Pushback in the Jet Age: Investigating Neighborhood Change, Environmental Justice, and Planning Process in Airport-Adjacent Communities

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Pushback in the Jet Age: Investigating Neighborhood Change, Environmental Justice, and Planning Process in Airport-Adjacent Communities

Abstract
Beneath the shadow of the aircraft and beyond the airport fence, communities wrestle with the impacts of airport expansion and operations. This dissertation builds scholarly foundations to explore the tensions between local residents who want to maintain healthy and stable communities and airport owners who want to grow operations and promote regional economic growth. The literature review contributes an overview of existing scholarship that investigates airports in an urban planning context, a realm of study I term ‘aviation urbanism’. To address gaps in aviation urbanism scholarship, I derived and investigated three research questions pertaining to neighborhood change, environmental justice outcomes, and the airport infrastructure planning process for airport-adjacent communities. The dissertation first asks: How has the population of historically marginalized groups living near airports changed with the rise of the jet age? The spatial analysis and descriptive statistics show that airport-adjacent communities in multi-airport regions generally increased persons of color and increased renters more than their respective metropolitan regions. Additionally, the communities often underperformed socio-economically with respect to their region. The second research question asks: Were hub airports more likely to expand if historically marginalized groups surrounded them? The exact logistic regression model, which was designed to be suitable for binary outcomes and small sample sizes, did not offer statistical evidence that environmental injustice is a concern at a systemic, institutional level for major airport expansion decisions. Next, I investigated environmental injustice on a case-by-case basis during the planning process, asking: How did the Federal Aviation Administration and airport owners frame and evaluate environmental justice in the planning process for airport expansion projects? After investigating the methodological framing of environmental justice in Environmental Impact Statements, I found that the methodological variation in comparison geography prevented the FAA and airport owners from recognizing and mitigating disproportionate impacts at two of the three airports with the most obvious and egregious levels of environmental justice concern. Overall, this dissertation contributes a methodological approach to define airport-adjacent communities and offers a basis for further inquiries into the relationship between airport infrastructure, airport-adjacent communities, and airport-centric activity centers.

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For Mom and Dad. I earned one degree for each of us!
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In Fall 2007, an enthusiastic doctoral student in Ugg boots regularly stood in front of me (and dozens of my fellow Cal engineering students) in the McLaughlin Hall basement and led supplementary lectures on statistical analysis. She was the graduate teaching assistant for CE93: Engineering Data Analysis, a required undergraduate class. I visited many of her office hours over the course of the semester, drawn to her effective teaching style and strong understanding of statistics. Later, she helped me secure my first professional internship and she offered me a job as an undergraduate research assistant. She would later become Dr. Megan Ryerson, my dissertation advisor and, affectionately, my ride-or-die mentor.

It is difficult for me to adequately describe the impact Dr. Ryerson has had on my professional development. I hope that in listing what I was willing to do to be her student, you can begin to comprehend her value as a mentor, educator, and researcher. When she started her first professorship, she invited me to accompany her to the University of Tennessee, Knoxville as her graduate student. I left my job with the Federal Highway Administration in Vancouver, Washington and started as her Transportation Engineering PhD student in Fall 2011. When she accepted a faculty position at the University of Pennsylvania and invited me along, I transferred with her to the Penn Planning program in Fall 2013. I enthusiastically followed her across the country twice and studied for two qualifying exams at two different universities because I hold her mentorship in such high esteem.
Since becoming Dr. Ryerson’s student, many doors opened up for me. I am so fortunate to have learned from her experience and received her encouragement for the past nine years. She is a tremendous example of early-stage academic success, firmly establishing herself as an expert, continuously winning awards and recognition, and aggressively publishing innovative research. As a mentor, she offers unyielding encouragement during rough patches. She exudes a brand of optimistic confidence and thoughtful advice, punctuated by straight talk about the reality of industry and the academy. It has been my joy to work alongside her and I am so grateful for the relationship we cultivated over these years.

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Finally, thank you to Lady Luck and Father Time. Sometimes you just need to be in the right place at the right time. So far, I am really happy with my existence on the space-time continuum.
ABSTRACT

PUSHBACK IN THE JET AGE: INVESTIGATING NEIGHBORHOOD CHANGE, ENVIRONMENTAL JUSTICE, AND PLANNING PROCESS IN AIRPORT-ADJACENT COMMUNITIES

Amber Victoria Woodburn
Dr. Megan Ryerson

Beneath the shadow of the aircraft and beyond the airport fence, communities wrestle with the impacts of airport expansion and operations. This dissertation builds scholarly foundations to explore the tensions between local residents who want to maintain healthy and stable communities and airport owners who want to grow operations and promote regional economic growth. The literature review contributes an overview of existing scholarship that investigates airports in an urban planning context, a realm of study I term ‘aviation urbanism’. To address gaps in aviation urbanism scholarship, I derived and investigated three research questions pertaining to neighborhood change, environmental justice outcomes, and the airport infrastructure planning process for airport-adjacent communities. The dissertation first asks: How has the population of historically marginalized groups living near airports changed with the rise of the jet age? The spatial analysis and descriptive statistics show that airport-adjacent communities in multi-airport regions generally increased persons of color and increased renters more than their respective metropolitan regions. Additionally, the communities often underperformed socio-economically with respect to their region. The second research question asks: Were hub airports more likely to expand if historically marginalized groups surrounded them? The exact logistic regression model, which was designed to be suitable for binary outcomes and small sample
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# TABLE OF CONTENTS

ACKNOWLEDGMENTS

ABSTRACT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 1: INTRODUCTION

Pushback

Four Examples of Pushback Tension

Research Design

Dissertation Outline

Overview of Results and Contributions

Tables and Figures

CHAPTER 2: AIRPORTS IN AN URBAN PLANNING CONTEXT

Introduction

Form

Growth

Environment

Concluding Planning Questions

Tables and Figures
Introduction........................................................................................................................................149
Overview of NEPA................................................................................................................................150
Methodology.......................................................................................................................................155
Results................................................................................................................................................161
Discussion: See the forest for the trees.................................................................................................168
Tables and Figures...............................................................................................................................171

CHAPTER 6: POLICY IMPLICATIONS.................................................................................................177
Introduction..........................................................................................................................................177
Summary of Findings and Contributions..............................................................................................178
Research and Policy Implications..........................................................................................................181
Closing Thought....................................................................................................................................186

APPENDIX.............................................................................................................................................188

BIBLIOGRAPHY....................................................................................................................................225

INDEX....................................................................................................................................................265
LIST OF TABLES

Table 2.1 Overview of aviation urbanism scholarship

Table 3.1 Decennial census variables used to characterize and compare airport-adjacent communities (AAC)

Table 3.2 Summary of airport-adjacent communities by population characteristic

Table 3.3 Centroids for scatterplots depicted in Figure 3.5

Table 4.1 Aggregated population data for 2000

Table 4.2 Two-way contingency table for expansion and capacity strain

Table 4.3 Three-way contingency table for expansion, capacity strain, and persons of color

Table 4.4 Three-way contingency table for expansion, capacity strain, and Hispanic persons

Table 4.5 Three-way contingency table for expansion, capacity strain, and foreign-born persons

Table 4.6 Three-way contingency table for expansion, capacity strain, and median household income

Table 4.7 Variables tested in exact linear regression model

Table 5.1 Two methodologies to determine the level of environmental justice concern for the 50 AACs

Table 5.2 Results for level of environmental justice concern

Table 5.3 Characteristics of the three AACs with moderate to high level of environmental justice concern

Table 5.4 Results of NEPA document review
LIST OF ILLUSTRATIONS

Figure 1.1 Residential displacement around Lambert-St. Louis International Airport
Figure 1.2 Creative use of excess capacity at Lambert-St. Louis International Airport
Figure 1.3 Aerial view of Hartsfield-Jackson Atlanta International Airport
Figure 1.4 Airport landscapes in Denver and Stapleton, Colorado
Figure 1.5 Airport commissioners at Burbank city council meeting
Figure 3.1 Map of multi-airport regions (MAR)
Figure 3.2 Airport-adjacent community (AAC) comparison geography
Figure 3.3 Boxplots summarizing total change in each population characteristic from 1970 to 2010, across 20 airport-adjacent communities
Figure 3.4 Boxplots summarizing percentage point change† in each population characteristic from 1970 to 2010, across 20 airport-adjacent communities
Figure 3.5 Scatterplot of percentage point change: AAC vs Metro
Figure 4.1 Map of 50-airport sample
Figure 4.2 Adherence to 5km airport-adjacent community boundary
Figure 4.3 Boxplots for AAC population data
Figure 4.4 Average daily capacity profile for the 50 airports (by hour)
Figure 5.1 Concept map of ‘environmental justice concern’ and ‘airport capacity strain’
CHAPTER 1 Introduction

Pushback

Airports sprouted throughout America at the beginning of the 20th century, virtually in tandem with the rise of urban planning. In an early study of airports conducted in 1930, Austin MacDonald, a Professor of Political Science at the University of California, remarked, "In a way, airport planning is simpler than most phases of the planning movement, because it has no hoary traditions gathered about it and no century-old mistakes to be corrected" (MacDonald, 1930, p. 273). Nearly a century after MacDonald’s assessment, modern airports have grown from humble airfields of the Winged Gospel to become regional transportation hubs fostering economic growth and global connectivity. It is appropriate to reflect on the traditions that now accompany airport planning and consider modern aviation’s place in the broader planning movement. Towards this end, this dissertation evaluates modern airport planning in an urban context to provide insight on how the next century of airport development can sustainably integrate with urban regions.

Broadly, urban planners consider the spatial arrangement of populations, housing, employment centers, transportation services, environmental resources, and open space. Transit, active transportation, and roadways constitute the main focus of modern transportation planning academia and practice. Although airports are less frequently addressed in collegiate planning curriculums, they are a significant transportation amenity within the urban planner’s domain (Ryerson, 2016). Urban planners are uniquely equipped to anticipate, study, and intervene in the tensions that define 21st
century airport infrastructure. I frame this tension in terms of competing senses of ‘pushback’. Airport planners are tasked with anticipating and planning for community pushback, which largely stems from unwanted environmental impacts. Tension arises as airport planners are also tasked with anticipating and planning for aircraft pushback, a technical term for an aircraft leaving the gate and preparing for departure. This ‘pushback’ tension between community impacts and air travel demand permeates aviation literature and practice. Scholars, airlines, airport owners, and municipal leaders around the world are struggling to create a sustainable balance of aircraft and passenger throughput, economic benefit, and environmental impact.

Demand in the US and global aviation system continues to grow, building pressure on airport planners to expand airport facilities. Nearly 700 million passengers boarded a plane in the US during the 2009 calendar year. The Federal Aviation Administration (FAA) predicts it will exceed one billion by 2036 (FAA, 2015b). Although the US aviation system includes nearly 20,000 airports, most of these airports remain unnoticed by passengers and urban dwellers. Roughly 19,000 US airports are either rural landing strips or small facilities that lack commercial service. American air travel is concentrated at a comparatively small number of commercial airports located in metropolitan regions. Just 137 airports accounted for 97% of total US passenger enplanements in 2009 (FAA, 2015a). Through their Operational Evolution Plan (OEP) released in 2001, the FAA concentrated major infrastructure investments at the busiest 30 airports, which accounted for about 70% of total US passenger enplanements in 2009. Consequently, more than a dozen new runways opened at US hub airports since 2001 in addition to other significant airfield, gate, and terminal projects intended to increase capacity.
As the largest metropolitan airports swell into their surrounding neighborhoods, the aviation industry is forced to reconcile the consequences of growth. Below the shadow of the aircraft and beyond the airport fence, lie ecosystems and communities wrestling with the negative externalities of airports. Aircraft noise, air pollution, community displacement, and ecological disturbance are among the significant local environmental impacts caused by airport development and operations. This research aims to explore and impart the tension between airport expansion and the concerns of airport-adjacent communities, such that municipalities and planners are better equipped to work towards reconciliation.

Four Examples of Pushback Tension

The tension between community impacts and airport expansion can manifest in very different ways. The following section briefly highlights four recent airport expansion stories to demonstrate the variation in community and operations outcomes: St. Louis, Missouri; Atlanta, Georgia; Denver, Colorado; and Burbank, California.

First, consider Lambert St. Louis International Airport. In the spirit of capacity expansion, St. Louis disrupted and displaced two different communities, one to the East and one to the West of the airport. The expansion to the West was in support of a new runway that opened in 2006. More than 2,000 homes, in addition to businesses, churches and schools, near the airport were demolished in the St. Louis suburb of Bridgeton (Crouch, 2007). The photo in Figure 1.1 shows the western end of the new runway along with an outline of the residential parcels that formerly existed there. St. Louis’ airport was effectively dehubbed after American Airlines’ parent company acquired Trans World Airlines (TWA) in 2001 and American Airlines significantly reduced operations in St
Louis. Even as TWA floundered in the 1990s, municipal leaders opted to continue to move forward with the new runway under the “strong belief that if they built up the airport, struggling airlines like TWA would re-invest and survive, and other newer prospective airline tenants…might take a close look at Lambert Airport as an attractive option” (Schmid, 2012, p.238). In 2016, the airport still has excess capacity and there is a lingering sense that the residential displacements in Bridgeton were unnecessary. The expansion to the East of the airport had a similar displacement effect, but was driven by incremental land acquisitions. In 1980, more than 4,000 people lived to the East in a community called Kinloch. There were about 300 residents as of 2014, with the population decrease largely attributed to airport land acquisitions (Schuessler, 2014). While the residents remain permanently displaced, the airport has implemented creative solutions to utilize their excess capacity – for example, converting an unused terminal area into a children’s play space shown in Figure 1.2.

Atlanta is another expansion example, but with a different operations outcome than St Louis. Hartsfield-Jackson Atlanta International Airport opened its fifth runway in 2006, which is visible in the aerial map in Figure 1.3. The project displaced more than 1,200 homes, 250 businesses, 7 churches and a convention center, but alternative proposals to place the runway to the north were expected to be even more disruptive to local communities (FAA, 2001; McCartney, 2005; Hendricks, 1997). The fifth runway was technically challenging, requiring builders to construct the runway over the existing highway and requiring planners to accommodate access to a historically significant cemetery near the runway. Unlike St. Louis, Atlanta survived two sets of airline mergers (in 2008 and 2010) after the runway opened and remains a strong hub in 2016, particularly for Delta Air Lines. The airport announced ATLNext in March 2016, a $6
Billion proposal for new parking structures, terminals, and a sixth runway (HJAIA, 2016).

Delta Air Lines used their stronghold over the airport to secure an airport lease agreement that specifically prohibits the city from planning to own or operate an additional commercial airport (Yamanouchi, 2016). Without the possibility for development as a multi-airport region, Hartsfield-Jackson’s surrounding communities will continue to bear the impacts of Atlanta’s long-term air travel demand.

In contrast to both Atlanta and St. Louis, Denver provides an example of a local community successfully resisting airport expansion while still allowing for air travel growth. Members of the Park Hill community, near Denver’s Stapleton International Airport, filed a lawsuit in the early 1980s regarding aircraft noise. As a result of this lawsuit and in anticipation of future air transportation needs, the city opted to close Stapleton and open a replacement airport by 2000 (O’Driscoll, 1993). Denver International Airport, the replacement airport known for its iconic tensile roof structure, opened in 1995 and was built on land annexed from Adams County about 20 miles from the city center. As of 2016, the replacement airport remains a strong hub for Frontier and United. Notably, the airport relocation occurred on primarily vacant and agricultural land. Across the 54 square-mile site, only 150 residential units and 1000 residents in a residential development required relocation to construct the new airport (FAA, 1989; Frerking, 1989). Land use around the replacement airport is slated to change: Denver and Adams County voters approved a measure in 2015 to undo parts of the original annexation land-use agreement and promote Aerotropolis-style development around the new airport (Snowden, 2015). Land use around Stapleton changed as well. In Figure 1.4, you can see that the control tower for Denver’s former hub in Stapleton is now
surrounded by homes, open space, and businesses as part of the New Urbanism-style development.

Unlike the Denver, Atlanta, and St. Louis airports, Burbank Bob Hope Airport is situated in one of the US’s eight multi-airport regions. Los Angeles, San Francisco, Dallas, Houston, Chicago, Washington D.C., New York City, and Miami are the eight major metropolitan areas that each have multiple hub airports. The pressure to meet Los Angeles’ air travel demand is spread across Burbank Bob Hope Airport, Los Angeles International Airport, Ontario International Airport, and John Wayne Airport. Bob Hope Airport is not just complex because it is situated in a multi-airport region; it is also owned and operated by three municipalities (Burbank, Glendale, and Pasadena) through a joint agreement. Of the three municipalities, Burbank residents live immediately adjacent to the airport perimeter. In 2000, Burbank voters (some of whom wanted to stop a proposed airport expansion) approved a local measure requiring voter approval for any airport terminal projects (Barlow, 2000). In addition to planning a new terminal that will meet seismic safety requirements and boost operations, the airport owners must specifically lobby Burbank voters for support to build it, as seen in Figure 1.5 (Hsin, 2015). The City of Burbank is planning to hold its first vote in November 2016 to ask residents to approve the proposed terminal upgrade (Sherwood, 2016). Meanwhile, Los Angeles International Airport, whose nearby residents do not have voter control of the expansion planning process, undertook a major airfield reconfiguration from 2006 to 2010 to increase capacity.

These four stories offer distinct examples of expansion trends in the US. Like St. Louis, hub airports in Cincinnati and Pittsburgh have expanded and subsequently been
dehubbled. Like Atlanta, hub airports in Chicago and Los Angeles remain strong hubs and are forging ahead with aggressive expansion plans. Both the St. Louis and Atlanta airport stories signal the tension in prioritizing airline and regional business interests over local residents’ interests. Denver is the sole example of hub airport relocation and Burbank is one of only two instances of voter integration into the airport planning process. Although Burbank and Denver are unique, they also signal the importance of nearby residential concerns and intergovernmental stakeholders in the 21st century airport planning process. This dissertation focuses on airport-adjacent communities in an effort to further investigate the pushback tension present during the airport planning process. With a deeper and broader understanding of the local stakeholders, academics and practitioners will be better equipped to anticipate and resolve stakeholder conflicts and plan for sustainable air travel.

