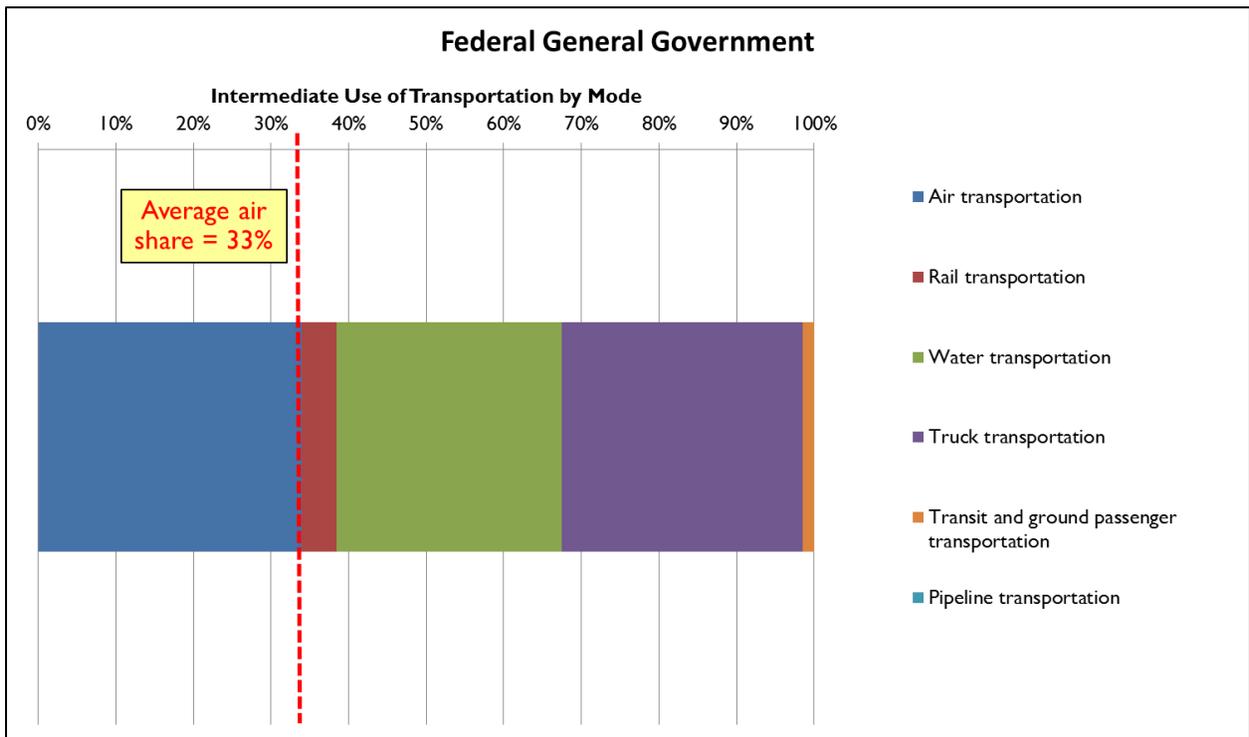


Figure C-15: Modal share of purchased-services for Federal General Government sector

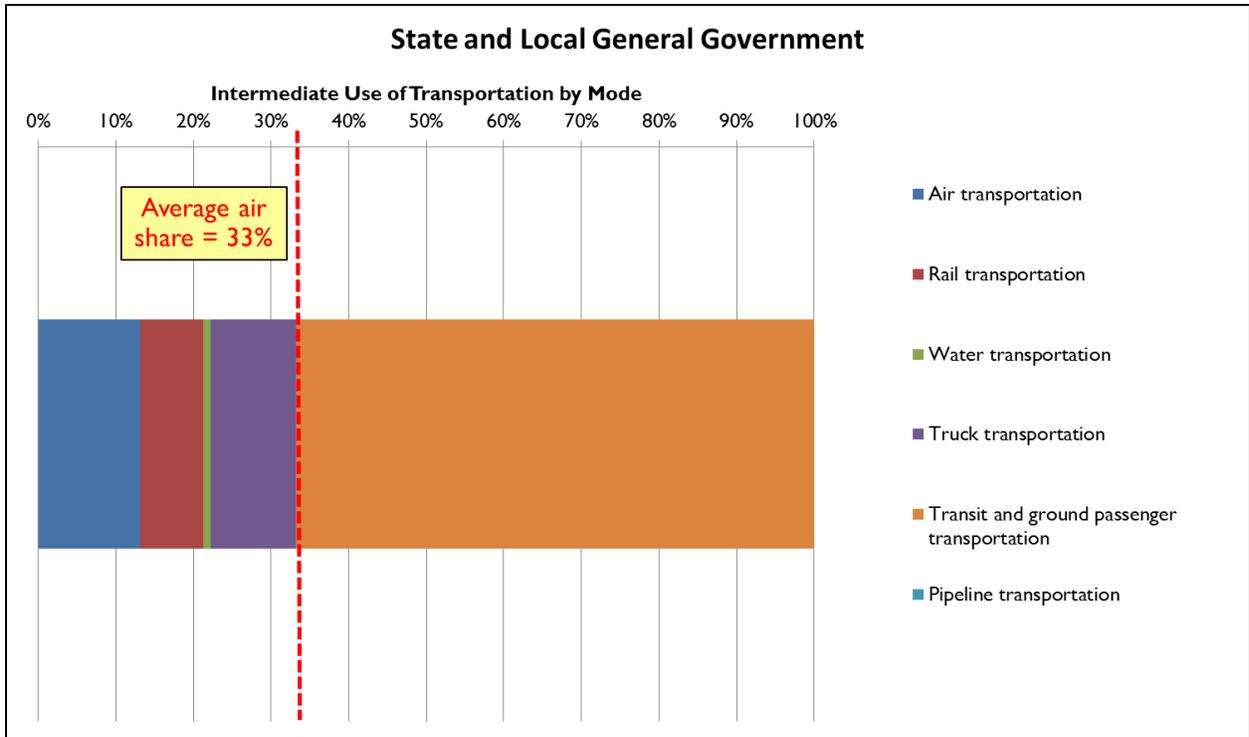


Figure C-16: Modal share of purchased-services for State and Local General Government sector