Research Design

This dissertation develops the scholarly foundations to explore the tensions between local residents who want to maintain healthy and stable communities and airport owners who want to promote regional economic growth. I completed an extensive literature review to identify gaps in knowledge and bound the scope of the research. From the literature review, I developed three complementary research questions. In this section, I summarize the three research questions and provide an overview of the research design.

The first task in the research design included a literature review to understand how well aviation is integrated into urban planning scholarship. Since aviation is a widely researched technical field, I sifted through a wide range of research to narrow in on work
that specifically assessed airport infrastructure in an urban context. The underlying goal of the literature review was to document the extent that community concerns are documented, analyzed, and theorized in the planning literature. I grouped key literature into three categories: form, growth, and environment. In form, I reflect on architecture and spatial theories to understand how the airport facility is integrated with the urban landscape. In growth, I reflect on the literature addressing air transport demand and regional economic growth. In environment, I focus on literature that explores the environmental impacts that are of the greatest concern to airport-adjacent communities.

From these three categories of literature, I distill research gaps that relate back to the concerns of airport-adjacent communities. Specifically, I argue for more research that evaluates neighborhood stability, the distribution of environmental and health impacts, and community representation in the planning process.

In the next task for the research design, I developed three overarching and complementary research questions that address the gaps in literature. The following research questions were designed to inquire about the relationship between US airport development and airport-adjacent communities and reflect on how those communities are incorporated in the planning process:

(1) How has the population of historically marginalized groups living near airports changed with the rise of the jet age?

(2) Were hub airports more likely to expand if historically marginalized groups surrounded them?

(3) How did the Federal Aviation Administration and airport owners frame and evaluate environmental justice in the planning process for the airport expansion projects?
I designed the first question to provide insight on neighborhood stability in airport-adjacent communities. This question aimed to uncover patterns and trends in the racial and socioeconomic composition of airport-adjacent communities since 1970. The goal was to understand whether airport-adjacent communities experienced similar patterns of change since the rise of the jet age. I applied a qualitative narrative to a quantitative spatial-statistical analysis. In the quantitative component, I employed spatial analysis to define the perimeter of the 21 airport-adjacent communities situated in the eight multi-airport regions. I also used spatial analysis to define the perimeter of the eight regions. Then, I compared demographic, housing, and socio-economic changes in airport-adjacent communities, both in terms of raw counts and percentages. I also employed a difference in differences approach to compare the changes in airport-adjacent communities to changes in their respective regions. I qualitatively contextualized the data with three case studies that consider airport planning, airport ownership, and zoning regulations. Overall, this research question probes into neighborhood change and stability in airport-adjacent communities and offers a historical perspective to explore the relationship between community composition and hub airport activity.

The second question investigates the distribution of environmental and health impacts related to hub airport expansion. Hub expansion exacerbates environmental and health externalities on local communities because it accommodates more and larger aircraft. For this research, I evaluated the concentration of historically disadvantaged groups near hub airports that added a new runway and those that did not add a new runway post-2000. In essence, the goal was to understand if communities of a certain composition were more likely to experience an airport expansion, and, consequently, receive a larger or disproportionate distribution of environmental and health impacts.
Through a quantitative method of regression analysis, I tested the correlation between expansion and historically marginalized groups. I broadened my sample of airports to include 50 of the largest hub airports in the US. Similar to the first question, I used census data and spatial analysis to define and characterize the airport-adjacent communities. In addition, I used airport operations data to quantitatively assess whether an airport arguably demonstrated a need for hub expansion. Overall, this question probes into the distribution of environmental impacts of airport expansion, looking broadly at the national system of airports and invoking discussion of environmental justice in national airport capacity planning.

The third question investigates how airport-adjacent communities are represented in the planning process. There are multiple ways that airport-adjacent communities could be included or represented in the airport planning process, but this research question focused on documentation within the ‘NEPA’ planning process. I focused on the NEPA process because it is a consistent and prescribed stage of the airport planning process across the US. Due to stipulations in the National Environmental Policy Act of 1969 (NEPA), nearly all airport capacity expansion projects require an Environmental Impact Statement (EIS) and Record of Decision (ROD). In the 1990s, environmental justice became one of many impact categories that must be quantified and documented in the EIS and ROD. I used a qualitative method of document review to investigate how the Federal Aviation Administration and airport owners framed and evaluated environmental justice in the NEPA process for airport capacity projects post-2000. I looked specifically at the methods used to define and quantify environmental justice impacts in practice. Then, I compared these to academic understandings and theories of environmental justice. Finally, I consider the influenced that such documentation of impacts had on the
overall expansion planning process. Ultimately, this research question probes into airport planning practice to see how airport-adjacent communities are considered through the lens of environmental justice.

In this dissertation, I describe neighborhood change for airport-adjacent communities, offer a national perspective of environmental justice across the US hub airport system, and develop insight into airport planning practice. Together, the work generates a broader and deeper understanding of community pushback during the airport planning process.

**Dissertation Outline**

This dissertation is organized into six chapters. In the first chapter, I introduce the general topic of airport planning and orient the reader with four examples that show the variation in airport planning processes and outcomes. The second chapter, Airports in an Urban Planning Context, is an in-depth literature review that guided the development of the three main research questions in the dissertation. The subsequent three chapters explore and answer the three research questions in depth.

In chapter three, Airport-Adjacent Communities in Multi-Airport Regions, I explain trends and patterns of neighborhood change in airport-adjacent communities since the rise of the jet age. I compare demographic and socioeconomic characteristics over time at ~20 airports, within and across multi-airport regions. In chapter four, Airport Expansion and Environmental Justice in the 21st Century, I broaden the analysis scope to the 50 largest hub airports in the United States. I explain the differences and similarities between airport-adjacent communities near hub airports that have expanded and those that have
not expanded in the 21st century. This chapter also includes a discussion of environmental justice outcomes related to modern airport planning. Chapter five, Environmental Justice in the NEPA Process, evaluates environmental planning documents in the airport planning process. Specifically, I assess the extent that environmental justice issues were incorporated into the Environmental Impact Statements for 21st century airport expansion projects.

The final chapter, Policy Implications, offers conclusions and policy implications related to the three complimentary research questions. After summarizing and synthesizing key results, I present a vision for how this knowledge can be used to drive planning scholarship and practice.

Overview of Results and Contributions

In this dissertation, I generated new knowledge on the composition of airport-adjacent communities across the United States. I use spatial analysis and statistical methods to ask questions about neighborhood change and environmental justice. Broadly, my research congeals into overarching questions such as “How are the impacts of expansion distributed across populations?” and “How are impacts evaluated in planning practice?”

The main contributions of this work are as follows:

Chapter 2 offers a comprehensive literature review to advance the field of aviation urbanism. This literature review covers airport design, spatial theories of airport urbanization, air travel demand, urban agglomeration economies, and environmental impacts. Chapter 3 generates new knowledge in the demographic and socioeconomic
characteristics of airport-adjacent communities to better understand patterns of exposure to the negative externalities of hub airports over time. Chapter 4 statistically tests, using spatial analysis and regression modeling, whether hub airport development in the 21st century occurred disproportionately in communities with certain demographics and socio-economic status. Chapter 5 offers insight into the effectiveness of the National Environmental Policy Act and other social and environmental laws that inform the airport planning process. Finally, Chapter 6 summarizes the dissertation’s results and reflects on research and policy implications. With respect to research implications, I reflect on the future of aviation urbanism: the need for scholars with a key focus area in aviation urbanism, the value of mixed-methods research to answer questions related to equity and environment, and the challenges of operationalizing environmental justice. With respect to policy implications, I reflect on the way ahead for airports to adopt ‘Good Neighbor’ policies: acknowledging the limitations of NEPA, the need for regional planning engagement, and the need for metrics beyond operations and passenger delay to motivate and justify capacity expansion policy. Overall, this work contributes to the broader narrative of airport planning, transportation mega-projects, and environmental justice outcomes. This work builds toward foundational theory to understand how airport planning processes influence and are influenced by community and place.
Figure 1.1 Residential displacement around Lambert-St. Louis International Airport

These satellite images from 2000 (top) and 2008 (bottom) show the residential parcels occupied by the northern portion of Runway 11-29 at Lambert St Louis International Airport in Missouri. The suburban cul-de-sacs are clearly visible in the orange parcel outline. In total, Bridgeton residents in more than 2000 homes were displaced. *Top and bottom images generated using St Louis CountyParcel Viewer (St Louis County, 2014).*
After the decline of air travel demand at Lambert St Louis International Airport in Missouri, airport owners sought out creative uses for the airport’s excess terminal capacity. One solution included collaborating with The Magic House St. Louis Children’s Museum, a popular local organization, to install a children’s play space in the C Concourse (top). Airport officials are also renting out the unused space in the B Concourse for private events. Nikki Roach and Patrick Weller were the first couple to

Figure 1.3 Aerial view of Hartsfield-Jackson Atlanta International Airport The five runways at Hartsfield-Jackson Atlanta International Airport are visible in this aerial photo. The fifth runway is located to the South of the main terminal area. As indicated by the arrow, the fifth runway overlaps Interstate-285 with a grade-separated intersection. Image by Hartsfield-Jackson Atlanta International Airport (HJAIA, 2010).
Developers planned for 30,000 residents, walkable neighborhoods, and open space in the New Urbanism development at the site of the former Stapleton airport in Denver, Colorado. The control tower remains as an artifact of the past (top). The replacement airport, Denver International Airport, is known for its iconic tensile structures (bottom). *Top and bottom images photographed by Amber Woodburn in June 2015.*
Figure 1.5 Airport commissioners at Burbank city council meeting Terminal expansion in Burbank Bob Hope Airport in California requires consensus from representatives of three municipalities as well as voter approval from residents in the City of Burbank. Burbank Airport Commissioners discuss options to build a replacement terminal at the Burbank City Council Meeting in 2015. Only one other airport, Kansas City International, has a similar public referendum that requires residential support for airport planning projects. *Top and bottom images photographed by Ross Benson (Hsin, 2015).*
CHAPTER 2 Airports in an Urban Planning Context

Introduction

In an effort to place airports in an urban planning context, this chapter explores the state of scholarly conversation that links airport infrastructure to cities. I refer to this topic area as ‘aviation urbanism,’ which blends urban planning, urban sociology, and aviation studies to understand how urban dwellers and urban environments interact with air transport systems. An aviation urbanist might ask questions such as: How does aviation infrastructure integrate into the urban landscape? What motivates aviation growth and airport development? Or, what impact does aviation have on the quality of life of the city dweller? Towards identifying the extent that such questions have already been addressed, this literature review draws heavily from the work of aviation-focused geographers, planners, engineers, and economists. However, aviation is a widely researched technical field and much research has been generated outside the conventional boundaries of urban planning scholarship. Therefore, I also draw from the work of epidemiologists, statisticians, logisticians, natural scientists, and others who occasionally venture into airport planning topics. In collectively presenting work from these typically disparate disciplines, I frame the extent that aviation is directly integrated into urban planning scholarship, identify the key scholars and occasional scholars of aviation urbanism, identify gaps in research, and derive critical questions that investigate airports in an urban planning context.

To advance the study of aviation urbanism, I propose three foundations of study, organized in three research areas: Form, Growth, and Environment. First, I address Form with a discussion of architecture, design, and spatial arrangement to understand
how the airport facility is integrated with the urban landscape. Second, I review Growth occurring within the aviation industry and as a result of the aviation industry. The Growth section focuses on key literature describing the links between air transportation demand, the urban economy, and airport capacity expansion to understand what motivates growth and infrastructure development. Third, I review Environment through a community and ecological lens to understand how airports impact the quality of the human and natural environment, particularly those impacts that are of the greatest concern to urban dwellers in airport-adjacent communities.

The goal of the overarching literature review is to position the reader to understand the critical scholarly conversations about aviation urbanism and to identify research gaps that the dissertation will address. Ultimately, this chapter forms the basis for the dissertation's focus on airport-adjacent communities. Specifically, I argue for more research that evaluates neighborhood stability, the distribution of environmental and health impacts on nearby residents, and community representation in the airport planning process.

**Form**

The first section discusses the academic conversation pertaining to Form, the most visual of the three foundations of aviation urbanism. Within Form, I address architecture, engineering, and urban geography. From an architectural perspective, I discuss how airport design elements influence the passenger experience. From an engineering perspective, I discuss how the overall physical design and function of the airport influences the nearby residential experience. Finally, from an urban geography and
urban planning perspective, I discuss how the airport’s spatial arrangement in the urban landscape influences its relationship to the host city.

*Spectatorship and immobility in airport design*

Even as the function of airports changed since the 1920s, themes of spectatorship and immobility in airport design remain applicable to the passenger experience and the urban dweller experience.

Donald Albrecht, a celebrated museum curator, has published multiple books to accompany his museum exhibitions. In *Now Boarding*, his book on airport architecture, Albrecht (2012) included a chapter from art historian Peter Christensen who proposes a chronological synthesis of the history of airport architecture. In that chapter, Christensen broadly described airport design across the ‘ages’: Heroic Age (1920s-40s), Golden Age (1950s-60s), Democratic Age (1970s-90s), and the New Optimism Age (1990s-onward).

Airport architecture during the Heroic Age accommodated spectators arriving at the aerodrome for fantastic aerial shows. In addition to aerial performance, airports were geared toward postal freight and military activity. By the Golden Age, airports were beginning to incorporate service for passenger airlines. International airlines such as Pan American World Airways transformed the fantastic to the romantic. Architects responded with “continuous surfaces that mimicked aerodynamic design” and “saucerlike structures” to inspire a ceremonial sentiment to passenger travel (Albrecht, 2012, p. 17). The Democratic Age brought about standardization and streamlining. The introduction of jetways created seamless transitions between airport and airplane; open and airy spaces became “officious” in response to safety and security needs; and airport malls consumed increasing amounts of floor space in the airport terminal. Finally,
Christenson argued that architects in the New Optimism age not only adjusted to, but embraced the technical and engineering complexity of airport operations. Architects incorporated the “High Tech” movement into terminal design and transformed “elite monuments into popular places of social and cultural exchange, woven into the heart of the city” (Albrecht, 2012, p. 21). Airports constructed on artificial islands, fabric-tensile roof structures, and terminals with mechanical roof openings are testaments to the engineering ambition of the architectural movement in the New Optimism age.

Geographer Peter Adey (2007) echoed some of Christensen’s themes in a paper exploring the relationships between airport architecture and passenger immobility. Adey argued that airports are places of passenger mobility and immobility, spaces of spectatorship, and testing grounds for social control. While Christensen’s sense of spectatorship focuses on the aerial performances of the Heroic Age, Adey’s spectatorship analysis extends from the Heroic Age to the New Optimism Age. In Adey’s account, architectural aspects of the airport terminal intentionally pull the attention of the individual so that they are drawn to observation and spectatorship. In the 1920s, local residents were drawn to specific locations to observe aerial shows; by the 2000s, passengers were drawn to specific locations within the terminal area to observe other travelers and await information. Across all the ages, the architect strategically placed balconies, windows, screens, and meeting areas to encourage spectatorship and consumption. In placing concessions and restaurants near where the individual is suspended in observation, the architect promotes commerce and significantly improves airport revenue streams. Thus, airport architecture that steers mobility and immobility sustains a critical link between passengers and airport revenue.
Themes of mobility and immobility are also important in the relationship between nearby residents and airport expansion. Geographer Julie Cidell (2013) insightfully challenged our temporal and spatial understanding of the airport’s built environment. The mobility of the adjacent communities’ built environment operates on a slower time scale than the mobility of the airport’s built environment. As an example, she explained how Chicago O’Hare International Airport owners “downplay[ed] physical changes on airport property and its surroundings by relying on discourses of mobility” (Cidell, 2013, p. 538). Airport planners used “language of relocation”, contending that new runways were not built; rather, old runways were moved and modernized (Cidell, 2013, p. 529). As an airport rapidly changes, the surrounding built environment remains relatively static. This mobility inequity creates serious consequences for airport-adjacent residents and business owners. For example, they have a reduced capacity to adapt to new noise contours, demolished housing, or lowered property values caused by airport expansion. Thus, she argued that the relative mobility of the built environment is an important consideration in airport planning.

As the US moves past Christenson’s “New Optimism” age of the 1990s, themes of spectatorship and immobility remain critical to understanding local stakeholders. As Cidell (2013) suggested, I also argue that modern-day airport expansion conflicts are rooted in immobility. Community pushback during the expansion projects of the 2000s revealed some local residents as unwilling spectators of aviation activity who struggle with a sense of stifled mobility due to their relatively static built environment. Airport planners, architects, and engineers in the coming airport design age will need to better understand the nuance of social control and community planning to reconcile the consequences of growth. Perhaps airport architecture should not end at the airport
perimeter. Perhaps airport owners should be more accountable, professionally and financially, for reconciling the disparity between the mobility of the airport and the surrounding built environment. Community design elements built beyond the airport fence could promote a sense of “reconciliation” through design, bringing us closer to a sustainable air transportation system.

Theories of airport-centric land use

In the previous section I discussed how architects and engineers, as airport builders, influence the passengers’ and urban dwellers’ experiences of mobility and spectatorship. In this section I approach airports more abstractly to consider their spatial relationship with the urban environment. By the 1990s, few scholars had introduced spatial theories to identify and name the relationship between the airport periphery and the host city. As hub airports grew to prominence in the 21st century, scholarship began to characterize the airport facility in the broader socio-spatial experience, questioning concepts of place and framing strategies for land use planning and development.

First, consider that the airport, as a manifestation of mobility in the era of supermodernity, has been characterized as a ‘non-place’. Anthropologist Marc Auge (1995) argued that airports, alongside other modern means of transport, are not anthropological places and cannot be defined as relational, historical, or concerned with identity. He argues airports create a shared, temporary, and anonymous identity as ‘passenger’, but airports remain a non-place, lacking individual identities, language, and local references. Sociologists Mimi Sheller and John Urry (2006) challenged Auge’s assertion, arguing that even though airports may be boring and routine spaces of global mobility, they are spaces with “considerable social complexity.” With their New Mobilities
paradigm, Sheller and Urry also challenged sedentarist theory, where “stability, meaning, and place” are treated as normal, while “distance, change, and placelessness” are abnormal. Planner Nathalie Roseau (2012) was less concerned with the airport as place, and more interested in how the airport mirrors place. She argued that the airport reflects the crucial issues of the airport’s urban environment, often bringing “the thorniest urban issues to the fore without necessarily being accorded the noble status of prized urban spaces” (Roseau, 2012, p 34).

While 21st century airports arguably lack an independent identity of ‘place’, they maintain a synergistic identity with their urban hosts and global environment. Airports are instruments facilitating global networks between urban regions, notably referenced in Saskia Sassen’s (2005) concept of the ‘global city’ and Manuel Castells’ (2010) concept of the ‘space of flows.’ Australian urban planning scholars Nicholas Stevens, Douglas Baker, and Robert Freestone (2010) represent a school of thought that moves beyond the airport as instrument and ascribes an urban-spatial context to airports. Their work, along with landscape urbanist Laura Cipriani’s (2014) book, offer brief summaries of airport-centric land use models that have appeared with the rise of the jet age. These spatial models guide our understanding of how airports interact with and integrate into the urban landscape.

Through spatial models, we can begin to conceptualize and name the airport space and its periphery. Airport practitioners and scholars frequently, and perhaps most generically, refer to the ‘Airport Region.’ The precise meaning of ‘Airport Region’ can vary across authors, but the term communicates a shared vision for planning the territory around a centrally positioned airport. The term suggests self-aware, intentional planning and
governance that supports airport-centric development (Cipriani, 2014; Schlaak, 2010; Stevens, Baker, & Freestone, 2010). The Airport City, the Decoplex, the Airport Corridor, and the Airea are more nuanced conceptualizations that describe airport activity centers and airport-centric urban development. Their common view is that airports are the primary drivers of development in certain parts of the urban landscape, but each model offers a slightly different interpretation of the extent of the airport’s influence.

H. McKinley Conway, an aeronautical engineer, wrote of the ‘Airport City’ in a series of books released in 1977, 1980 and 1993. In the series, he broadly characterized the Airport City as the city-like aviation-related activity that exists within the airport and the surrounding hinterland. He proposed varying options for development such as “fly-in communities”, where the runway serves as the community’s main street and residents fly in and out on personal aircraft, and “the jetport decoplex,” where the airport functions as its own city and airport managers govern a network of supporting infrastructure systems and services (Conway, 1980; Conway, 1993). In 2010, Maurits Schaafsma, an urban planner with Schiphol Group in Amsterdam, introduced a spatial arrangement called the ‘Airport Corridor.’ This model describes a development that extends from an airport to the center of the host city along a spine of transportation infrastructure, such as a train or highway. In this spatial arrangement, the airport remains outside the city and is not characterized as a city in its own right. He argued the corridor arrangement positions the airport more broadly in society and the region, while also making airport activity more sustainable. Alternatively, architect Johanna Schlaak proposed the ‘Airea’ in 2010. The Airea is composed of small, fragmented islands of development with activity correlated to the airport. The islands are scattered throughout the metro area and are not necessarily well connected to each other. Where Schaafsma’s corridor model describes
relatively few airport developments, Schlaak offers a model of the status quo and a way ahead for improved management and integration of the Airea.

While the Airport City, Decoplex, Airport Corridor, and Airea offer geographic descriptions of the airport’s relationship with the city and metro region, the ‘Airfront’ and ‘Aerotropolis’ models promote economic strategy as the basis of the spatial model. John Kasarda, an aviation logistics academic and consultant, developed the idea of the Aerotropolis in the 1990s, which culminated in a book released in 2011. Kasarda and Lindsay (2011) predict that this century’s cities will build up around airports, as a response to the economic demands of globalization. The Aerotropolis is the industrial and commercial development surrounding an airport, radiating outward up to 20 miles. Kasarda’s concept is fundamentally rooted in the economics of just-in-time logistics, capitalism, and globalization (Irwin and Kasarda, 1991; Kasarda and Lindsay, 2011). Charles et al (2007) critiqued the Aerotropolis model, highlighting the shortsightedness of Kasarda’s economic assumptions. They argued that Kasarda’s model requires long-term reliance on fossil fuels (a non-renewable resource), creates a vulnerable concentration of critical infrastructure, and underestimates the role of maritime ports.

In contrast to the Aerotropolis, which is presented as the normative fate of our globally-connected society, the Airfront is presented as a prescription for strategic revitalization. Similar to waterfront or riverfront planning strategies, the Airfront is a revitalization strategy proposed by planner Whit Blanton intended to rejuvenate failing or distressed neighborhoods (Blanton, 2004). On the surface, the Aerotropolis and Airfront models market a similar style of land use that leverages the airport to create an activity cluster in the form of a localization economy. However, they differ in their deference to place and
to people. The Aerotropolis leverages the airport in service to the global economy’s need for just-in-time logistics, while the Airfront leverages the airport in service to the local community’s need for a stable economy.

Academics have characterized the airport as a non-place, as a mirror for place, and as a place synergistic with its urban host. Airport-centric land use models, like the Airport Region, Airport City, Airport Corridor, and the Airea recognize that airports function as an instrument for globalization, attracting certain types of economic activity and patterns of land use. Other models, such as the Aerotropolis and Airfront, incorporate a normative interpretation of airport-centric land use, seeing it as a tool to promote economic growth globally and locally. I argue that these spatial models do not fully acknowledge or account for the needs of the residents of airport-adjacent communities. Conway’s ‘fly-in’ community model may yet be possible on a small, niche scale, but does not translate to the scale of commercial hub operations. Blanton’s Airfront model, which is posed as an urban regeneration strategy, is complementary to the economic needs and interests of local residents and business owners. However, it is still a work-in-progress concept. To be considered a community planning or land-use model, the airfront strategy requires more holistic reflection on the unique costs and benefits associated with living, working, and recreating in close proximity to a commercial airport. Only Schaafsma’s Airport Corridor model broadly considers sustainable integration with local communities and governance. In their own review of the spatial models of airport development, Freestone and Baker (2011, p. 274-5) argued for “greater convergence between airport and city planning” and specifically called for a “more explicit embrace of collaborative planning.” More work is needed to evaluate these airport-centric spatial theories beyond the
economic context, and pursue more holistic evaluations of their sustainability for local communities.

Emerging airport planning frameworks

The previous section uncovered a ‘community’ gap in the spatial models that describe the relationship between airport infrastructure and the urban landscape. There is much opportunity for planning scholarship to enhance the conversation surrounding airport-centric development. For example, planners are uniquely equipped to evaluate development using Scott Campbell’s planner’s triangle model (Campbell, 1996). Additionally, planners can look to Susan Fainstein’s discussion of segregation, diversity, and equity from architectural, racial, and socio-economic perspectives (Fainstein, 2010). A few planning scholars are emerging with airport planning frameworks that reign in a more holistic view of infrastructure, land use, environment, and community.

Stevens, Baker, and Freestone (2007) introduced the Airport Metropolis as a conceptual device to understand the complexity in planning airport activity centers and airport-centric land use. Consistent with the planner’s triangle, they considered economic, social, and environmental sustainability. However, they proposed four (not three) interfaces between the airport and the surrounding metropolitan milieu: economic development, land use, infrastructure, and governance. While their conceptual device is useful for considering the airport within the wider urban system, we still need research that explains the real-world phenomena associated with these interfaces.

Alternatively, Cipriani (2012) offered a planning framework rooted in practical airport design. In her book, Ecological Airport Urbanism: Airports and Landscapes in the Italian
North East, Cipriani introduced the term ecological airport urbanism. Her work outlines the connections between environmental landscapes and the airport facility. Through this ecological lens, she explored airport design strategies that reduce environmental impacts. Although the list of sustainable practices on airport facility design is a useful and important contribution, the book falls short of offering a planning framework to guide the development of nearby communities.

Airport-centric land use planning requires greater integration of the airport-adjacent community. If cities, airport city or otherwise, are planned in deference to infrastructure over citizens, can we expect the outcome to be just, resilient, or sustainable? Urban planners need to integrate with aviation industry and academia to ensure these concerns are addressed.

**Growth**

This section discusses the academic conversation pertaining to Growth, with a focus on the demand, capacity, and economic aspects of airport planning. Airport facility planning and business logistics planning rely heavily on estimates of current and forecasted air travel demand. Since airline deregulation in 1978, airlines have controlled the design and re-design of the route network. The airlines reorganize origins, destinations, and transfer points according to growth in passenger demand and such that the routes maximize profitability. At the same time, municipal and federal airport financers have aimed to anticipate, attract, and respond to changes in the route network with strategic investments in publicly-owned airport infrastructure. Generally, municipal airport owners have pursued airport capacity expansion as a means to alleviate congestion or grow a regional economy. Over time, new activity centers and patterns of land use emerged as
the metropolitan economy responded to changes in the prominence of the airport in the route network. In academia and practice, the link between economic development, air traffic operations, and airport access is central to arguments in favor of airport-centric development. This section reviews the scholarly conversation surrounding the growth within the aviation industry and growth influenced by the aviation industry.

*Patterns of air travel demand*

Passenger demand manifests as more than a network of origin and destination airports, it also includes intermediary connecting ‘hub’ airports. The increased concentration of activity at ‘hub’ airports, referred to as the hub-and-spoke network, is fundamental to understanding air travel demand. In 1998, transportation economist Aisling Reynolds-Feighan penned an overview of the evolution of air service in the US, specifically focusing on the transition to hub and spoke networks after the Airline Deregulation Act of 1978. After deregulation, airlines were granted authority to set their own schedules and define their own routes. She found that "concentration in the traffic patterns at the larger airports was at a high level even prior to deregulation", but has become even more concentrated since 1978 (Reynolds-Feighan, 1998, p.251). This increase in hub and spoke concentration instigated a massive reorganization for airlines and an overall decline in the number of airline competitors. Business economist Severin Borenstein (1992) cautioned that future airline mergers must be met with skepticism and argued that regulators should focus on ensuring that the airlines continue to survive because they truly have efficient production methods, not just because they employ anticompetitive marketing devices.
Airports function as the nodes for global passenger flows and are widely considered critical junctures in the era of globalization. Consequently, global passenger airline data has been used to understand the structural patterns and hierarchies of cities on the global network (Dereuudder and Witlox, 2005; Mahutga et al, 2010; O’Connor, 2010).

Political scientist Mike Aaltola argued that the geography of hub-and-spoke networks is a reflection of empire and the "modern hierarchical world order" (Aaltola, 2005, p.261). Airports in places of high imperial status, which tend to be primary hubs, have the highest expectation to maintain security and state-of-the-art facilities. The smoothness of the individual’s experience through the airport reflects their position in the hierarchy of global citizenship. Urban planner Kevin O’Connor (2003) uncovered a pattern of emerging demand in second-tier cities, ranked just below global cities. From 1990-2000, the airports in cities ranked just below global cities grew in prominence, in terms of airport passengers and connectivity. He argued that patterns of air travel growth in the 21st century will fall outside the typical list of global cities. This is somewhat echoed in work completed by transportation planner Megan Ryerson and geographer Hyun Kim. They found that when hub hierarchies are defined according to airline operations metrics (connectivity, frequency, and passenger loads), they are organized into multiple hub tiers that do not necessarily correlate with the global status of the city (Ryerson and Kim, 2013). Using cluster analysis, they found five tiers of US airline hubs in 2004 and 2012. The top hubs in Atlanta and Dallas were each identified in a class all their own, while global cities like New York and Los Angeles were in the lower tiers. In practice, cities continue to conflate hub status with global status and interurban competition.

While the urban boosterism mentality may have been relevant at the dawn of airport infrastructure or during the major reorganization of the network in the 1980s-1990s, it
may not be as critical for cities to compete for connecting traffic in the 21st century hub-and-spoke network. It is true that hub-and-spoke networks allow a more economically efficient method for airlines to compete for passenger demand, but it allows fewer airlines to survive. The smaller group of surviving airlines amounts to fewer market options for passengers. Further, when an airline dominates activity at the hub airport, the airline gains status as a powerful stakeholder during hub airport planning. However, connecting hub activity may not be critical for maintaining city status in the 21st century: it may be more critical to attract origin-destination passengers than connecting passengers. Studies using airline passenger flow data to assess the world city hierarchy seem to prefer origin and destination data, regarding connecting hub traffic as less significant. More research is needed to explain the extent that increased hub-and-spoke concentration actually strengthens the position of a city in interurban competition. Even though some studies show that a connecting hub does not necessarily elevate a city to global significance, the next section discusses evidence that hub airports can still make a significant contribution to the host city’s urban economy.

Aviation and the urban economy

In addition to using aviation data to understand how cities relate to one another, researchers also use aviation data to understand how airports influence the economy of its host city. I characterize the latter work into research that either (1) explores the airport as its own activity or jobs center or (2) investigates the link between airport activity and urban economic performance.

Among the research that explores the airport as its own activity or job center, researchers look for links between the location of the airport and the location of
complimentary jobs. Sociologist Stephen Appold (2015) investigated employment at airport activity centers in the 51 largest US metropolitan areas. He found that 80% of the commercial airports can be characterized as employment agglomerations. He further divided employment into three categories: transportation-providing, transportation-supporting, and transportation-using. Across all airport cities, he found that transportation-providing employment is driven by the need for airport access. The other two forms (transportation-supporting and transportation-using) are more dependent on urban land costs and agglomeration benefits. Transportation-using sectors, such as warehousing and logistics, are not necessarily located at the airport since they are more concerned with access than proximity. In another study of 143 metropolitan counties, John Bowen (2008) found that air and highway accessibility correlated with the county-level importance of warehousing, further confirming the significance of airport access.

Even when the airport does function as an economic activity center, it does not necessarily translate to employment for nearby residents. Transportation geographers Angela Antipova and Esra Ozdenerol (2013) tested the distribution and centralization of jobs and housing in Memphis International Airport’s airport-centric development, which they refer to as an Aerotropolis. They found that more higher-paying jobs are located in the Aerotropolis, but female and minority workers benefit less than white male workers around the airport. Black and female workers who reside in the Aerotropolis did not hold a representative portion of the Aerotropolis jobs.

The literature is still conflicted on the business dynamics of airport-centric development. Stephen Appold and John Kasarda (2011) explained the mechanics of development around the airport as part of the airport owner’s two-sided market business strategy.
Using five case studies, they explored the extent that compatible land use can attract passengers and airlines (the two sides of the market) to the airport. They found that air traffic alone does not seem to seed development, but concluded that the ‘two-sided’ market strategies warrant more research to better explain airport business strategy. Also seeking to better understand drivers for airport-centric development, the Government Accountability Office (GAO) developed a case study report. Airport-centric development officially garnered national significance after Congress specifically referenced the Aerotropolis concept in The Moving Ahead for Progress in the 21st Century Act (MAP-21). Consequently, the GAO report (2013) heavily referenced the work of John Kasarda (the father of the Aerotropolis concept) and lists five factors that facilitate airport-centric development: development at the airport, air and surface connectivity, funding sources, development in the region, and stakeholder collaboration.

In another conceptual review, transportation engineers Rouzbeh Boloukian and Jurgen Siegmann (2016) wrote of the need for airport-centric development to be integrated with urban planning processes. Overall, the literature suggests that air traffic alone is not the prominent driver of airport-centric development. Rather, traditional urban planning issues of financing, intermodal transportation access, connectivity, and municipal management strategies are central issues.

Looking more broadly at the metropolitan area, there are many scholars who suggest that airports are drivers for the regional economy, specifically employment and population growth. Michael Irwin and John Kasarda (1991) assessed the relationship between the centrality of the airline network (from 1950 to 1980) and employment growth at 104 metropolitan areas. They found that the reorganization of the airline network during that time caused an increase in employment growth. Geographer Andrew Goetz
(1992) studied the relationship between air transportation passengers and the metropolitan area’s population growth and employment growth from 1950-1987. He also found the relationship was positive, but concluded that the relationship diminished over time. Another geographer, Keith Debbage (1999), found that the counties that hosted the three largest airports in the US Carolinas experienced employment gains, particularly in the manufacturing sector, after those airports experienced significant gains in passenger volume. Transport economists Ken Button and Somik Lall (1999) also found that air traffic caused increases in employment from 1979 to 1997. Economist Jan Brueckner's seminal study found that a high level of passenger enplanements had sweeping positive benefits for service-employment in metropolitan areas. He argued that, given the link between airline traffic and employment, the planned expansion at Chicago O'Hare International Airport would be a "powerful economic development tool" generating 185,000 jobs (Brueckner, 2003, p. 1455). Further specifying the air travel effect, economist Richard Green (2007) found that passenger activity, not cargo activity, is a powerful predictor of population and employment growth.

The previous studies focused on large metropolitan areas, but some scholars have looked specifically at rural airports to understand the link between airport service and rural economies. Douglas Baker, Rico Merkert, and MD Kamruzzaman (2015) evaluated 88 small (regional, rural, and remote) airports in Australia and empirically recorded a bidirectional relationship between total airport passenger movements and aggregate real taxable income. Rural sociologist Guangqing Chi looked at the effect of airport infrastructure access and improvement on rural, suburban, and urban areas in Wisconsin. He found that population growth in suburban and rural areas was associated
with airport accessibility, but population growth in urban areas did not correlate with airport accessibility (Chi, 2011).