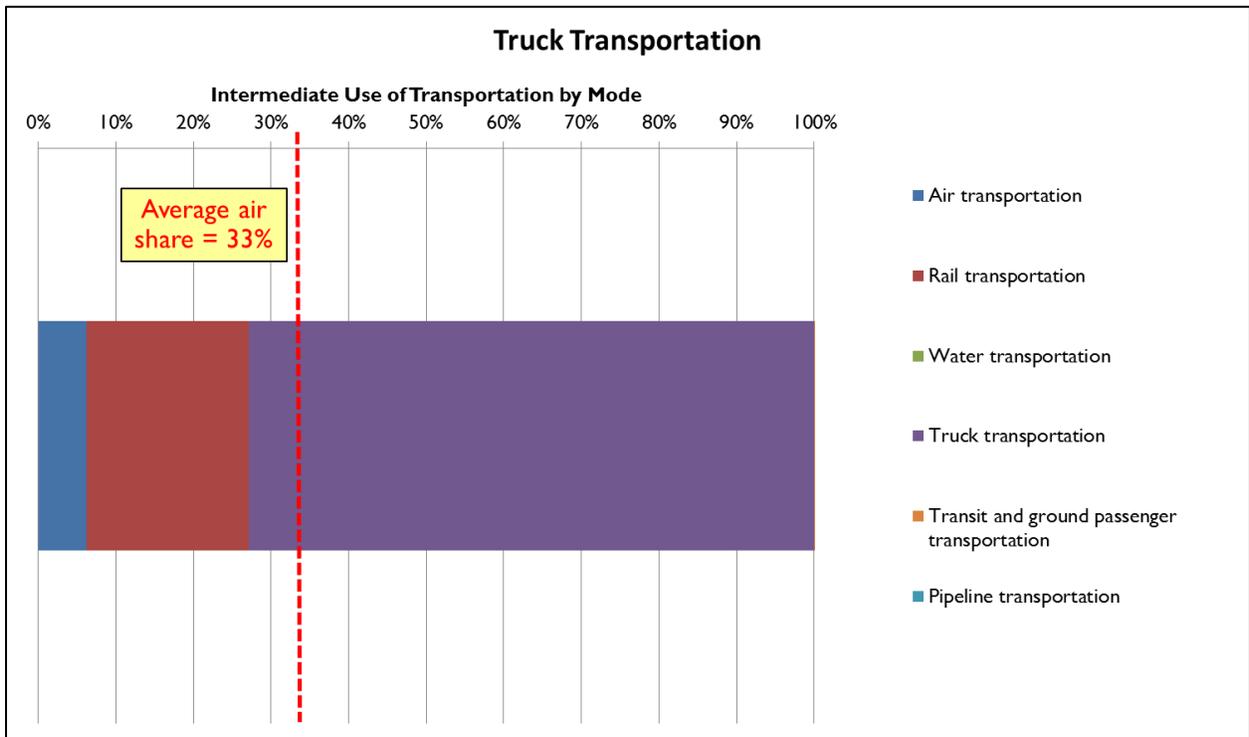


Figure C-17: Modal share of purchased-services for Truck Transportation sector

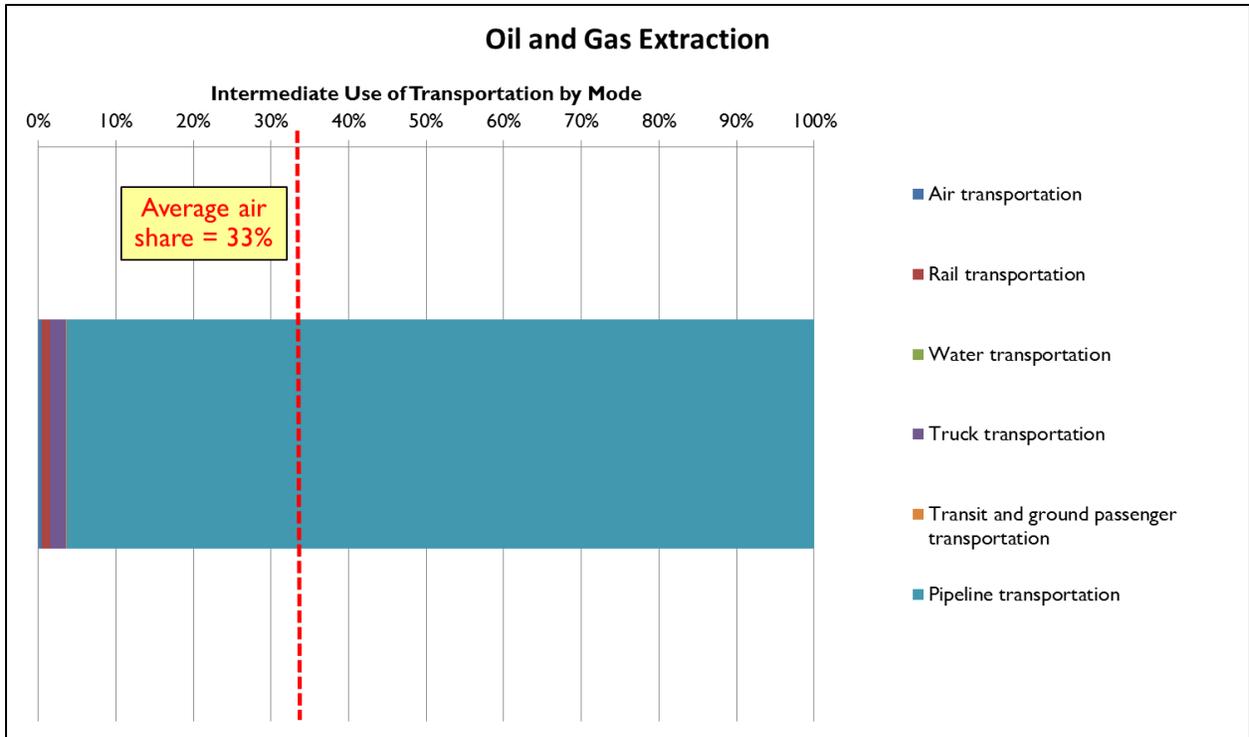


Figure C-18: Modal share of purchased-services for Oil and Gas Extraction sector

# APPENDIX D

Table D-1: U.S. large hub airports matched to Metropolitan Statistical Area (MSA)

ID	Airport Name	Hub Type	2010 Enplanements	Metropolitan Statistical Area (MSA)	2010 MSA Population
ATL	HARTSFIELD - JACKSON ATLANTA INTL	L	43,130,585	Atlanta-Sandy Springs-Marietta, GA Metro Area	5,268,860
ORD	CHICAGO O'HARE INTL	L	32,171,831	Chicago-Joliet-Naperville, IL-IN-WI Metro Area	9,461,105
LAX	LOS ANGELES INTL	L	28,857,755	Los Angeles-Long Beach-Santa Ana, CA Metro Area	12,828,837
DFW	DALLAS/FORT WORTH INTL	L	27,100,656	Dallas-Fort Worth-Arlington, TX Metro Area	6,371,773
DEN	DENVER INTL	L	25,241,962	Denver-Aurora-Broomfield, CO Metro Area	2,543,482
JFK	JOHN F KENNEDY INTL	L	22,934,047	New York-Northern New Jersey-Long Island, NY-NJ-PA Metro Area	18,897,109
IAH	GEORGE BUSH INTERCONTINENTAL/HOUSTON	L	19,528,631	Houston-Sugar Land-Baytown, TX Metro Area	5,946,800
SFO	SAN FRANCISCO INTL	L	19,359,003	San Francisco-Oakland-Fremont, CA Metro Area	4,335,391
LAS	MC CARRAN INTL	L	18,996,738	Las Vegas-Paradise, NV Metro Area	1,951,269
PHX	PHOENIX SKY HARBOR INTL	L	18,907,171	Phoenix-Mesa-Glendale, AZ Metro Area	4,192,887
CLT	CHARLOTTE/DOUGLAS INTL	L	18,629,181	Charlotte-Gastonia-Rock Hill, NC-SC Metro Area	1,758,038
MIA	MIAMI INTL	L	17,017,654	Miami-Fort Lauderdale-Pompano Beach, FL Metro Area	5,564,635