There is also a body of research that obscures the theory that the airport drives urban economic growth. For example, urban planners in Giuliano et al (2012) did not find a significant relationship between proximity to the airport and employment center growth between 1990 and 2000 in Los Angeles. They reasoned this may be because there was less potential for growth on land near the airport as time went on. Geographer Julie Cidell (2014) argued strongly against the theory that airports significantly drive urban economic growth. She evaluated the area around large hub airports, the central business district, the largest shopping mall, the largest wastewater treatment plant, and a random point in 22 different metropolitan areas in the US. She found that professional and administrative employment frequently did not significantly cluster at the airport infrastructure when compared to these other points. She also challenges the idea that airports are the significant driver of metropolitan growth, noting that “a wide range of individual histories and morphologies that may have affected the location of jobs to a greater extent than the presence of the airport has” (Cidell, 2014, p. 1130). Economist Volodymyr Bilotkach (2015) used panel data from 1993-2009 to investigate the relationship between the metropolitan economy and aviation activity at all airports with more than 10,000 annual passengers. He found that, on average, adding one additional non-stop flight destination adds 100-200 jobs and 4-15 businesses to the metropolitan statistical area. General increases in flights to existing destinations resulted in minor increases to average wages, but had a statistically insignificant impact on the number of business establishments or total employment. Given the modest effects, he stated “it would probably be an exaggeration to call local airports ‘engines of economic
development" (Bilotkach, 2015, p. 1592). Other work has found mixed results when evaluating the effect of a runway capacity enhancement on real gross metropolitan product and labor productivity (Tittle, McCarthy, and Xiao, 2013) and highlighted the role of national economic decline and growth in the link between urban economy and airport activity (Neal, 2012).

It is possible that the airport is overstated as a job generator, both locally and across the metropolitan area. These works hint at the need for greater contextualization of the urban fabric surrounding airports to understand when and why some airport-centric development strategies succeed. And, importantly, to understand how ‘success’ is operationalized. Even if airports strengthen local development or boost the metropolitan economy, it is important to consider the scale of the effect when compared to other forms of urban infrastructure and other urban development strategies. Additionally, the capital costs, congestion, and environmental externalities attached to aviation activity must also be weighed against the economic impact, particularly as the federal government considers subsidizing airport expansion and airport-centric development.

*Planning airport capacity*

From the previous sections, it is clear that economic goals can motivate airport expansion. Expansion designed to ‘accommodate demand’ can obscure other goals to maintain airline loyalty (to preserve hub status and global city status), induce passenger demand (to increase metropolitan status, employment, and population), and attract logistics firms (to seed economic activity centers near the airport). This section reviews the academic conversation about the strategies available to manage airport capacity: (1) take no action, (2) holistically evaluate regional infrastructure to spur efficient use of
multimodal capacity, (3) implement policies or technology to spur efficient use of existing hub airport capacity, or (4) build additional runways and terminals to expand hub airport capacity.

The first option is to simply do nothing, essentially constraining capacity even as global passenger and flight demand increases. The following studies were completed by air transport researchers, who traditionally focus on operations and delay research. Antony Evans and Andreas Schafer (2011) simulated airline response to capacity constraints. The authors argue that, without capacity enhancement, airlines will alter their business strategy to compete in the constrained environment. Their capacity-constrained simulation suggests that airlines will maintain flight frequency before upgauging to larger aircraft. Although delay would substantially rise at hub airports without added capacity, they found that air travel would still grow and emissions would actually be lower than a scenario with added capacity. Marc Gelhausen, Peter Berster, and Dieter Wilken conducted another study of constrained capacity. They estimated that 70% of flights would operate at capacity constrained airports by 2016 if demand continued unabated and capacity stays constant (Gelhausen, Berstern, & Wilken, 2013). Constrained capacity can also be evaluated in the context of the total cost of delay. Aviation researchers in Ball et al (2010) found that flight delays incur direct and indirect costs to airlines, passengers, and the US economy, which totaled to $37 billion in 2007. Delay also impacts other operations throughout the system. As evidenced in Churchill et al (2010), propagated delay accounts for 20-30% of all flight delay. Clearly, it is important to add capacity to manage delay, but when, how much, and where must be considered alongside the potential of airlines to alter their business strategy as well as with consideration for the disbenefits of inducing demand and concentrating increased
negative externalities at hub airports. Overall, airport operations research offers insight to the driving forces for airport expansion: airlines prefer efficient hub airports; airlines compete with each other for frequency, which increases operation demand; and, in the event that airport planners do nothing, demand may increase such that some hub airports could experience delays of an hour or more per flight by 2030.

A second option is to consider enhancing regional infrastructure to spur efficient use of multimodal capacity. Planners can design regional infrastructure to redistribute passengers across regional transportation options, such as other airports, railways, and highways. In research I completed with transportation researchers Megan Ryerson and Mikhail Chester, we specifically evaluated the challenges to assessing the competitive and complementary nature of high speed rail and aviation during the planning process (Woodburn, Ryerson, Chester, 2013; Ryerson and Chester, 2014). Mikhail Chester and Arpad Horvath completed additional life-cycle analysis research comparing highways, railways, and airports in California’s intercity markets and determined that supply-chain factors were critical to measuring system sustainability (Chester and Horvath, 2012). Milan Janic (2011) considered the impact of transforming an airport into a multimodal transport node with high speed rail service. He found that even modest substitution (2% of short-haul flights switch to rail service) significantly reduced social and environmental impact (20% reduced passenger delay and 17% reduced noise and greenhouse gas emissions costs). Looking to regional airport systems, Julie Cidell (2006) evaluated the redistribution of flights from a congested hub to smaller airports in the Boston region. She argued that regional airport systems effectively make use of limited land area in dense urban areas, benefit travelers, and spread the burden of air travel more equitably across the region.
A third suite of options involves implementing policies or technology to spur efficient use of existing hub airport capacity. Slot controls are one example of encouraging more efficient use of available capacity, but remains an uncommon practice in the US (despite use in Europe since 1993). Slots function as hourly airport operations limits, where only a specific number of operations ‘slots’ are permitted per hour and each ‘slot’ is allocated, by assignment or auction, to different airlines. Churchill et al (2013) studied the best time to implement airport arrival slots. They created a stochastic optimization model that builds an hourly slot profile over the course of day at an airport. They found that it is best to use slots earlier in the day to prevent delay from propagating. Swaroop et al (2012) also evaluated slot controls. After comparing schedule delay costs against queuing delay savings when slots are implemented at different levels, the authors recommended slot controls at 16 US airports. Focusing on Europe, Peter Forsyth (2007) found that even if the airports use slots, there are still concerns about the efficiency of the allocation of slots across airlines.

A similar ‘demand management’ option to slots, airport owners can also consider different pricing structures to spur efficient use of existing hub airport capacity. Brons et al (2002) studied the price elasticity of demand. The authors used a meta-regression to evaluate whether the price elasticities reported in the literature were statistically equal. Importantly, the authors found that business travelers across North America, Europe, and Australia are less sensitive to price. This insensitivity to price is problematic for environmental pricing policies seeking to reduce impacts through emissions charges. In response to greenhouse gas emissions regulations in the European Union (EU), Mendes and Santos (2008) explored how environmental incentive policies can change air transportation demand. Neither of the regulations that the EU were considering
(auctioning or grandfathering emissions trading schemes) reduced demand by 2%. The authors argued that stringent emissions charges are better instruments to achieve demand reductions, and actually reduce emissions through reduced demand. However, the charges would need to be high in order to influence demand, so it has not gained much traction with airline stakeholders. In a series of three papers, Madas and Zografos (2006, 2008, 2010) reported five different strategies that employ a combination of instruments and rules to manage demand in Europe. In the collective rankings across surveyed experts, the congestion pricing strategy was the superior choice for all airport hub types. The authors argued that air traffic management must include both capacity expansion (capacity-side efforts) and slot allocation (demand-side efforts) - and they must be considered together, not as separate activities.

The final option is physical capacity expansion, such as new or extended runways and terminals. Capacity expansion can translate to benefits for air travel consumers. Wenbin Wei and Mark Hansen (2006) developed an aggregate demand model for air passenger traffic in a hub-and-spoke network to estimate the monetary benefit of airport capacity expansion for passengers. They found that increasing the hourly arrival rate leads to fare reduction and consumer surplus. However, mega-projects on the scale of airport capacity enhancements often do not adequately incorporate risk or institutional accountability. Some scholars argue that this leads to pervasive cost overruns and deficiencies in environmental impact assessment at a detriment to urban dwellers (Flyvbjerg, Bruzelius, and Rothengatter, 2003; Szyliowicz and Goetz, 1995). Forsyth (2007) also critiques whether political and environmental solutions will be efficient or cost effective when an airport ultimately decides to expand. Additionally, even if that airports expand capacity to retain an airline, there is no guarantee airlines will remain loyal to the
airport over the lifetime of the infrastructure. As an example, Fangwu Wei and Tony Grubesc (2015) reported a case study overview of the Cincinnati/Northern Kentucky International Airport (CVG). Nearly a decade after major capacity enhancements for Delta Air Lines, CVG was dehubbed by the airline. Wei and Grubesc argued CVG’s status as a fortress hub for Delta led to predatory pricing that forced out low-cost carriers and instigated market leakage, wherein passengers chose other airports in the region due to lower fares. Local issues of predatory pricing and proximity to alternative airports, combined with national issues of industry upheaval (terrorist attacks, rise of low cost carriers, increasing fuel costs, carrier consolidation) eventually led to CVG’s dehubbing.

In airport planning practice, US airport owners have exhibited a pattern of defaulting on capacity expansion when faced with the challenge of accommodating future demand. I critiqued this pattern of capacity expansion in research with Megan Ryerson (Ryerson and Woodburn, 2014). Specifically, we reviewed the practitioner’s approach to alternatives analysis in environmental assessments. We argued that there are three barriers preventing airports from evaluating demand management alternatives: narrow project objectives, uncertainty over the FAA’s stand on demand management, and economic development concerns. We call for strengthened participation from regional planners in the airport planning process so as to uncover and implement innovative solutions to airport congestion. This will be critical for the future of eastern and western coastal megaregions in the United States. Coastal megaregions are expected to grow in population and economic activity, with the latest forecasts suggesting there will be insufficient air transportation capacity to meet the needs of those regions. In a report for the Airport Cooperative Research Program, Coogan et al (2010) argued that the airport planning process requires more multi-jurisdictional involvement to consider options to
meet the forecasted demand. They also suggest that airports should be awarded more control and authority to implement demand management and pricing policies and should consider multimodal infrastructure.

The main takeaway for this body of Growth research is to understand the major considerations in airport planning and airport-centric development: the economics of travel delay, the presumed link between air traffic and the urban economy, and the geography of hub-and-spoke systems. As global aviation demand has increased, planning practice extensively defers to capacity expansion over other alternatives. While regional infrastructure alternatives have been revisited in the transportation research community, these alternatives have rarely manifested in planning practice. In some cases, airlines have actively hindered the consideration of alternatives, as seen in Delta’s 2016 airport leasing contract with Hartsfield-Jackson Atlanta International Airport. There is a need for planning and policy research that can, in a sense, level the playing field with airline stakeholders. Urban planners are positioned to enhance the current cost-benefit value framework, which primarily relies on passenger delay costs, so that it incorporates environmental externalities, risk of airline dehubbing, and risk that demand will not manifest as expected or as desired for urban economic growth. Further, planners are positioned to evaluate the extent that public infrastructure is subsidized according to airline profitability and urban economic growth, and whether it is at the expense of environmental and social sustainability.

Environment

Airport owners modify landside and airside airport capacity over time in response to actual and forecasted demand. As global cities continue to urbanize, the pressure for
airport growth conflicts with the concerns of airport-adjacent communities, particularly with respect to the human and natural environment. This section will summarize the scholarly conversation surrounding Environment, the third foundation of airport urbanism. First, I review the social and health impacts stemming from aircraft noise and emissions. Then, I broaden to a more general reflection on scholarship that addresses air transport sustainability. Finally, I discuss the call-to-action for aviation urbanists to investigate and participate in attempts to reconcile negative externalities on airport-adjacent communities.

Social and health impacts of aircraft noise and emissions

Medical and acoustic science has linked aviation noise to negative health outcomes for nearby residents. To test the link between noise and sleep disturbance, Joos Vos and Mark Houben (2013) conducted an 18-night study with 50 volunteers. They tested gun shots, aircraft landings, and door slams to simulate noise from military and civil activity. Aircraft noise at 55 dB woke participants nearly 1 in 5 times. At 80 dB, the proportion of awakening increased to slightly more than 1 in 2 times. Additionally, since the single bangs from rifle, machine gun, door slams, and aircraft had similar proportions of awakening, the authors concluded that the A-weighted sound exposure level (ASEL) was an adequate predictor of the proportion of awakening for single occurrences of each type of noise. In practice, airport planners often use $L_{\text{night}}$ as a measure for the average sound level during the nighttime period (11pm-7am). Sleep disturbance research provides little evidence that supports $L_{\text{night}}$ as an effective tool to measure the probability of awakening (Basner, Samel, and Isserman, 2006). Seasoned noise scientist and consultant, Nicholas Miller (2012) discussed the limitations of $L_{\text{night}}$ since the average...
metric masks the sleep disturbance affect. Also, Miller proposed that noise scientists seek an alternate method to better communicate the noise externality, such as deriving contours of the probability of awakening or estimating the percent of people who would be awakened by the noise. Medical researchers in a paper led by Charlotta Eriksson were the first to directly link metabolic health outcomes to aircraft noise exposure (Eriksson et al, 2014). They were motivated to design this study due to the substantial evidence in existing literature that (1) links noise exposure to stress and sleep disturbance and (2) links chronic stress and sleep disturbance to impaired metabolic function. They determined there is a statistically significant positive association between long term noise exposure and changes to waist circumference. They also found that noise exposure increased type 2 diabetes for women. The health impacts of aircraft noise are further chronicled in a synopsis of the state of current noise research: chronic hypertension, depression, annoyance associated with increased risk of illness, physical and mental performance deterioration in adults, and childhood learning disorders (Kaltenback et al, 2016).

Researchers have also made attempts to monetize the noise impact on airport-adjacent communities. Research led by Qinxian He proposed a new method of assessing the monetary impacts of aviation noise using personal income data instead of housing market data (He et al, 2014). They completed a meta-analysis of 67 hedonic pricing studies from around the world to derive a relationship between willingness-to-pay for noise abatement and income. From this relationship and their resulting noise monetization model, they calculated the net present value of global noise impacts at 181 airports from 2005 to 2035 to be $36.5 billion (in 2005 US dollars), with a standard deviation of $2.4 billion. The 95 US airports accounted for 41% of the global monetary
impact. In a more conventional housing market study, Daniel McMillan (2004) found that home values in Cook County were 9% lower if the home was within Chicago O’Hare International Airport’s 65 decibel noise contour (which is the FAA’s minimum threshold for significant noise impacts). He tracked the number of homes that were "noisy" in the years 1997, 2000, and in the long-range forecast after airport expansion. The aggregate number of ’noisy’ homes was reduced due to quieter aircraft and more efficient flight paths. Cidell (2008) referred to literature in critical cartography and science, technology, and society studies to critique the power dynamics inherent to airport noise contour maps. She studied resident, noise consultant, and airport administrator communication during the planning process at Minneapolis-St Paul International Airport. She argued that the different types of knowledge about the airport-adjacent community disturbance, namely official knowledge generated through government noise studies and local knowledge generated by residents’ experiences, were central issues in the planning conflict. She argued that the fixed federal methods for generating noise contours created a scenario where local knowledge was not treated as significant to the decision-making process, no matter how much local residents contested the validity if the federally sanctioned noise contour methods.

With respect to air quality, the concentration and distribution of aircraft emissions is greater and farther from the airport than previously estimated. Hudda et al (2014) found that emissions from Los Angeles International Airport (LAX) extended much farther downwind than initially reported in previous studies. They found a two-fold increase in particle concentration ten miles downwind (when compared to the urban baseline concentration), and up to a five-fold increase five miles downwind. Comparatively, this results indicates the emissions concentration effect of the airport is of a similar
magnitude of the entire urban freeway network in Los Angeles. Westerdahl et al (2008) found that aircraft-generated ultrafine particle concentrations persist up to 900m downwind of an LAX runway used for takeoffs. They observed ten-fold and twenty-fold increases above local background ultrafine particle concentrations. Although ambient air quality standards do not exist for ultrafine particles, they note that researchers suspect ultrafine particles may harm health and more research is needed to identify significance levels. Air quality impacts from aviation vary according to wind speed and wind direction. Different airports may find that different pollutant concentrations are more pronounced due to the quantity of aircraft operations, distinct land geography and climates, and ground transportation access (Yu et al, 2004).

Medical and air quality studies have linked aircraft emissions at airports to health impacts. There is a clear link between particulate matter emissions and respiratory health, which can lead to asthma and premature mortality (Li et al, 2003; Pope and Dockery, 2006). Levy et al (2012) studied the effect of increased flight activity (landing and takeoff emissions) on health risks caused by emissions exposure (premature death). Their work was unique because it considered the role of compounding factors, such as emissions concentration changes from non-aviation sources as well as population growth and aging. They estimated that aviation-related health impacts would increase by a factor of 6 from 2005 to 2025. Brunelle-Yeung et al (2014) estimated that 210 deaths per year are attributable to US aircraft emissions during landing and takeoff.