MCO	ORLANDO INTL	L	17,017,491	Orlando-Kissimmee-Sanford, FL Metro Area	2,134,411
EWR	NEWARK LIBERTY INTL	L	16,571,754	New York-Northern New Jersey-Long Island, NY-NJ-PA Metro Area	18,897,109
DTW	DETROIT METROPOLITAN WAYNE COUNTY	L	15,643,890	Detroit-Warren-Livonia, MI Metro Area	4,296,250
MSP	MINNEAPOLIS-ST PAUL INTL/WOLD-CHAMBERLAIN	L	15,512,487	Minneapolis-St. Paul-Bloomington, MN-WI Metro Area	3,279,833
SEA	SEATTLE-TACOMA INTL	L	15,406,243	Seattle-Tacoma-Bellevue, WA Metro Area	3,439,809
PHL	PHILADELPHIA INTL	L	14,951,254	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Metro Area	5,965,343
BOS	GENERAL EDWARD LAWRENCE LOGAN INTL	L	13,561,814	Boston-Cambridge-Quincy, MA-NH Metro Area	4,552,402
LGA	LA GUARDIA	L	12,001,501	New York-Northern New Jersey-Long Island, NY-NJ-PA Metro Area	18,897,109
IAD	WASHINGTON DULLES INTL	L	11,276,481	Washington-Arlington-Alexandria, DC-VA-MD-WV Metro Area	5,582,170
BWI	BALTIMORE/WASHINGTON INTL THURGOOD MARSHAL	L	10,848,633	Baltimore-Towson, MD Metro Area	2,710,489
FLL	FORT LAUDERDALE/HOLLYWOOD INTL	L	10,829,810	Miami-Fort Lauderdale-Pompano Beach, FL Metro Area	5,564,635
SLC	SALT LAKE CITY INTL	L	9,910,493	Salt Lake City, UT Metro Area	1,124,197
HNL	HONOLULU INTL	L	8,740,077	Honolulu, HI Metro Area	953,207
DCA	RONALD REAGAN WASHINGTON NATIONAL	L	8,736,804	Washington-Arlington-Alexandria, DC-VA-MD-WV Metro Area	5,582,170
MDW	CHICAGO MIDWAY INTL	L	8,518,957	Chicago-Joliet-Naperville, IL-IN-WI Metro Area	9,461,105
SAN	SAN DIEGO INTL	L	8,430,509	San Diego-Carlsbad-San Marcos, CA Metro Area	3,095,313
TPA	TAMPA INTL	L	8,137,222	Tampa-St. Petersburg-Clearwater, FL Metro Area	2,783,243

Table D-2: U.S. medium hub airports matched to Metropolitan Statistical Area (MSA)

ID	Airport Name	Hub Type	2010 Enplanements	Metropolitan Statistical Area (MSA)	2010 MSA Population
PDX	PORTLAND INTL	M	6,582,227	Portland-Vancouver-Hillsboro, OR-WA Metro Area	2,226,009
STL	LAMBERT-ST LOUIS INTL	M	6,044,760	St. Louis, MO-IL Metro Area	2,812,896
MCI	KANSAS CITY INTL	M	4,946,173	Kansas City, MO-KS Metro Area	2,035,334
MEM	MEMPHIS INTL	M	4,930,935	Memphis, TN-MS-AR Metro Area	1,316,100
MKE	GENERAL MITCHELL INTL	M	4,760,170	Milwaukee-Waukesha-West Allis, WI Metro Area	1,555,908
OAK	METROPOLITAN OAKLAND INTL	M	4,673,417	San Francisco-Oakland-Fremont, CA Metro Area	4,335,391
CLE	CLEVELAND-HOPKINS INTL	M	4,591,097	Cleveland-Elyria-Mentor, OH Metro Area	2,077,240
RDU	RALEIGH-DURHAM INTL	M	4,465,736	Raleigh-Cary, NC Metro Area	1,130,490
BNA	NASHVILLE INTL	M	4,432,527	Nashville-Davidson--Murfreesboro--Franklin, TN Metro Area	1,589,934
SMF	SACRAMENTO INTL	M	4,424,279	Sacramento--Arden-Arcade--Roseville, CA Metro Area	2,149,127
HOU	WILLIAM P HOBBY	M	4,357,835	Houston-Sugar Land-Baytown, TX Metro Area	5,946,800
SNA	JOHN WAYNE AIRPORT-ORANGE COUNTY	M	4,278,623	Los Angeles-Long Beach-Santa Ana, CA Metro Area	12,828,837
SJU	LUIS MUNOZ MARIN INTL	M	4,243,475	San Juan-Caguas-Guaynabo, PR Metro Area	2,478,905
AUS	AUSTIN-BERGSTROM INTL	M	4,201,136	Austin-Round Rock-San Marcos, TX Metro Area	1,716,289
MSY	LOUIS ARMSTRONG NEW ORLEANS INTL	M	4,088,889	New Orleans-Metairie-Kenner, LA Metro Area	1,167,764
SJC	NORMAN Y. MINETA SAN JOSE INTL	M	4,056,167	San Jose-Sunnyvale-Santa Clara, CA Metro Area	1,836,911
PIT	PITTSBURGH INTL	M	3,996,656	Pittsburgh, PA Metro Area	2,356,285
SAT	SAN ANTONIO INTL	M	3,916,320	San Antonio-New Braunfels, TX Metro Area	2,142,508
CVG	CINCINNATI/NORTHERN KENTUCKY INTL	M	3,906,826	Cincinnati-Middletown, OH-KY-IN Metro Area	2,130,151
DAL	DALLAS LOVE FIELD	M	3,783,407	Dallas-Fort Worth-Arlington, TX Metro Area	6,371,773
IND	INDIANAPOLIS INTL	M	3,728,698	Indianapolis-Carmel, IN Metro Area	1,756,241
RSW	SOUTHWEST FLORIDA INTL	M	3,714,157	Cape Coral-Fort Myers, FL Metro Area	618,754
CMH	PORT COLUMBUS INTL	M	3,145,962	Columbus, OH Metro Area	1,836,536
PBI	PALM BEACH INTL	M	2,958,416	Miami-Fort Lauderdale-Pompano Beach, FL Metro Area	5,564,635
ABQ	ALBUQUERQUE INTL SUNPORT	M	2,828,420	Albuquerque, NM Metro Area	887,077
JAX	JACKSONVILLE INTL	M	2,755,719	Jacksonville, FL Metro Area	1,345,596
BDL	BRADLEY INTL	M	2,640,155	Hartford-West Hartford-East Hartford, CT Metro Area	1,212,381
BUF	BUFFALO NIAGARA INTL	M	2,602,968	Buffalo-Niagara Falls, NY Metro Area	1,135,509
OGG	KAHULUI	M	2,587,214	Kahului-Wailuku, HI Micro Area	154,834
ONT	ONTARIO INTL	M	2,380,881	Riverside-San Bernardino-Ontario, CA Metro Area	4,224,851
ANC	TED STEVENS ANCHORAGE INTL	M	2,342,310	Anchorage, AK Metro Area	380,821
BUR	BOB HOPE	M	2,239,804	Los Angeles-Long Beach-Santa Ana, CA Metro Area	12,828,837
OMA	EPPLEY AIRFIELD	M	2,097,958	Omaha-Council Bluffs, NE-IA Metro Area	865,350
PVD	THEODORE FRANCIS GREEN STATE	M	1,951,566	Providence-New Bedford-Fall River, RI-MA Metro Area	1,600,852
RNO	RENO/TAHOE INTL	M	1,857,488	Reno-Sparks, NV Metro Area	425,417
TUS	TUCSON INTL	M	1,844,228	Tucson, AZ Metro Area	980,263

Table D-3: U.S. small hub airports matched to Metropolitan Statistical Area (MSA), part 1