Additional studies have offered insight into planning interventions to reign in aircraft emissions. For example, Head of Environmental Services at Zurich Airport in 2001, Emanuel Fleuti (2001) highlighted that incremental improvements to reduce per flight
emissions has not been enough to outweigh the emissions increase due to traffic volume. Hence, airports are increasingly asked to build emissions inventories. To assist with planning practice, Wasiuk, Lowenberg, and Shallcross (2015) compared outputs from two modeling software packages: the authors’ free Aircraft Performance Model Implementation (APMI) and the US Federal Aviation Administration’s System for Assessing Aviation’s Global Emissions (SAGE). They developed APMI in an effort to provide a free tool for modeling aviation emissions impacts. Geographer Morton O’Kelly (2012) considered emissions from a network perspective. He evaluated the environmental costs and benefits of concentrated flow, using fuel burn as an indicator of environmental costs. He found that a concentrated ‘single allocation’ network requires greater fuel burn than a highly connected ‘multiple allocation’ network because the former requires more passenger miles to complete a trip. Finally, Nahlik et al (2016) offered a method to monetize emissions impacts for the 70 busiest airports in the US. Collectively, the impacts from particulate matter, sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide and carbon dioxide totaled $1.9 billion in damages in 2013. The top five airports with the largest monetized impacts (each over $100 million in 2013) included: Los Angeles International Airport, John F. Kennedy International Airport, O’Hare International Airport, LaGuardia Airport, and Hartsfield–Jackson Atlanta International Airport.

A few scholars have attempted to address equity and the distribution of environmental impacts on airport-adjacent populations. Rissman et al (2013) evaluated fine particulate matter pollution at the Hartsfield-Jackson Atlanta International Airport. The authors found that populations that have less income, less education, and are more nonwhite are more likely to be located in areas that are strongly affected by aircraft emissions. Wolfe et al
(2014) studied the spatial and temporal scales of noise, air quality, and climate change impacts from aviation activity at 84 commercial airports in the US. They identified that neighborhoods within 5km of an airport bear a disproportionate environmental cost per person, particularly with respect to airport noise. Populations living near airports face average damages of approximately $100-$800 per person per year, increasing with proximity to airport, and dominated largely by noise and air quality effects. These estimates did not include the health effects from noise nor the ecological impacts of air pollution. Tomkins et al (1998) suggested that these negative health and monetary effects may be negated by a potentially positive opportunity effect. They argued that improved airport access and increased employment opportunity could be more highly valued by local residents than the negative externalities associated with living near the airport. The results are not overwhelming since the study did not consider noise contours, instead relying on linear-distance proximity to the airport. Conversely, Ogneva-Himmelberger and Cooperman (2010) used noise contours and spatial analysis methods to evaluate the distribution of airport noise across different socio-demographic groups at Boston Logan International Airport. They found the minorities and low-income populations were more concentrated in spatial areas with the greatest noise externality.

Within this component of the scholarly conversation, there are research gaps pertaining to equity, distributive justice, and displacement. There are serious public health consequences to aircraft noise and emissions, yet only a few studies have attempted to understand the distribution of impacts across different demographics and socio-economic population groups. Additionally, the social and health effects of residential displacement appears to be missing from the aviation urbanism literature.
Reflecting on sustainability

Some scholars have characterized the social, environmental, and economic characteristics of hub airports as unsustainable. Aviation scholars Peter Morrell and Cherie Lu (2007) studied eight hub airports around the world to better understand the difference in environmental costs for two patterns of service: hub-to-hub and hub bypass. Social costs, as measured through airport noise and emissions, were substantially lower for hub bypass than hub-to-hub. Nero and Black (1998) argued that expanding hub airports exacerbates negative environmental externalities. From an economic sustainability perspective, Massouf Bazargan and Bijan Vasign (2003) found that smaller hub airports outperformed larger hub airports in terms of relative efficiency. Andrew Goetz and Brian Graham questioned the role of globalization, liberalization, and sustainability in air travel. They argued that the excessive focus on the globalization-liberalization links has generated "excessive air traffic growth and wasteful competition" (Goetz and Graham, 2004, p 275).

The tensions inherent to airport planning stakeholders represent a core challenge to planning for sustainability. Graham and Guyer (1999) argued that five sets of fundamental and irreconcilable tensions inhibit a transition to sustainable air transport. Essentially, they argue that airport economics are not compatible with 'rational' use of scarce resources, making it difficult to frame market mechanisms that actually spur efficient use of resources. Urban planner Robert Freestone (2009) wrote a conceptual review of the two opposing views of airport-centric urban development: the "bullish pro-growth perspective" and the "critical perspective". He summarized the complexity of reconciling global and local externalities of aviation activity, particularly as airports
around the world become more commercialized and seek Aerotropolis forms of development.

Insofar, the rhetoric of aviation sustainability can be characterized as an ineffective and weak interpretation of sustainability. Walker and Cook (2009) completed a discourse analysis designed to understand how different discourses of sustainability are competing to influence aviation policy. They found that the dominant rhetoric style, termed environmental and economic ‘balance,’ has not been an effective rhetorical strategy to frame, shape, or contain the aviation sustainability dilemma. Echoing this concern, sustainability scholar Paul Upham argued that European and UK governments effectively played lip service to sustainability ideals, but there was no evidence of actual reduced environmental impacts (Upham, 2001). He reasoned that this is because airport managers are more concerned with environmental efficiency, regulatory compliance, and cost reduction than overall emissions reductions. Upham delves deeper into rhetoric and argues that there does not seem to be a clear vision or terminology for air transport sustainability among practitioners (Upham, 2001b; Upham et al, 2004). He compared and contrasted the terms ‘environmental capacity’, ‘carrying capacity’, and ‘sustainability’ in a critique of policy frameworks. He further investigated perceptions of ‘environmental capacity’ among industry professionals from airports, airlines, air navigation service providers, government agencies and non-governmental organizations in Europe. The focus groups consistently yielded mixed meanings of ‘environmental capacity’ and mixed opinions of optimal regulatory scenarios to address environmental capacity.
Aviation urbanist’s call to action

The aviation literature establishes negative externalities as a problem and calls for greater attention from the urban planning community. There is considerable opportunity to contribute to urban planning scholarship. Nero and Black (1998) argued that academic research has provided insufficient attention to the airport’s negative externalities. The Transportation Research Board’s committee on the Environmental Impacts of Aviation prepared a research circular that suggests additional research is needed to further reduce environmental impacts of aviation (TRB, 2014). They first proposed areas of research to enhance our understanding and measurement of noise, air quality, climate change, and water quality impacts. Then, they highlighted research needs related to four proposed ‘sustainable solutions’: climate change adaptation, natural resource management, renewable energy sources, and alternative fuels development and deployment. Similarly, Upham, Thomas, Gillingwater, and Raper (2003) identified the following impacts as those expected to have the greatest political priority for the future of airport operations: aircraft noise, air quality, third-party exposure to accident risk, biodiversity, climate change, and community opposition to growth.

Additionally, there is considerable opportunity for urban planners to guide airport planning practice. The TRB research circular also discussed research areas related to developing tools and processes to implement sustainable solutions: environmental review under NEPA, sustainability measurements, environmental modeling tools for decision-making, and incorporating public health in aviation. Freestone (2009, p. 172) cataloged the growing debate on the global impacts of aviation, arguing that urban planning must “play a key role” in balancing the pro-growth industry perspective and the
sustainability perspective. Robert Caves and Geoffrey Gosling’s *Strategic Airport Planning* text highlighted the difficulties of airport development throughout the world: shortage of land, environmental impacts from aircraft and ground traffic, opposition from those questioning the need for further air travel, uneven power relationships, funding problems, investment risk, and traffic uncertainty. In a near call-to-action for the aviation urbanist, they concluded “there has been almost no attempt to assess the full societal balance sheet for air transport which would allow firmer conclusions to be drawn about whether and where society should support further expansion of the system” (Caves & Gosling, 1999, p. 409). Finally, Murray May and Stuart Hill argued for increased participation from independent policy institutes to “challenge the prevailing hegemony of the business-political nexus” and “question the values and practices of a consumer society” (May and Hill, 2006, p. 448).

**Concluding Planning Questions**

In conclusion of this literature review, I identify the key scholars of aviation urbanism, frame the extent that aviation is directly integrated into urban planning scholarship, identify gaps in research, and derive critical questions that investigate airports in an urban planning context.

In *Form*, I explained how the spatial theories for airport-centric development cast a wide net around the airport, with tendrils reaching far into surrounding communities and entwining them in airport-related employment and commerce. By some accounts, hub airports are transforming from singular waypoints operating outside the city to essential nuclei pulsing within their own activity center. The spatial development theories developed to explain airport-centric activity centers do not fully acknowledge or account
for the needs of the residents of airport-adjacent communities. Some residents may find themselves as unwilling spectators of aviation activity, struggling with the rigid nature of their built environment as the airport expands. Who are the residents of such places? How have they changed over time? More work is needed to evaluate these airport-centric spatial theories beyond the economic context, and pursue more holistic evaluations of the sustainability of airport-adjacent communities. Critically, urban planners need to integrate with aviation industry and academia to ensure just, resilient, and sustainable planning outcomes for airport expansion and airport-centric development. Community design elements that incorporate urban planning principals of placemaking and sustainability could promote a sense of “Reconciliation” through design, bringing us closer to a sustainable air transportation system. In order to move towards designing such interventions, we need to understand the stability and composition of the airport-adjacent communities. Thus the first derived research question is: How has the population of historically marginalized groups living near airports changed with the rise of the jet age?

In Growth, I explained that aviation scholars are questioning how the US national airport system will handle long-term air transportation demand. While the urban boosterism mentality may have been relevant at the dawn of airport infrastructure or during the major reorganization of the network in the 1980s-1990s, it may not be as critical for global cities to compete for connecting traffic in the 21st century hub-and-spoke network. Urban planners are positioned to evaluate and shape the extent that public infrastructure is subsidized according to airline profitability, urban economic growth, and environmental and social sustainability. If capacity enhancement remains the inevitable result and regional alternatives continue to be ignored, then what are the checks and balances to
ensure national airport expansion policy is equitable from the perspective of airport-adjacent communities? Thus the second derived research question is: Are hub airports more likely to expand if historically marginalized groups surround them?

Finally, in *Environment*, I documented the extent that concerns about the environment were analyzed and theorized in the aviation urbanism literature. I primarily focused on the most significant impacts for airport-adjacent communities: overall sustainability, aircraft noise, and aircraft emissions. Within this component of the scholarly conversation, I identify research gaps pertaining to equity, distributive justice, and displacement. There are serious public health consequences to aircraft noise and emissions, yet only a few studies have attempted to understand the distribution of impacts across different demographics and socio-economic population groups. Additionally, the social and health effects of residential displacement appears to be missing from the aviation urbanism literature. Thus, the third derived research question relates to planning practice: How did the Federal Aviation Administration and airport owners frame and evaluate environmental justice in the planning process for the airport expansion projects?

As discussed throughout this chapter, a scholar of *aviation urbanism* must acquire expertise in airport design, spatial theories of urbanization, operations management, urban agglomeration economies, and environmental planning. I reflected on important scholarship in each of my three proposed foundations of aviation urbanism: Form, Growth, and Environment. A summary of key literature topics is further presented in Table 2.1. Key scholars emerged whose larger body of work critically engaged with and advanced the topic of aviation urbanism: urban geographer Julie Cidell; urban planning
scholars Nicholas Stevens, Douglas Baker, and Robert Freestone; landscape urbanist Laura Cipriani; aviation logistician and consultant John Kasarda; transportation engineer and planner Megan Ryerson, and sustainability scholar Paul Upham. Overall, the contributions from these key scholars and the broader bank of occasional scholars of aviation urbanism call for more research investigating quality of life for airport-adjacent communities. The gap in research that this dissertation will fill involves questions of distributive justice, environmental impacts, and airport-adjacent communities. In this dissertation, I systematically investigate the effects of air travel on airport-adjacent communities in terms of health, community, livability, and social justice. I ultimately evaluate neighborhood stability, the distribution of environmental and health impacts, and community representation in the planning process.
Chapter 2 Tables and Figures

Table 2.1 Overview of aviation urbanism scholarship

<table>
<thead>
<tr>
<th>Foundations of Study</th>
<th>Topic</th>
<th>Key Concepts</th>
<th>Planner’s Triangle Component</th>
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<td></td>
<td>Spectatorship and Immobility in Airport Design</td>
<td>Architecture, Commerce, Spectatorship, Immobility</td>
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<td>Emerging Airport Planning Frameworks</td>
<td>Ecological airport urbanism, Airport metropolis</td>
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<td>Patterns of Air Travel Demand</td>
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<td>Growth</td>
<td>Aviation and the Urban Economy</td>
<td>Airport-centric activity center, Metropolitan employment and population, Job opportunity</td>
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<td>Planning Airport Capacity</td>
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<td>Monetization of impacts, Noise, Emissions, Health, Distributive justice</td>
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<td>Reflecting on Sustainability</td>
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<td>Aviation Urbanist’s Call to Action</td>
<td>Urban planning, Business-political nexus</td>
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CHAPTER 3: Airport-Adjacent Communities in Multi-Airport Regions

Introduction

Hub airports are transforming from singular waypoints operating outside the city to essential nuclei pulsing with their own commerce and employment. As reviewed in Chapter 2, spatial theories such as the Airea, the Airport Corridor, and the Aerotropolis, describe the spatial relationship between airport infrastructure and airport-centric activity centers. These existing spatial development theories often focus on the economics of the airport-centric activity center and neglect to account for nearby residents. In order to develop planning interventions that serve airport-adjacent residents, planners need to understand trends in the airport-adjacent communities’ stability and composition. With enhanced knowledge of demographic and socio-economic trends in airport-adjacent communities, urban planners can integrate with aviation researchers and practitioners to work towards just, resilient, and sustainable planning outcomes for airport expansion and airport-centric development. Towards this end, this chapter aims to answer the following research question: "How has the population of historically marginalized groups living near airports changed with the rise of the jet age?"

This research is a comparative analysis that evaluates the change in population and housing characteristics of communities near hub airports since 1970. The study evaluates metropolitan areas that contain more than one hub airport in order to compare airport-adjacent communities within and across multi-airport regions. I use the data to reflect on three hypotheses from the literature that attempt to explain the relationship between local residents and airport-centric development: (1) the ‘power to resist’ effect,
(2) the ‘locally-unwanted land use’ effect, and (3) the ‘airport-centric activity center’ effect. Overall, I evaluate the change in composition of airport-adjacent communities to better understand the residential stakeholders in planning processes for airport infrastructure and airport-centric development. The results set the tone for the next chapter, which evaluates environmental justice outcomes from American airport expansion in the twenty-first century.

The remainder of this chapter is organized into the following sections: background, hypotheses, methods, results, discussion, and conclusion. The background section reviews academic literature on social inequities related to transportation systems. The hypothesis section summarizes the three hypotheses, as theorized in the planning literature. The methodology section explains the data collection and spatial analysis procedure. The results section explains how the data supports the second hypotheses regarding the “locally-unwanted land use” effect, but not the first or third hypotheses regarding the “power to resist” effect and the “airport-centric activity center” effect. The discussion section contextualizes the key findings with a case study narrative centered on three airport-adjacent communities. Finally, the conclusion summarizes the findings and offers recommendations for future research.

**Background: Social Inequity in Transportation**

Transportation systems have been and will continue to be central to urban economies. However, transportation systems have also contributed to social inequity. As demonstrated over the course of American transportation and aviation history, social inequities manifested in the treatment of transportation workers, transportation passengers, and transportation-adjacent residents. Overall, aviation’s potential
contribution to social inequities for nearby residents has received less attention than surface transportation.

Even though the development of interstate transportation systems instigated broad economic growth, the treatment of transportation workers often exemplified America’s longstanding racism and sexism. In the 1830s Jacksonian Democracy, the influx of immigrants and slaves in the south provided the majority of unskilled labor to construct interstate transportation systems (Taylor, 1951, p. 17289; Howe, 2009). Construction of the era’s turnpikes, canals, and railroads was associated with poor working conditions, sickness, and meager wages, especially for those lacking distinction as an adult, white male. Over 100 years later, White male privilege continued to influence the treatment of minority and women transportation workers. Even as African American individuals and women gained legal rights, they continued to face discrimination in the workplace. Discrimination against African Americans was prevalent throughout employment centers in the mid-1900s, including automobile manufacturing centers in Detroit and wartime aviation manufacturing centers throughout the nation (Albrecht, 1995; Sugrue, 2005). Despite their tremendous contributions to the wartime aviation industry, postwar working women experienced a sharp decline in employment, child-care, and social services as men were given priority for employment. Additionally, postwar African Americans experienced abrupt razing of war worker housing projects (Albrecht, 1995, p. 236).

As the aviation industry transitioned to widespread commercial service, aviation workers onboard the aircraft faced discrimination. Although women and African Americans had found success as experimental aviators and war pilots, they were shunned in the commercial airline industry. Discriminatory all-male pilot unions, in addition to airline advertising campaigns that promoted pilots’ whiteness and masculinity as proxies for
aircraft safety, aggressively reinforced racial and gender divisions. Continental Airlines hired the first African-American pilot in 1963, but only because they were compelled by a Supreme Court ruling to do so. The pilot had been rejected by ten airlines despite nearly a decade of service in the Air Force, prompting him to fight the discrimination in the courts (VanVleck, 2013, p. 224). When airlines did hire women, they were predominantly White and relegated to aircraft cabin work. The carefully cultivated “stewardess mystique” subjected women workers to strict age, weight, and cosmetic requirements and airlines enforced marriage bans. Simultaneously, airline advertising campaigns were widely known for sexualizing the jet age, juxtaposing flirtatious and seductive female bodies alongside sleek aircraft. Post-2000, African American pilots still expend emotional labor to navigate blatant, subtle, and covert forms of racism in a predominantly White work environment (Evans and Feagin, 2012).