ID	Airport Name	Hub Type	2010 Enplanements	Metropolitan Statistical Area (MSA)	2010 MSA Population
OKC	WILL ROGERS WORLD	S	1,710,993	Oklahoma City, OK Metro Area	1,252,987
ORF	NORFOLK INTL	S	1,663,294	Virginia Beach-Norfolk-Newport News, VA-NC Metro Area	1,671,683
RIC	RICHMOND INTL	S	1,651,131	Richmond, VA Metro Area	1,258,251
SDF	LOUISVILLE INTL-STANDIFORD FIELD	S	1,651,037	Louisville/Jefferson County, KY-IN Metro Area	1,283,566
GEG	SPOKANE INTL	S	1,545,115	Spokane, WA Metro Area	471,221
ELP	EL PASO INTL	S	1,509,093	El Paso, TX Metro Area	800,647
LGB	LONG BEACH /DAUGHERTY FIELD/	S	1,451,404	Los Angeles-Long Beach-Santa Ana, CA Metro Area	12,828,837
BHM	BIRMINGHAM-SHUTTLESWORTH INTL	S	1,443,215	Birmingham-Hoover, AL Metro Area	1,128,047
GUM	GUAM INTL	S	1,411,024	#N/A	#N/A
BOI	BOISE AIR TERMINAL/GOWEN FLD	S	1,406,750	Boise City-Nampa, ID Metro Area	616,561
MHT	MANCHESTER	S	1,391,797	Manchester-Nashua, NH Metro Area	400,721
TUL	TULSA INTL	S	1,382,895	Tulsa, OK Metro Area	937,478
KOA	KONA INTL AT KEAHOLE	S	1,276,343	Hilo, HI Micro Area	185,079
ROC	GREATER ROCHESTER INTL	S	1,263,965	Rochester, NY Metro Area	1,054,323
ALB	ALBANY INTL	S	1,250,282	Albany-Schenectady-Troy, NY Metro Area	870,716
DAY	JAMES M COX DAYTON INTL	S	1,248,787	Dayton, OH Metro Area	841,502
LIH	LIHUE	S	1,175,203	Kapaa, HI Micro Area	67,091
LIT	ADAMS FIELD	S	1,097,403	Little Rock-North Little Rock-Conway, AR Metro Area	699,757
GRR	GERALD R. FORD INTL	S	1,089,002	Grand Rapids-Wyoming, MI Metro Area	774,160
SYR	SYRACUSE HANCOCK INTL	S	1,024,505	Syracuse, NY Metro Area	662,577
CHS	CHARLESTON AFB/INTL	S	1,013,418	Charleston-North Charleston-Summerville, SC Metro Area	664,607
HPN	WESTCHESTER COUNTY	S	999,831	New York-Northern New Jersey-Long Island, NY-NJ-PA Metro Area	18,897,109
DSM	DES MOINES INTL	S	898,840	Des Moines-West Des Moines, IA Metro Area	569,633
COS	CITY OF COLORADO SPRINGS MUNI	S	877,367	Colorado Springs, CO Metro Area	645,613
ISP	LONG ISLAND MAC ARTHUR	S	858,741	New York-Northern New Jersey-Long Island, NY-NJ-PA Metro Area	18,897,109
GSO	PIEDMONT TRIAD INTL	S	855,073	Greensboro-High Point, NC Metro Area	723,801
PWM	PORTLAND INTL JETPORT	S	851,566	Portland-South Portland-Biddeford, ME Metro Area	514,098
TYS	MC GHEE TYSON	S	804,917	Knoxville, TN Metro Area	698,030
SAV	SAVANNAH/HILTON HEAD INTL	S	798,194	Savannah, GA Metro Area	347,611
MYR	MYRTLE BEACH INTL	S	782,737	Myrtle Beach-North Myrtle Beach-Conway, SC Metro Area	269,291
CAK	AKRON-CANTON RGNL	S	771,107	Akron, OH Metro Area	703,200
MSN	DANE COUNTY RGNL-TRUAX FIELD	S	766,953	Madison, WI Metro Area	568,593
ICT	WICHITA MID-CONTINENT	S	751,601	Wichita, KS Metro Area	623,061
PSP	PALM SPRINGS INTL	S	751,068	Riverside-San Bernardino-Ontario, CA Metro Area	4,224,851
PNS	PENSACOLA GULF COAST RGNL	S	729,748	Pensacola-Ferry Pass-Brent, FL Metro Area	448,991
SRQ	SARASOTA/BRADENTON INTL	S	670,992	North Port-Bradenton-Sarasota, FL Metro Area	702,281
ACY	ATLANTIC CITY INTL	S	669,470	Atlantic City-Hammonton, NJ Metro Area	274,549
MDT	HARRISBURG INTL	S	664,968	Harrisburg-Carlisle, PA Metro Area	549,475
GSP	GREENVILLE SPARTANBURG INTL	S	642,512	Spartanburg, SC Metro Area	284,307
BTV	BURLINGTON INTL	S	640,790	Burlington-South Burlington, VT Metro Area	211,261
JAN	JACKSON-EVERS INTL	S	618,373	Jackson, MS Metro Area	539,057

Table D-4: U.S. small hub airports matched to Metropolitan Statistical Area (MSA), part 2

ID	Airport Name	Hub Type	2010 Enplanements	Metropolitan Statistical Area (MSA)	2010 MSA Population
ITO	HILO INTL	S	611,782	Hilo, HI Micro Area	185,079
STT	CYRILE KING	S	606,137	#N/A	#N/A
HSV	HUNTSVILLE INTL-CARL T JONES FIELD	S	606,127	Huntsville, AL Metro Area	417,593
FAT	FRESNO YOSEMITE INTL	S	569,879	Fresno, CA Metro Area	930,450
SFB	ORLANDO SANFORD INTL	S	553,892	Orlando-Kissimmee-Sanford, FL Metro Area	2,134,411
XNA	NORTHWEST ARKANSAS RGNL	S	549,195	Fayetteville-Springdale-Rogers, AR-MO Metro Area	463,204
LEX	BLUE GRASS	S	539,492	Lexington-Fayette, KY Metro Area	472,099
PHF	NEWPORT NEWS/WILLIAMSBURG INTL	S	519,906	Virginia Beach-Norfolk-Newport News, VA-NC Metro Area	1,671,683
LBB	LUBBOCK PRESTON SMITH INTL	S	508,858	Lubbock, TX Metro Area	284,890
FNT	BISHOP INTL	S	497,649	Flint, MI Metro Area	425,790
CAE	COLUMBIA METROPOLITAN	S	486,879	Columbia, SC Metro Area	767,598
MLI	QUAD CITY INTL	S	477,086	Davenport-Moline-Rock Island, IA-IL Metro Area	379,690
CID	THE EASTERN IOWA	S	462,670	Cedar Rapids, IA Metro Area	257,940
GPT	GULFPORT-BILOXI INTL	S	461,072	Gulfport-Biloxi, MS Metro Area	248,820
MAF	MIDLAND INTL	S	445,043	Midland, TX Metro Area	136,872
FAI	FAIRBANKS INTL	S	435,392	Fairbanks, AK Metro Area	97,581
GSN	FRANCISCO C. ADA/SAIPAN INTL	S	433,577	#N/A	#N/A
IWA	PHOENIX-MESA GATEWAY	S	417,862	Phoenix-Mesa-Glendale, AZ Metro Area	4,192,887
BGR	BANGOR INTL	S	416,328	Bangor, ME Metro Area	153,923
ABE	LEHIGH VALLEY INTL	S	414,427	Allentown-Bethlehem-Easton, PA-NJ Metro Area	821,173
ILM	WILMINGTON INTL	S	408,058	Wilmington, NC Metro Area	362,315
BLI	BELLINGHAM INTL	S	398,368	Bellingham, WA Metro Area	201,140
AMA	RICK HUSBAND AMARILLO INTL	S	394,593	Amarillo, TX Metro Area	249,881
BIL	BILLINGS LOGAN INTL	S	388,329	Billings, MT Metro Area	158,050
PIE	ST PETERSBURG-CLEARWATER INTL	S	384,394	Tampa-St. Petersburg-Clearwater, FL Metro Area	2,783,243
SBA	SANTA BARBARA MUNI	S	382,894	Santa Barbara-Santa Maria-Goleta, CA Metro Area	423,895
BTR	BATON ROUGE METROPOLITAN, RYAN FIELD	S	382,687	Baton Rouge, LA Metro Area	802,484
SGF	SPRINGFIELD-BRANSON NATIONAL	S	381,172	Springfield, MO Metro Area	436,712
HRL	VALLEY INTL	S	373,438	Brownsville-Harlingen, TX Metro Area	406,220
AVL	ASHEVILLE RGNL	S	371,226	Asheville, NC Metro Area	424,858
EUG	MAHLON SWEET FIELD	S	369,397	Eugene-Springfield, OR Metro Area	351,715
FAR	HECTOR INTL	S	365,963	Fargo, ND-MN Metro Area	208,777
BZN	BOZEMAN YELLOWSTONE INTL	S	364,521	Bozeman, MT Micro Area	89,513