Social inequities were also apparent in the way governments and businesses treated passengers in the transportation system. In the 1950s and 1960s, American highways in urban areas were designed to enhance the mobility of suburban commuters, primarily serving White passengers. Redlining, a form of discriminatory zoning, actively excluded African Americans from participating in the suburban homeowner lifestyle while highways tore through their urban neighborhoods (Lipsitz, 1995). At the same time, public transportation systems struggled to gain traction in suburban communities because of fear of African American passengers. In the 1970s, White suburban residents were fearful that Atlanta’s MARTA transit system would spread African Americans to the suburbs and “speed up the dreaded school desegregation process” (Konrad, 2009, p.54). In a view more sympathetic to social justice, one politician expressed concern that the Washington DC Metro Line would create a segregated
system of “the poor and Black squeezed into sweltering buses while the rich and White use the fancy new suburban railroad” (Schrag, 2006, p. 244). In addition, project managers for the DC Metro system were resistant to the costs of accommodating passengers with disabilities. They even staged a demonstration of an able-bodied man riding an escalator in a wheelchair to argue against the need for elevators at the metro stations (Schrag, 2006, p. 166). It was not until the Americans with Disabilities Act of 1990 that transportation systems were required to accommodate a range of physical abilities.

Airline passengers were also subject to discriminatory practices. Singer Ella Fitzgerald filed a civil damage suit after Pan Am Airways refused to honor her and her band’s first-class tickets on an international flight in 1956. Until the Supreme Court case Boynton v. Virginia in 1960, many American airport terminals were legally segregated along color lines (Dixon, 1963). Prior to the Boynton case, local and state segregation laws applied to the municipally-owned airport infrastructure. After the Boynton case, air transportation carriers and airport terminal lessees became subject to federal non-discrimination clauses in the Motor Carriers Act. To prevent African American passengers from booking fares, reservation agents screened calls from addresses in African American neighborhoods and lied about the availability of seats if a caller “sounded Black”. As Yale Historian Jenifer VanVleck recounted, aviation liberated people from the “pull of gravity,” not the “forces of social inequality” (VanVleck, 2013, p. 112).

In addition to transportation workers and passengers, transportation-adjacent residents have also faced inequitable treatment. Often, it is a result of the planning and construction of transportation systems. Despite intentions to revitalize failing post-war
city centers, highway development and urban renewal orchestrated devastating displacement of poor and minority communities in the urban core (Mohl, 2004). Highway projects in urban areas benefited suburban White families at the cost of disproportionate displacement of urban African American families: hence the political slogan “White men’s roads through Black men’s bedrooms” (Rose, 1990, p 107). As well-documented in the planning literature, highway development had lasting impacts that racially segregated urban form and housing stock (Bayor, 1989; Sevilla, 1971; Teaford, 2000). Residents near highway projects also suffered harmful indirect effects from construction. For example, consider the sand-mining activity in Gary, Indiana that was completed in support of highway construction. The abundance of leftover vacant pits enabled chronic hazardous waste dumping near minority communities (Hurley, 1995, p. 163). By 1994, President Clinton issued Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. This legislation prioritized consideration of environmental and human health impacts on minority and low-income communities during the planning phase for federal projects, including federally-funded transportation projects (Clinton, 1994). Subsequent research in environmental justice has debated the significance of siting decisions and subsequent housing market dynamics near highway facilities and other locally unwanted land uses (Been, 1994; Greenberg, 1993; Mohai and Saha, 2007; Most et al, 2004; Pulido, 1996).

As briefly summarized, multiple demographics of the American public have repeatedly fought for inclusion during the planning and operations of transportation systems. The intersection of social inequity and transportation has largely been studied for surface transportation, but gaps remain in the study of aviation. For example, the topic of disproportionate siting near minority communities is well-known for highway
transportation, but has not been explored for airport facilities. Additionally, it is not clear if potential economic benefits from airport-centric activity centers counterbalances the known environmental disbenefits of residential proximity to an airport. Fundamentally, the literature has not investigated residential, population, or socioeconomic trends for airport-adjacent communities. Despite extensive literature on the environmental impacts of aviation, there is a gap in understanding who exactly is experiencing the environmental impact. This research is a first venture into understanding how the population of historically marginalized groups living near airports has changed with the rise of the jet age. An historical perspective of whether social inequities are pervasive near airports will provide useful insight for planning sustainable, just, and resilient airport-centric activity centers and airport expansion.

**Three Hypotheses**

The three hypotheses explored in this work are based on assumptions regarding the dynamics of hub airports as locally unwanted land uses (LULUs), yet also as economic activity centers. I identify the hypotheses as the “power to resist” effect, the “LULU” effect, and the “airport-centric activity center” effect. The data analysis is framed to understand if the change in composition of airport-adjacent communities lends credence to theories in the literature that attempt to explain the relationship between residents and airport-centric development. The analysis does not provide an avenue to establish a direct, causal link between the three effects and the change in AAC composition; however, the analysis does offer one avenue to establish the necessary condition of correlation and guide future research.
The first hypothesis addresses the difference in the scale of operations at hub airports and differences in political power in nearby communities. Only four hub airports in the sample processed at least 500,000 annual operations during 1998 to 2015, eleven processed less than 250,000, and the other six airports hovered around 375,000 annual operations. This hypothesis aims to uncover whether airports that shared a similarly large scale of operations (>500,000) also shared similar characteristics in demographic, housing, or socioeconomic characteristics. In this analysis of airports with extreme activity, I seek to understand whether these airports were more likely to develop into highly concentrated hubs as a result of the nearby communities’ lack of power to resist additional nuisance over time. This follows from environmental justice theories contending that socio-economically weak populations are unable to mobilize the resources necessary to resist pollution-intensive development (Bullard and Johnson, 2000; Campbell, 1996; Pollock, 1995; Wolsink, 2006). An underlying assumption is that the airports with the most flights also historically exhibited a significantly noticeable and larger nuisance (in terms of noise and emissions) than the less dominant hub airports.

**H1:** The first hypothesis predicts that communities near the busiest airports (>500,000 operations) in the dataset maintained higher percentages of disadvantaged groups throughout the analysis timeframe than communities near less dominant hub airports (<250,000 operations).

The second hypothesis addresses the rise of airports as locally-unwanted land uses (LULU) after the jet age. The push-pull ‘LULU effect’ assumes that facilities that exhibit an extreme nuisance are more likely to attract settlement of historically marginalized persons than White persons over time (Been, 1994; Liu, 1997). Minorities and persons
with low socio-economic status may be drawn to LULUs because of discriminatory housing markets that prohibit access to more desirable neighborhoods, greater access to resources for White persons who opt to move away from the nuisance, and potentially cheaper land and housing values near LULUs. There is also a rational “come to the nuisance” theory that suggests even if minority population groups are just as concerned about health consequences of the nuisance as Whites, the minority groups do not experience diminishing marginal utility of income due to pervasive income inequality (Depro et al, 2015). In other words, household income affects residential mobility and willingness to pay to avoid the nuisance. Since minority groups often have lower incomes, they are more likely to live near the nuisance.

H2: From this, the second hypothesis predicts a decrease in the percentage of the White population in the AAC that exceeds the regional trend, an increase in the percentage of minority groups in the AAC that exceeds the regional trend, and an increase in the percentage of renter-occupied homes in the AAC that exceeds the regional trend.

The third hypothesis addresses the rise of the airport-centric activity center. An increase in hub concentration is generally associated with an increase in the concentrations of hotels, restaurants, logistics firms, and other airport-centric services. Whit Blanton’s Airfront model specifically looks to leverage airport-centric development as a strategy to revitalize local economies in nearby neighborhoods (Blanton, 2004). However, Angela Antipova and Esra Ozdenerol (2013) found that even though more higher-paying jobs were located in the Aerotropolis around Memphis International Airport, female and minority workers benefited less than White male workers. Even LULU theory suggests public goods generate an economic benefit large enough to counter the disbenefits of
the facility (or, in this case, facility expansion over time) (Mansfield et al, 2001). Since it is not understood whether airport-centric activity centers broadly result in economic benefit to nearby residents, this hypothesis aims to understand trends in the change in socioeconomic status of the nearby community over time.

**H3: Thus, the third hypothesis predicts that changes in the AAC unemployment rate, poverty rate, and percent of college-educated persons were on par with or more favorable than the change in the regional rates.**

Taken together, these three hypotheses are a first step to characterize neighborhood change in airport-adjacent communities and understand their relationship with airport-centric activity centers. Each hypothesis is rooted in an expectation suggested in the planning literature. First, I consider whether the busiest airports rose to prominence, at least in part, due to the inability of disadvantaged groups to resist expansion. Were minority groups present throughout the lifetime of the infrastructure and in greater proportion than found near less busy hubs? Second, I consider if the airport exerted a push-pull LULU effect that pushed Whites away and pulled minorities closer. Is there any evidence that the change in proportion of minorities near the airport is consistently more pronounced than the trends in the broader urban region? Third, I consider if “airport-centric activity centers” created socio-economic stability or improvement for nearby residents. Is the socio-economic status of airport-adjacent communities at least on par with their respective regions? While the results will not be able to make claims of causality or offer full confirmation of the hypotheses, they are a first step in identifying trends in population change and exploring the likelihood that such changes are explained by these effects.
Methodology

The goal of the data analysis is to calculate the change in population and housing characteristics of airport-adjacent communities (AACs) since the rise of hub airport activity in the jet age (1970-2010). In the following subsections, I identify the timeframe, airports, geographies, and census variables for analysis. I also summarize my approach to testing the three hypotheses.

The analysis timeframe spans 1970 to 2010. The airport sample includes the 21 large and medium hub airports (those with 0.25% or more of America’s annual passenger boardings). Those 21 airports represent the complete set of hubs that existed in the eight multi-airport regions (MAR), which are metropolitan areas with more than one hub airport in operation in 2010. The geographic boundary of the AAC represents the area that experiences the most adverse effects of hub airport operations, defined as a 5-kilometer radius around each airport. Overall, the subset of 21 AACs and eight MARs enables comparisons or airport-adjacent communities within and across multi-airport regions and ensures a regional benchmark for comparison to gauge whether changes were consistent with the region.

Timeframe

First, I selected 1970-2010 as the appropriate timeframe over which to track demographic changes in AACs. Although 1970 was not the dawn of aviation, it is arguably the dawn of the American jet age and represents a turning point in the effect airport activity would have on nearby residents. With this timeframe, I evaluated the change in AAC characteristics and considered trends associated with (1) the rise of the
busiest hubs, (2) the transformation of airports into locally-unwanted land uses, and (3) the growth of the airport-centric activity center.

Airports were planted across the American landscape throughout the 1910s. Post World War I, American aviation experienced a shift from exhibitions and experiments to regular, scheduled service for the Postal Service and the US Army Air Service. In these early stages, newly built airports primarily facilitated domestic communication and defense (Bednarek, 2001). As aircraft improved, notably with the introduction of the DC-3 in 1936, passenger air travel increased (Geels, 2006). By 1944, American diplomats and politicians in the Roosevelt administration sought to leverage aviation on a global, commercial scale. They instigated the earliest efforts towards “Open Skies”, which led to international agreements for rights to peaceful airborne passage and emergency landings. The US government aggressively increased passenger markets to Western Europe and postcolonial nations until the 1960s as part of the US government’s effort to “ensure that Americans could fly everywhere” and to “prevent the Soviets from flying there first” (Van Vleck, 2013, p.201). Boeing’s 747 aircraft, the 550-passenger jet announced in 1966 and operated in 1970, solidified the shift into the jet age (Geels, 2006). By 1970, passenger air travel was a standard part of American culture, though flying was still not financially accessible to all. As the jet age was underway, the Airline Deregulation Act of 1978 disrupted the industry. Importantly, deregulation motivated airlines to transition to an even more concentrated hub-and-spoke airport network, further exacerbating the noise and emissions footprints of primary hubs (Nero and Black, 1998; Reynolds-Feighan, 1998). The integration of loud jet aircraft, the continued growth of passenger air travel, and the increased concentration of operations at hub airports post-1970 fundamentally transformed the function and impact of airport infrastructure.
Thus, the most suitable timeframe to evaluate the relationship between AACs and the jet age begins in 1970, when airports were just beginning to generate significant noise and air quality impacts and airlines were beginning to significantly concentrate the hub-and-spoke network.

**Airports**

The Federal Aviation Administration (FAA) designates each airport’s hub status. In 2010, the FAA classified 65 airports as large or medium primary hubs. Referencing this list of hub airports, I identified metropolitan areas that contained at least two hub airports in 2010, which I refer to as multi-airport regions (MAR). MARs are an advantageous phenomenon, enabling comparative analysis of AACs both within and across metropolitan areas. The US has eight multi-airport regions. Identified by their largest city, the regions include Los Angeles (BUR, LAX, ONT, and SNA airports), San Francisco (OAK, SFO, and SJC airports), Dallas (DAL and DFW airports), Houston (HOU and IAH airports), Chicago (ORD and MDW airports), Washington DC (BWI, DCA, and IAD airports), New York City (JFK, EWR, and LGA airports), and Miami (FLL and MIA airports). In total, the eight multi-airport regions host 21 hub airports.

To compare airport operations, I aggregated data from the FAA’s Aviation System Performance Metric database dating back to 1998 (the earliest available data). Combined, the 21 airports in the MARs represented more than 6 million operations in 2010, or about 20% of commercial US airport traffic. From 1998-2015, the Dallas, Houston, Los Angeles, and Chicago regions each had one airport that handled more than double the operations of the other airport(s) in their region (respectively: DFW, IAH, LAX, and ORD). These four airports also had significantly more operations than the
other airports in the sample (See Appendix 3). The Miami and San Francisco regions each had one marginally dominant airport (respectively: MIA and SFO). In contrast, the New York City and Washington D.C. regions had similar activity levels across airports.

**Geography**

I compared two different types of geography in this research: the multi-airport region (MAR) and the airport-adjacent community (AAC). I used spatial aggregation analysis to generate the geographic area of AACs and MARs, such that they individually maintain spatial continuity over the 1970-2010 analysis timeframe.

I first collected geographic data for the airport hub location. The Federal Aviation Administration (FAA) maintains geographic data for each airport, referred to as Airport Reference Points (ARP) (FAA, 2015). The ARP is the latitude and longitude of the approximate center of the airport, calculated as the geometric center of all usable runways. In the context of this research, the ARP serves as the point estimate of the hypothetical ‘epicenter’ of noise and emissions. The precise location pinpointed by the ARP depends on the layout of the airport’s infrastructure (e.g. airfield, terminals, and other structures) and may not necessarily pinpoint a runway.

2010 through NHGIS. All geographic data was collected and assessed using the 2000
Tiger/Line.

Next, I defined the geographic area of analysis for each of the 8 MARs. The geographic
area of the MAR is composed of census tracts that are completely within the
metropolitan statistical area boundary. Since metropolitan statistical areas are redefined
over time (usually increasing in size over time in urban regions), I reference the
metropolitan statistical area boundaries from year 2000. The baseline geographic area
of the MAR is defined as the area of census tracts (in year 1970) that were completely
within the metropolitan statistical area (in year 2000). To generate each MAR’s
geographic area for the subsequent census years, I selected all census tracts whose
centroid fell within the 1970 baseline area, as shown in Figure 3.1. Additional information
on the change in area over time is available in Appendix 3.

Next, I defined the geographic area of analysis for each of the 21 AACs. In this work, I
defined the AAC area as the area of persons who live with the most environmentally
adverse impacts of the airport. Noise and air pollution are broadly considered to be the
most harmful effects for airport-adjacent communities, but their impacts are not static or
uniform across time or space. At the local and regional level, air quality impacts may
vary hourly according to wind speed and wind direction. Pollutant concentrations may be
more pronounced due to the quantity of aircraft operations, distinct land geography, local
climates, or emissions from airport-related ground transportation (Yu et al., 2004).
Similarly, noise impacts are not uniform across the local geography; they vary according
to takeoff and landing flight paths, aircraft size, and flight frequency. In addition to day-
to-day impact fluctuations, persons living near the airport are subject to long-term
fluctuations. Airport capacity expansion, FAA regulation changes, or flight procedure
updates can cause drastic changes in the airport’s environmental impact. These
changes often take the form of residential displacement or altered emissions profiles and
noise contours. For this research, it was important to identify the generic area that was
facing disproportionate exposure to noise and emissions in 2000, and who would also be
likely to absorb the altered or exacerbated impacts stemming from expansion. Thus, I
opted for a radially-defined geographic boundary to define the AAC. Prior scholarship
identified that neighborhoods within 5-kilometers of an airport bear a disproportionate
environmental cost per person, particularly with respect to airport noise (Wolfe et al.,
2014). All residents within that boundary are likely to experience harmful environmental
impacts from airport operations, although some neighborhoods within that area will be
more negatively impacted than others. Thus, the geographic area of adverse
environmental impacts is defined as the subset of census block groups whose centroid
falls within a 0-5km radius of one of the 21 airports in the sample.

Since the area of census tracts are redefined over time (generally decreasing in size
over time in urban regions), I used the census tracts in 1970 to create the baseline area
of study, as shown in Figure 3.2. To generate each AAC’s geographic area for the
subsequent census years, I selected census tracts that maintained as much of the 1970
baseline area as possible. By maintaining a similar area over time, I prepare a more
accurate and descriptive assessment of how demographics changed over time.
Additional information on the change in area over time is available in Appendix 3.

In the Washington DC region, IAD is not well suited for comparative analysis because
the AAC’s area is significantly larger than the expected area. In the Dallas region, DFW
requires special consideration because the AAC area is nearly double the expected area. The AAC area for IAD and DFW are approximately 350 km\(^2\) and 150 km\(^2\), respectively (larger than the expected AAC area of 78 km\(^2\)). All other AACs are suitable for time series analysis since their area is close to the expected area (of 78 km\(^2\)) and their area remains relatively stable from 1970 to 2010.

*Census variables*

I used decennial census data to trace the change in population of historically marginalized groups near the airport (in AACs) and in the metro (in MARs). This research aggregated population characteristics at the census tract level, which have an average population around 4000 people. I selected demographic variables (total population, race, ethnicity, and age), socio-economic variables (nativity, employment, poverty, and education), and housing variables (total housing units, occupancy, and tenure) to describe the diversity and economic status of the geographic areas over time. The variables are shown in greater detail in Table 3.1. The data was retrieved from the time series package prepared by NHGIS.

The data collection methodology for the US Decennial Census changed over the analysis timeframe. This research analyzed variables that demonstrated the most methodological consistency over time. The variables that describe persons by race and ethnicity have some notable inconsistencies. In the 1970 census, Asian Indians were counted as White, which resulted in 10% underreporting in the Asian race variable nationwide and up to 20% in some regions. In the 1980 census, persons who marked "Other Asian and Pacific Islander" race groups were included in the "Other" category instead of the "Asian" category. Additionally, persons of Spanish/Hispanic origin were
sampled and counted in such a way that would lead to underreporting. Only 5% of the population was asked to report if they were of Hispanic or Spanish descent in 1970. Further, persons of Hispanic or Spanish descent were counted as White in the 1970 census if they marked "Other Race" category. As a result of these inconsistencies, the Asian demographic variable is only assessed for years 1990, 2000, and 2010 and the Hispanic demographic variable is only assessed for years 1980, 1990, 2000, and 2010.

Unlike the demographic data, the socioeconomic data is derived from sample-based population data. The socioeconomic variables are not available in 2010 due to the significant change in data collection. Poverty, nativity, employment, and education level are now collected via the American Community Survey, which is not comparable to the Decennial Censuses. As a result, the college-educated, foreign born, poverty, and employment data are only aggregated for years 1970, 1980, 1990, and 2000.

_Hypothesis Testing_

For the first hypothesis, I consider whether the communities’ power to resist may have potential to explain the rise of extreme airport activity at the busiest hubs. This theory is predicated on the fact that social and economic barriers limit the ability of disadvantaged groups to resist expansion. Thus, I studied whether disadvantaged groups were present throughout the lifetime of the infrastructure and in greater proportion near the busiest hubs (>500,000 operations) than the less dominant hubs (<250,000 operations). I calculated and plotted the percentage of different population groups present in each AAC in each decennial census year. Appendix 3 includes detailed plots that illustrate the change in composition over time for each region and each AAC. If higher proportions of disadvantaged population groups were consistently present near the busiest hubs, then
it is possible that community power dynamics played a significant role in the growth of airport activity.

The second and third hypotheses compare the change in population, housing, and socioeconomic characteristics over time in AACs to changes in their respective regions. The second hypothesis evaluates push-pull settlement outcomes that exceed regional outcomes, while the third hypothesis looks for socioeconomic status outcomes that are on par with or more favorable than regional outcomes. Both hypotheses are tested using a difference in differences approach. The AAC's percentage point difference from 1970 to 2010 is compared to the percentage point difference in its respective region. If the push-pull outcomes are consistently more extreme in AACs than their regions, then the LULU effect may play a significant role in settlement patterns near hub airports. If the socioeconomic outcomes are consistently on par with or more favorable than the region, then the airport-activity center may be a significant contributor to local socioeconomic success.

To assist with comparative interpretations across the three hypotheses, I also calculated the interquartile range for each census variable. I pooled every data point for the 21 AACs across the 1970 to 2010 timeframe into one dataset. For example, census variables that are comparable across all five decennial censuses have a total of 105 observations (5yrs*21AACs = 105 observations). From this pooled dataset of 105 observations, I determined the interquartile range for the census variable. With this method, I can identify which AACs consistently had unusually high proportions of certain population groups across the timeframe (fell outside the interquartile range). The first
column of Table 3.2 reports the upper and lower quartiles for each population and housing variable

Results: AAC Population and Housing Characteristics Since 1970

Overall, the 20 AACs in the analysis experienced moderate population and housing growth. All eight regions and 16 AACs experienced an overall increase in total population (EWR, DCA, ORD, and BWI decreased). All eight regions and 19 AACs experienced an overall increase in total housing units (EWR decreased). The change in AAC characteristics across the analysis timeframe, measured as the difference in the total count, is summarized in a boxplot in Figure 3.3. The change in AAC characteristics, measured as the percentage point difference, is summarized in boxplots in Figure 3.4.

For multiple census variables, the AACs experienced a percentage point difference that was different from the region’s percentage point difference. Figure 3.5 shows a series of scatterplots that compare the change in the region to the change in the AAC for each variable. The AAC’s change in percent is on the y-axis and the region’s change in percent is on the x-axis. The change is measured as the difference between the percentage in 2010 and the percentage in 1970 (e.g. 70%White in 2010 – 60%White in 1970 = +10). The centroids of each scatterplot are listed in Table 3.3.

The results are organized into three sections that each address one of the three hypotheses. With respect to the first hypothesis, the analysis did not find evidence to confirm that communities near the busiest hubs consistently had the highest percentages of historically marginalized groups. With respect to the second hypothesis, the analysis did find evidence that associates changes in airport-adjacent communities
with the push-pull LULU effect. Finally, with respect to the third hypothesis, the analysis did not find strong evidence to suggest airport-adjacent communities are performing on par with or better than their regions in terms of socio-economic change since the rise of the jet age.

**AAC snapshots over time: Power to resist’ effect**

These results do not support the first hypothesis, which predicted that communities near the busiest hubs consistently had the highest percentages of historically marginalized groups. Across all airports in the sample, Dallas/Fort Worth International Airport (DFW), George Bush Intercontinental Airport (IAH), Los Angeles International Airport (LAX), and Chicago O’Hare International Airport (ORD) had the most operations from 1998 to 2015.

Overall, the largest proportions of disadvantaged groups from 1970-2010 were not located in the AACs for the busiest four airports (ORD, DFW, IAH, and LAX). In fact, the percentage of some disadvantaged groups was comparatively lower near the busiest airports, as seen in Table 3.2. When compared to the other AACs, ORD maintained a lower percent of Black residents, lower percent of renter-occupied homes, and a lower poverty rate. LAX maintained a comparatively higher percent of college-educated residents. Although questionable due to the larger catchment area, DFW maintained a lower percent of foreign-born, elderly, and Hispanic residents, as well as lower unemployment and poverty rates. Finally, IAH maintained a lower percentage of foreign-born and elderly residents. Further, airports with fewer operations (<250,000) often had comparatively higher representations of disadvantaged populations than other AACs.
If I limit the timeframe to more recent years (2000 and 2010), ORD, DFW, IAH, and LAX still did not consistently have the largest proportion of minority groups. When compared to the other airport(s) in their region in 2000, the busiest airports each had the highest percentage of college-educated persons. At ~25%, LAX and DFW were among the most college-educated of all AACs and were both higher than their overall metro area. Additionally, the busiest airports each had the lowest percentage of Hispanic persons (by a significant margin) when compared to the other airports in their region in 2010. In 2000, ORD, DFW, and IAH had the lowest unemployment rate among other airports in their region and were lower than their metro area. ORD and DFW also had a lower poverty rate than the other airport in their region, were among the lowest of all AACs, and, again, were lower than their regional rate. Of the four busiest airports, IAH is the only one to have a high percentage of a historically marginalized community. In 2010, IAH had the fourth largest percent of Black persons across all AACs in the sample and nearly double the Houston regional average.

While the busiest airports in the sample did not seem to be caught in patterns of segregation in 1970, the phenomena is present at other airports in the sample and persisted through to 2010. For example, in comparison to other AACs and their respective regions, four airports (DCA, EWR, JFK, and OAK) all started with significantly high percentages (>30%) of Black persons in 1970. In the subsequent decades, the percent of Black residents continued to increase near JFK, but decreased near the other three airports. Despite those decreases, by 2010, the percent of Black persons near all four airports was still higher than their respective regions and still among the highest of the 21 airports.
AAC change over time: ‘LULU’ effect

The analysis did find that changes in airport-adjacent communities were consistent with the push-pull LULU effect. With respect to the change in the percent of White persons, AACs generally decreased more than their respective regions (“pushed”). With respect to racial and ethnic minority groups, AACs generally increased more than their respective regions (“pulled”). Finally, with respect to renter-occupied housing, AACs generally increased more than their respective regions.

Evaluating each AAC individually, more AACs provided evidence for the second hypothesis than against it. Five AACs (MDW, SJC, LGA, HOU, ORD) saw a substantial drop in the percent of White persons, an increase in at least one minority group, and an increase in foreign-born residents, all of which were more extreme than the regional trend. Another five airports (SFO, IAH, DFW, ONT, JFK) saw a substantial drop in the percent of White persons and an increase in at least one minority group, both more extreme than the regional trend. Another three AACs (DAL, SNA, LAX) showed a similar percent decrease in White persons as their region, but a greater increase in one or more minority groups. The percent of White persons near three airports (EWR, DCA, OAK) did not decrease nearly as much as their region because they started out with an unusually low percentage of White residents and high percentage of Black residents in 1970. The relatively high percent White for MIA also includes a substantial amount of Hispanic residents, which cannot be parsed in the data. When compared to other AACs and the Miami region, MIA had a substantially larger proportion of Hispanic residents in 1970 (43%) and 2010 (89%). Only two airports (BWI, FLL) seemed to start Whiter than their regions and remain so until 2010. Only one airport (BUR) seemed to maintain the most
consistent representation of the region from 1970 to 2010, though somewhat underrepresenting Black persons.

Overall, the percent of White persons decreased more near airports than their respective regions. As expected, the percent of White persons decreased from 1970 to 2010 for all AACs and all regions. While only one region (New York City) experienced a decrease in the actual count of the White population, fourteen AACs saw a decrease in the count of White persons despite overall population growth. Six AACs (DFW, IAH, MIA, FLL, ONT, and SNA) increased the count of White persons, but still decreased in percentage of White persons. In addition to the consistent decrease in both count and percentage of White persons in AACs, the percent of White persons in most AACs also decreased significantly more than their respective regions. As shown in Figure 3.5, twelve observations fall well below the trendline, indicating that %White decreased by a larger magnitude in the AAC than the region. However, four observations fall near the trendline and four fall above the trendline. The centroid further illustrates that the average decrease in %White for AACs (-31.5 points) was larger than the average decrease in their respective regions (-25.7 points). The communities near the Houston airports exhibited the largest difference in magnitude when compared to their region. While %White in the Houston region decreased 21 points from 80% to 59%, the community near IAH decreased 43 points from 87% to 44% and the community near HOU decreased 51 points from 99% to 48%. In 1970, just two AACs were less than 50% White nonhispanic (DCA and EWR were both 50% Black). By 2010, nine AAC’s were less than 50% White and another four were more than 50% Hispanic. This indicates that thirteen AACs were primarily composed of minority groups by 2010.
The percent of minority and Foreign Born persons consistently increased since 1970, but generally increased more near airports than in their respective regions. Generally speaking, the percent of Black persons in AACs and regions either increased or stayed relatively constant since 1970. In both 1970 and 2010, four AACs were at least 30% Black. JFK, EWR, and DCA remained well above 30%, while IAH increased from 13% to 35% Black and OAK decreased from 40% to 17% Black. The number of AACs with at least 30% Asian persons increased from three in 1990 to ten in 2010. The number of AACs with at least 30% Hispanic persons increased from two in 1980 to thirteen in 2010. The number of AACs with at least 30% Foreign Born persons increased from one in 1970 to eleven in 2000. Some of this increase is attributed to the general increase in these demographics over time, however the percentage point increase of these populations in AACs was often larger than the region’s percentage point change. The magnitude of change was at least three percentage points larger for nine AACs with respect to percent Asian, ten AACs with respect to percent Hispanic, ten AACs with respect to percent Black, and fourteen AACs with respect to percent Foreign Born. Overall, the increase was largest in the Hispanic and Foreign Born demographics. The centroids in Table 3 indicate that the average increase in percent Hispanic for the AACs (+22.2 points) was larger than the average increase in their respective regions (+16.7 points). The same is true for percent Foreign Born, where AACs increased by 21.2 points and regions increased by 16.5 points.

The percent of renter-occupied housing units almost always increased in the AAC, but either decreased or remained stagnant in the region. For sixteen AACs, the percent of renter-occupied housing units increased more near the airport than in their respective regions by more than three percentage points. The centroid value shows an average 7.1
point increase for AACs and an average 3.3 point decrease for regions. DFW and JFK reported the largest difference between AAC change and regional change. At DFW, the AAC percent of renter-occupied housing units increased 35 points from 23% to 58% while the region remained stagnant around 39%. At JFK, the AAC rate increased 16 points from from 32% to 48% while the region decreased 7 points from 56% to 49%. The number of AACs with at least 50% renter-occupied housing units increased from five in 1970 to eleven in 2010.

**AAC change over time: ‘Airport-centric activity center’ effect**

The results do not support the third hypothesis. With respect to change in unemployment rate, poverty rate, and percent of college-educated persons, the changes in AACs were not consistently more favorable than the changes in the regional rates. Evaluating each AAC individually, more AACs provided evidence against the third hypothesis than supported it. Only one AAC (SNA in the LA region) had more favorable changes in each socioeconomic variable than its region: the percent of college-educated persons increased more than the region, the poverty rate decreased more than the region, and the unemployment rate decreased more than the region. Three AACs (FLL, SJC, and SFO) had changes in socioeconomic demographics that were mostly on par with the region. Six AACs (HOU, MDW, DAL, JFK, MIA) had less favorable changes than the region for each socioeconomic variable. The remaining ten AACs all had at least one significantly more unfavorable outcome than the region.

There was no significant trend that correlates the rise of hub airport activity with decreased rates of unemployment for nearby residents. Although all the regions saw an increase in unemployment, the increase in AACs was often worse. As shown in Figure
3.5, the change in unemployment for six AACs was on par with the region (near the trendline), six AACs were better than the region (below the trendline), and eight AACs were worse than the region (above the trendline). Historical US unemployment rates often fall between 4% and 8%, so a one percentage point change, though small, is still significant. The number of AACs with at least an 8% unemployment rate increased from two in 1970 to nine in 2000. The number of AACs with at most a 4% unemployment rate decreased from fourteen in 1970 to five in 2000. From 1970-2000, fourteen AACs increased their unemployment rate by 1.7 to 6.5 percentage points. Of these fourteen, eight increased unemployment more than their regions by 1.3 to 3.2 percentage points. SJC, SFO, and SNA are the only AACs that decreased unemployment by at least one percentage point. SFO and SNA’s starting unemployment rate in 1970 was around 5%, while SJC was among the highest at around 8%.

There was no significant trend linking the rise of hub airport activity with decreased rates of poverty for nearby residents. The number of AACs with at least an 15% poverty rate increased from two in 1970 to eight in 2000. The number of AACs with at most a 10% poverty rate decreased from twelve in 1970 to six in 2000. The poverty rate did not decrease meaningfully near any airports from 1970 to 2000 and, often, the AAC poverty rate increased more than their respective regions. As shown in Figure 3.5, six points are near the trendline, three points are below, and nine points are above. Four AACs increased their poverty rate by three to five percentage points since 1970 and eight AACs increased by five or more percentage points. The centroid value shows an average 4.2 point increase for AACs and an average 1.8 point increase for regions. For three AACs, the increase in the poverty rate was two to five percentage points higher than in their respective regions. For six AACs, the increase in the poverty rate was five
to ten percentage points higher than in their respective regions. The largest differences were in HOU and DAL. HOU increased 12 points from 5% to 17% while the region increased 1 point from 13% to 14%. DAL’s poverty rate increased 10 points from 9% to 19% while the region remained stagnant at 11%.

There was no significant trend linking the rise of hub airport activity with an increase in the percent of nearby residents with college education. Importantly, 19 AACs and all regions increased their percentage of college-educated persons (those with 4 or more years of college). However, the percent of college-educated persons typically increased less near airports than in their respective regions from 1970 to 2000. Twelve AACs increased less than their respective region, ranging from 3 to 10 fewer percentage points. As shown in Figure 3.5, two points are near the trendline, twelve points are below, and five points are above. The centroid value shows an average 9.1 point increase for AACs and an average 11.7 point increase for regions. BWI and HOU reported the largest difference between AAC change and regional change. The percent of college-educated persons near BWI increased 7 points from 4% to 11% while the region increased 17 points from 10% to 26%. HOU remained stagnant while the region increased 10 points from 7% to 17%.

**Case Study Discussion**

This section reviews three case studies to explore the planning outcomes related to the neighborhood change findings. One community near the Fort Lauderdale/Hollywood International Airport (FLL, Miami region) stands out as a consistently White community, which differs from its region and other ACCs. Conversely, the community near George Bush Intercontinental Airport (IAH, Houston region) stands out as increasingly Black
community since the rise of the jet age. Finally, the community near Burbank Bob Hope Airport (BUR, LA region) stands out because it most resembles and mirrors the change in its host region.

**FLL: Privileged among AACs, unable to resist**

The residential community near FLL airport maintained a predominately White composition during the rise of the jet age, both when compared to other AACs and its region. While the Miami region grew to nearly 40% Hispanic and 40% foreign-born by 2000, the airport-adjacent residents grew to only about 20% Hispanic and 20% foreign-born. Despite socioeconomic characteristics that were favorable and on par with the region, the nearby community was still unable to effectively resist the will of the airport owners to expand.

A closer look at the 1990 spike in vacancy rate near FLL highlights an instance of poor treatment of local residents in the home buyout process, even in one of the more privileged AACs. FLL airport officials instigated a large housing buyout initiative in 1987 that left many vacant homes standing in 1990, all in the hopes of converting the area to an industrial park that would be complimentary to airport activity. The airport owners legally acquired the homes and apartment buildings through noise abatement programs and targeted others for voluntary sale. The Ravenswood community to the west of the airport was especially hard hit by the buyout program. In total, more than 900 properties west of the airport were acquired as part of the land acquisition program, prompting 89 lawsuits (Kaye, 1994). In an interview with the Sun Sentinel newspaper, the county Aviation Department’s assistant real estate officer hinted at the aggressive tactics used to incentivize residents to leave: "Once the children see that all their friends have
moved, they will complain to their parents, and eventually (the parents) will decide they want to move. "It will happen. Do you want to be the only one on your block?" (Samples, 1988).