# APPENDIX E

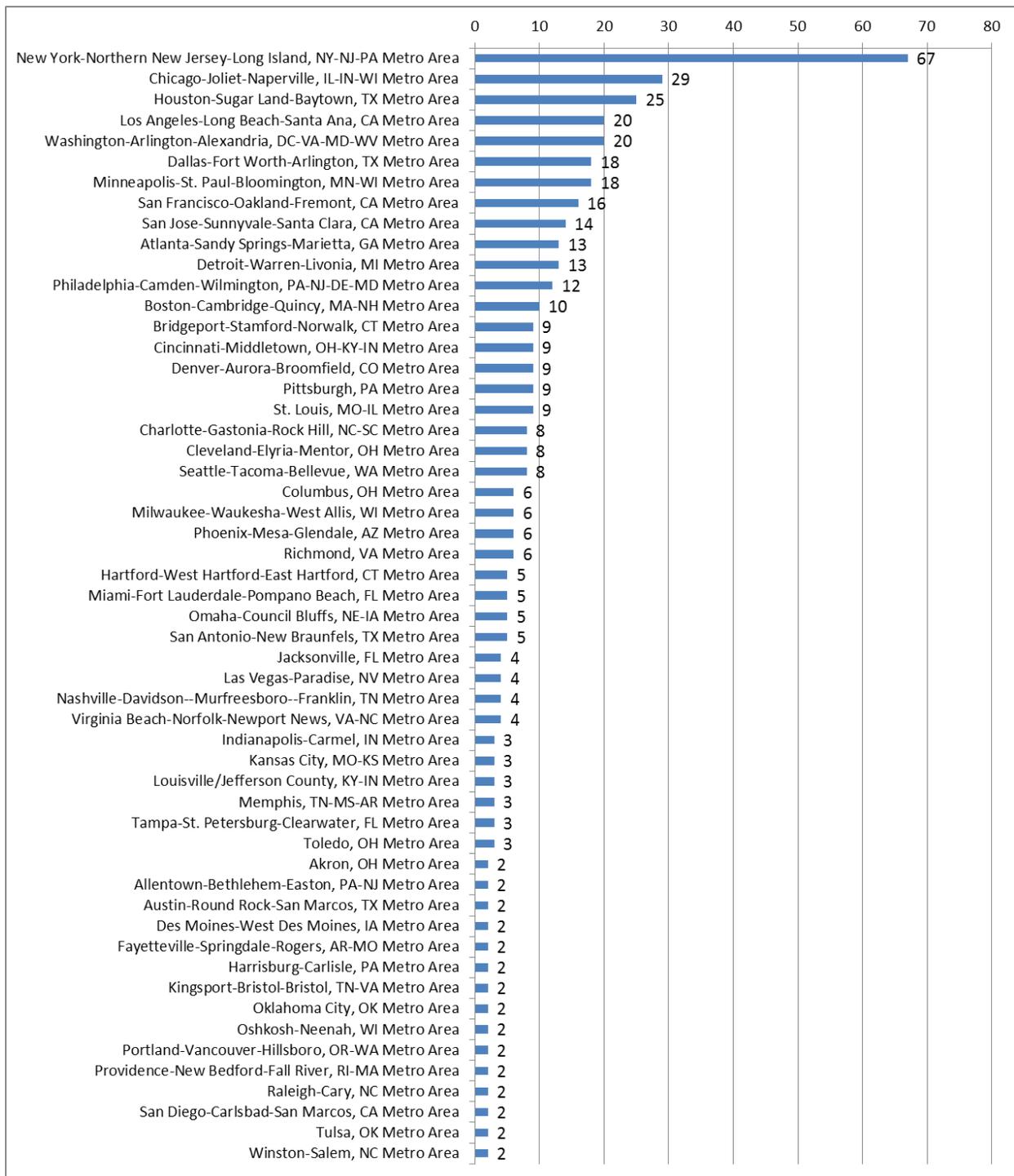


Figure E-1: Fortune 500 headquarters by Metropolitan Statistical Area (MSA)



# APPENDIX F

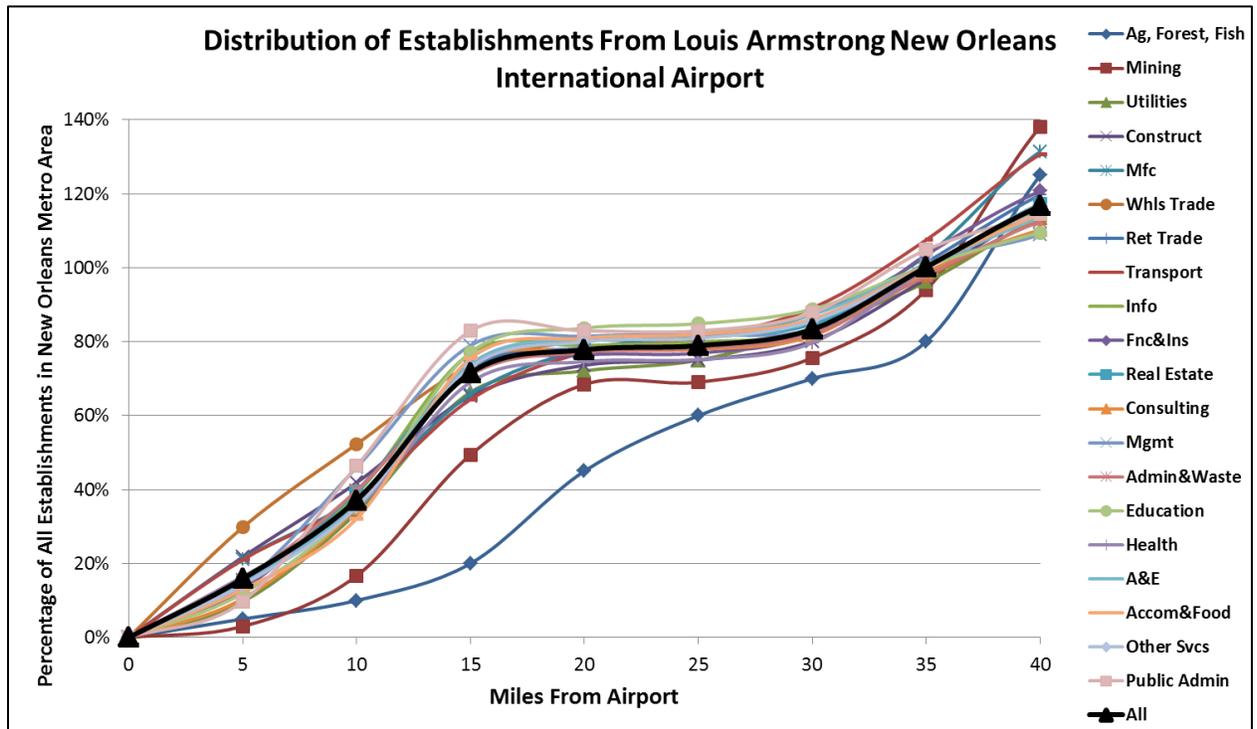


Figure F-1: Distributions of New Orleans establishments from Louis Armstrong New Orleans International Airport

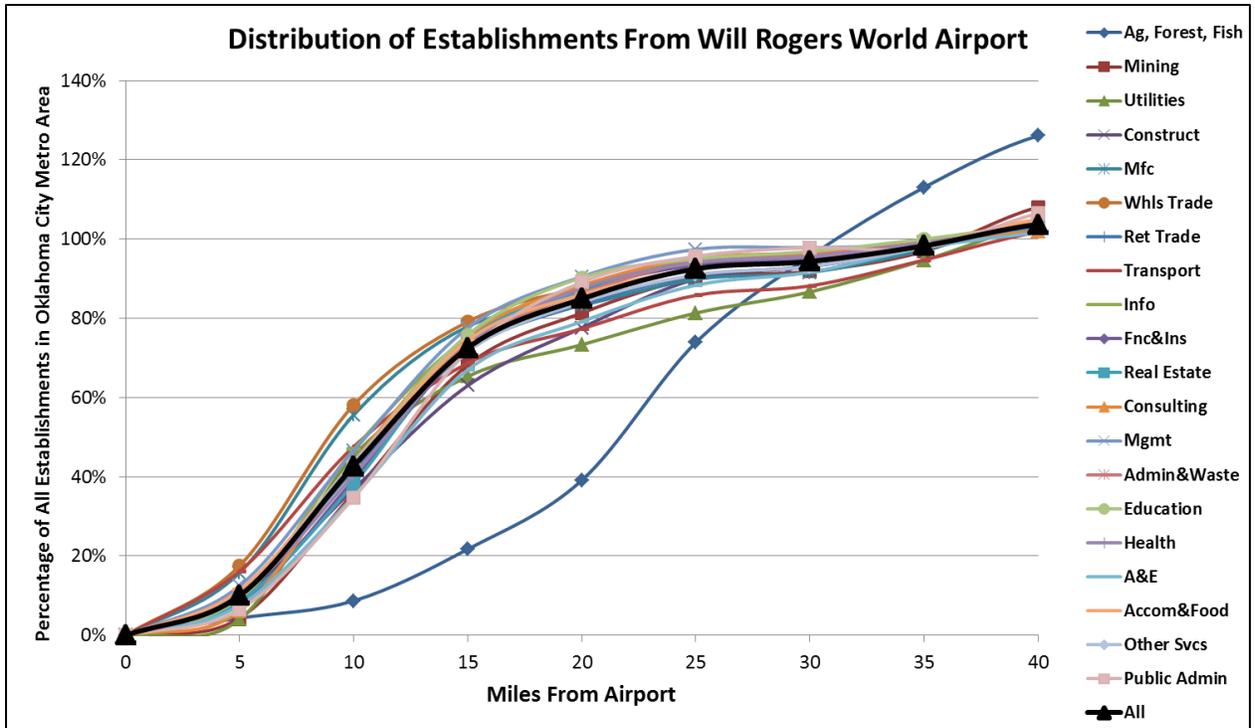


Figure F-2: Distributions of Oklahoma City establishments from Will Rogers World Airport

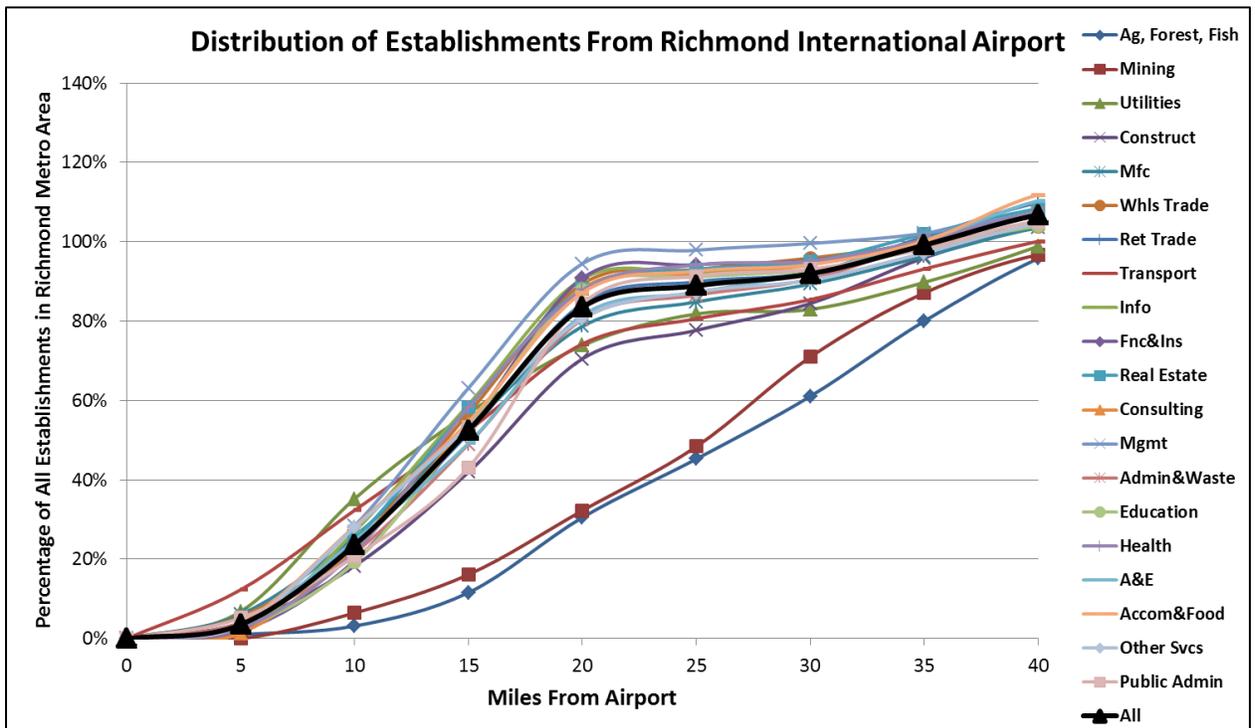


Figure F-3: Distributions of Richmond establishments from Richmond International Airport

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