Despite stated plans to bulldoze airport-acquired homes, lingering residents reported that the airport owners did not maintain the strategically purchased homes and allowed the homes to fall into disrepair. Residents argued that the resulting blight from vacant homes and lots full of gutted home appliances made the community look like "a warzone." Residents all cited concerns with inequitable treatment due to the fact they lived in an unincorporated area as well as a seeming conflict of interest inherent in the housing citation enforcement. In interviews, Ravenswood Civic Association President Pat Lang noted that the county, which owns the airport, was repeatedly citing homeowners and failing to cite the aviation department for code violations (Neal, 1989). Year after the buyout program was complete, Lang noted that she was compensated and happy with her new residence a few miles further west of the airport, but remained critical of the process, particularly the "inconsistent methods of compensation" for property owners (Kaye, 1994).

*IAH: Airport siting inequity, increasing racial segregation*

The residential community near IAH is an interesting case study for a few reasons. First, the community near IAH has the fourth highest Black population (by percent) in the sample and showed the steepest increase in the Black population from 1970 to 2010. Similar to FLL, it is one of three AACs with an extreme peak (>15%) in home vacancies. Finally, the airport itself stands out among the other airports since it is one of the four busiest airports in the sample and it is one of just seven major hub airports opened post-
1960 in the US. After probing into these dynamics, the AAC outcomes seem to be correlated with inequitable airport planning decisions and discriminatory settlement patterns.

The AAC population data for 1970 did not suggest any overwhelming inequities in the siting of the airport. Given the primarily rural location, the starting population (in 1970) for the community near IAH was considerably smaller than the starting population in the other AACs. The total population increased from 4,000 in 1970 to 40,000 in 2010. Over this time, the White community dropped from 87% to 44% and renter-occupied housing units increased from 20% to 38%. The proportion of the nearby Black and Hispanic communities increased substantially from 13% to 35% (Black) and from 6% to 41% (Hispanic). The spike in vacant housing seems to be best explained by the growth of the northern suburbs. The Houston region underwent a massive housing boom in the late 1970s. The boom included a HUD-sponsored ‘new town’ development called Kingwood, whose southern portion is partially included in IAH’s AAC boundary. The completed, but vacant, housing units awaiting purchase in Kingwood likely contributed to the sudden spike in vacancies near IAH in 1980 (Willmann, 1977).

Although the data did not initially show evidence of social inequity, there is a glaring example of inequity related to the siting of the airport. Aside from the affluent Kingwood development to the north, the community surrounding IAH was primarily rural subdivisions and a patchwork of annexed land. Houston annexed one such subdivision, Bordersville, in 1965 specifically as a means to secure land required to construct the IAH airport in the late 1960s. Bordersville is and was a small, primarily Black, and impoverished community. Despite promises of city services in exchange for supporting
the annexation and the airport, and even after renaming a street to honor the mayor in celebration, Bordersville residents only received city water service in 1982 and sewer service in 1997 (Zuniga, 1997; Sallee, 1996). City officials eventually named Bordersville as part of the IAH/Airport Super Neighborhood Council, a group specifically “aimed at bringing much-needed improvements to the long-neglected community” (Stanton, 2001).

It is likely that IAH’s Black population grew so substantially due to the dynamics of annexation, airport expansion in 2003, and racial dynamics in the northern suburbs. The existing pocket of rural Black poverty would be unlikely to attract White settlement, especially with IAH so near and Kingwood as a more desirable option. Nearby Kingwood, largely considered a White, affluent neighborhood, would have been more likely to draw White middle-class and upper-class residents and close off opportunity to Black residents, particularly during the 1970s. The percentage of the Black population near IAH changed most notably between 2000 and 2010. In 2003, the airport deployed a new runway and was the center of local controversy due to the resulting noise increase. Although the data analysis suggests a gradual market shift that attracted African American residents over time, there is evidence to suggest that inequitable treatment of Bordersville at the time of airport siting as well as discriminatory practices throughout Houston contributed to these market forces (Bullard, 1983).

**BUR: Power in numbers, atypical public involvement**

The community near Hollywood Burbank Airport (BUR) in Los Angeles stands out in the dataset because it is remarkably large and diverse. As of 2000, the AAC was 58% White, 4% Black, 30% Asian, 50% Hispanic, 42% foreign-born, and 13% college-educated. Also, unlike most AACs in the sample, it remained fairly representative of its
regional characteristics over time. The demographic, socioeconomic, and housing characteristics have roughly matched that of the Los Angeles region since the rise of the jet age. With more than 200,000 nearby residents, the community also has one of largest total populations across all AACs in the sample. The population is only exceed by LGA (New York), and on par with MDW (Chicago), DCA (Washington DC), JFK (New York), and EWR (New York).

The BUR airport community is also a rare example of securing extraordinary public influence in the airport planning process. The airport has handled 50,000-70,000 annual operations in the years since 2000. In contrast, LAX regularly handled well above 500,000 annual flights. Community members, led by Restore Our Airport Rights (ROAR), rallied against airport noise and airport expansion when the airport owners began planning for a new terminal facility. While the airport officials contended that the facility was necessary for safety, residents countered that it would bring an unwelcome increase in flights. In November 2000, local residents passed Measure B (33,000 total votes, 80% in favor), requiring voter approval of terminal construction and effectively gives local residents collective veto power over airport expansion (Oliande, 2000). The measure was part of a larger effort to negotiate public demands for nighttime noise restrictions and growth caps on the airport (Decker, 2001; Woodard, 2000). In October 2001, the Burbank residents also passed Measure A, which contained stronger language about setting caps on operation growth. However, Los Angeles Superior Court Judge Richard Montes overturned Measure A’s sweeping and vague language, declaring “Measure A impermissibly interferes with powers delegated exclusively to the Burbank City Council” (Abram, Aug 2002). In November 2002, Burbank airport officials abandoned expansion plans, citing a lack of support from the Federal Aviation Administration and the local
political environment (Grudin, 2002). After years of controversy and despite the local airport commission’s early and continued emphasis on the need to expand to remedy safety concerns, the Federal Aviation Administration announced in December 2002 that the airport fully complied with safety codes and there was no need to build a replacement terminal (Abram, Dec 2002). A decade later, the City of Burbank is planning to hold its first vote in November 2016 to ask residents to approve a proposed terminal upgrade (Sherwood, 2016).

Nationally, the community near Burbank airport has been one of the most successful in formally injecting their voice into the airport planning process. However, the population data does not paint the Burbank community as the obvious candidate for successful resistance and pushback in Los Angeles. The community near Los Angeles International Airport (LAX) has a much higher rate of college of education (25%), less unemployment, and less poverty. Yet, the LAX airport successfully undertook a much larger airfield reconfiguration and modernization project from 2008-2012, exceeding that which was proposed at BUR. More than 225 residents attended a meeting with the Board of Airport Commissioners, where the large majority of attendees opposed the projects (Sumers, 2013). In addition, Councilman Bill Rosendahl spoke out against the expansion component of the modernization project. Rosendahl was well-known for his critiques of airport expansion in the Los Angeles region, stating “The future of our airport depends on regionalization” (Daily News, 2013). Ontario Councilman Alan Wapner echoed calls for regionalization to make use of the Ontario International Airport (ONT) as a more environmentally responsible way to handle air traffic in Southern California. For LAX-adjacent residents, opposition expressed through public meetings, lawsuits, and some
city officials were not enough to successfully resist the will of the airport owners expand capacity (Marquez, 2013).

**Conclusions**

The relationship between residential communities and airport-centric activity centers are relatively unexplored in the current literature. This research addressed three theories regarding the interaction between airports and nearby residents. While the results cannot make claims of causality, they are a first step in identifying trends in population change and exploring the likelihood that such changes are explained by theories in the literature.

First, I considered whether the busiest airports rose to prominence, at least in part, due to inability of disadvantaged groups to resist expansion. I found that disadvantaged groups did not have a proportionally significant presence near the largest four hubs (>500,000 annual operations) during the rise of the jet age. Often, those groups constituted larger proportions in communities near the other less dominant hubs, but only later in the jet age (<250,000 annual operations). Thus, it seems unlikely that a lack of community power (as related to race, ethnicity, or socioeconomic status) played a significant role in the rise of the busiest hub airports. Since disadvantaged groups did not have a significant presence, there is no connecting link to the theory that their lack of political power enabled the most extreme levels of airport activity. However, the increasing presence of persons of minority status and and low socioeconomic status near hub airports warrants consideration for the long-term ‘power to resist’ of hub airport expansion.
Second, I considered if the airport exerted a push-pull LULU effect that pushed advantaged groups away and pulled disadvantaged groups closer. Overall, the push-pull effect seemed to be larger in AACs than in their regions. Thus, there is reason to suspect that the market has played a role in reshaping the composition of airport-adjacent communities, often in a way to that drastically increased the presence of historically marginalized groups. This suggests more detailed research is warranted to explore the potential causal link between the airport facility and patterns of residential settlement.

Third, I considered the potential for airport-centric activity centers to stabilize or improve the socio-economic status of nearby residents. I found that airport-adjacent residents frequently had less favorable socioeconomic outcomes when compared to their respective regions. This suggests that, even if airports are functioning as strong activity centers, the economic benefits for local residents are not high enough to keep pace with the average socio-economic performance of the region. More work is needed to understand how economic benefits of airport-centric development are distributed to airport-adjacent residents and understand the extent that the airport-centric activity center is a superior alternative to other possible interventions.

As illustrated in the case studies, pushback tension between airport owners and local residents is a battle of will. The battle is on a public stage that frequently favors the airport owner, granting them the most power to manipulate the justification for and process of airport expansion. Burbank airport officials led a charge for expansion under the guise of safety. After years of successful community pushback, the FAA revealed safety was ultimately a non-issue. Airport owners must now contend with the power of
the public to veto future terminal expansion. Houston airport officials led a charge for a new airport for the modern era, even gaining enthusiastic support from the locals. Yet, city leaders refused to deliver promised services to poor, Black residents after annexation. In subsequent years, racial segregation intensified and it took decades for the city to begin to rectify its treatment of the local, poverty-stricken community. Fort Lauderdale airport officials led the charge for airport-centric development for the economic benefit of the region, but engaged in intimidation tactics to the detriment of local residents. The airport arguably made the optimal choice to spur a conversion to more compatible land use, but the process of conversion was arguably unjust. In the Fort Lauderdale and Houston examples, the airport and municipal leaders were equally successful in overpowering the will and needs of local residents. However, in the Burbank example, the local residents mobilized enough political power to resist the airports unjustifiable intent. This suggests that sheer population size, not demographics, may be the most critical issue in the long term management and expansion of major hub airports.

*Future work*

The first area of future work relates to the airport dataset. This research only considered two classes of hubs with large-scale operations: medium and large hubs. Ultimately, the research did not reveal significant differentiation between the change in racial or ethnic composition of communities near medium and large hubs post-1970. This could suggest that the nuisance generated by both airport classes is enough to induce similar changes in community composition. Perhaps there would be differentiation near airports that existed in 1970, but continued to have small-scale (non-hub) operations in 2010. Or,
perhaps the effect is better explained by other market forces unrelated to airport infrastructure. Future work could expand the airport dataset to include airports in the region that remained in operation as nonprimary commercial service airports or general aviation airports. Small-scale airports may be a suitable control geography within the region, depending on when they were sited and where they are located in the region. If the change in composition in communities near small-scale airports is markedly different when compared to the large-scale hubs, there is more evidence to link the effect of airport nuisance. As airport planners consider expanding the regional airport network, it would be useful to understand the racial and ethnic dynamics that may be in play near the smaller airports who are likely to resist expansion, particularly in urban areas with only one major hub airport. Additionally, historical research that includes a mix of nonprimary commercial service airports alongside primary commercial service airports would offer insight into why certain airports ultimately rose to hub prominence.

The second area of future work relates to the geographic boundaries used in the dataset. The 5km radius represents a generalization of the size of the airport-adjacent community. However, it is possible to generate noise contours that specifically outline the areas with the greatest noise nuisance. As the runway orientations change and as operations increase, the noise contours also change. Population, housing, and socioeconomic outcomes could be assessed within this smaller geographic area, outlined by the noise contour, and then compared to the 5km AAC and to the broader region. Such work would contribute to an understanding of how airport nuisance influences patterns of settlement and may have applications to scholarship that explores the limitations of noise contours as de facto measures of nuisance.
The third area of future work involves altering the variables used to investigate housing and employment in airport-adjacent communities. The research results indicated a clear trend of homes converting from owner-occupied to renter-occupied. A subsequent study option includes investigating the change in home and rental prices over time near hub airports. Mapping the change in home tenure and home price could lend insight into how airport infrastructure impacts housing markets. Additionally, this may provide insight to the narrative that airport owners forcibly take homes and manipulate residents to leave through strategic buyouts that induce neighborhood decline. Another variable to consider is employment and commute trends for residents near the airport. Although the results showed that airport-adjacent residents typically did not have more favorable socio-economic outcomes than average residents in their region, it is still possible that local residents are a significant part of the labor force in airport-centric activity centers. A more detailed understanding of employment, wages, and poverty for residents near airports could lead to policy and planning ideas that improve socioeconomic outcomes for airport-adjacent residents. Although this research suggests that the benefits of airport-centric development are potentially overstated for local residents, further research could help airport-adjacent communities learn how best to capitalize on the economic possibilities of airport-centric development to induce more favorable local outcomes.
Chapter 3 Tables and Figures

Figure 3.1 Map of multi-airport regions (MAR) These plots map the eight multi-airport regions (MAR) in the United States. The mapped sample of ‘1970 Metro Tracts’ is a subset of census tracts within the metropolitan statistical area. The outline of the 1970 metro tracts constitutes the baseline area used to compare demographic changes in the MAR across the 1970, 1980, 1990, 2000, and 2010 decennial censuses.
Figure 3.2 Airport-Adjacent Community (AAC) Comparison Geography The following plots map the 21 airports in multi-airport regions in the United States. The circular ‘AAC 5km Buffer’ is the catchment buffer used to identify census tracts within the airport-adjacent community (AAC). The area of the ‘1970 AAC Tracts’ constitutes the baseline area used to compare demographic changes in the AAC across the 1970, 1980, 1990, 2000, and 2010 decennial censuses.
Table 3.1 Decennial census variables used to characterize and compare airport-adjacent communities (AAC) The table lists all population and housing variables considered in the analysis of airport-adjacent communities and multi-airport regions.

<table>
<thead>
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<td>Total Population</td>
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<td>●</td>
<td>●</td>
<td>●</td>
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<td>●</td>
<td>●</td>
<td>Housing units by occupancy status (Vacant)</td>
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<td>●</td>
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<td>Occupied housing units by tenure (Renter occupied)</td>
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<tr>
<td>Poverty</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>X</td>
<td>Poverty Rate = Persons below poverty level in previous year / Persons for whom poverty status is determined</td>
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<td>Unemp</td>
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<td>+</td>
<td>+</td>
<td>X</td>
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<td>Foreign Born</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>X</td>
<td>Persons by Nativity (Foreign Born)</td>
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</table>

● = COMPATIBLE, Available in 100% population data  
○ = NOT COMPATIBLE, Significant methodological change (variable tabulation changes)  
+ = COMPATIBLE, Available in sample-based population data  
X = NOT COMPATIBLE, Significant methodological change (American Community Survey)
Table 3.2 Summary of airport-adjacent communities by population characteristic

This table shows the AACs that maintained unusually high (greater than third quartile) or unusually low (less than first quartile) representation of each population group during the analysis timeframe.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Consistently Low</th>
<th>Consistently High</th>
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<td></td>
<td>$x &lt; Q1$</td>
<td>$x &gt; Q3$</td>
</tr>
<tr>
<td>AAC Area</td>
<td>LGA, OAK, SFO, SNA</td>
<td>DFW†, IAD†, IAH, SJC</td>
</tr>
<tr>
<td>Total Population</td>
<td>BWI, HOU, IAH</td>
<td>BUR, DCA, EWR, JFK, LGA†, MDW</td>
</tr>
<tr>
<td>Total Housing</td>
<td>BWI, IAH, ORD</td>
<td>BUR, DCA, EWR, LGA†, MDW</td>
</tr>
<tr>
<td>%White</td>
<td>DCA, EWR, JFK, OAK, HOU</td>
<td>BWI, MIA</td>
</tr>
<tr>
<td>%Black</td>
<td>ORD, SFO, SNA</td>
<td>DCA, EWR, HOU, JFK, OAK</td>
</tr>
<tr>
<td>%Asian*</td>
<td>BWI, FLL, MIA</td>
<td>LGA, ONT, SJC, BUR, OAK</td>
</tr>
<tr>
<td>%Native American</td>
<td>MIA</td>
<td>ONT, SJC, BUR, OAK</td>
</tr>
<tr>
<td>%Hispanic**</td>
<td>DFW, FLL, JFK, BWI, DCA, IAD</td>
<td>DAL, HOU, LGA, MDW, MIA†, ONT, BUR</td>
</tr>
<tr>
<td>%Youth</td>
<td>FLL, MIA, LAX, SJC</td>
<td>IAD, ONT</td>
</tr>
<tr>
<td>%Senior</td>
<td>DFW, IAD, IAH, ONT</td>
<td>FLL, MDW, MIA, SFO, OAK</td>
</tr>
<tr>
<td>%College***</td>
<td>EWR, MDW, ONT</td>
<td>IAD, LAX, SNA, DAL, DCA, DFW, SFO, SJC</td>
</tr>
<tr>
<td>%Foreign Born***</td>
<td>BWI, DFW, IAH</td>
<td>BUR, LGA†, MIA†</td>
</tr>
<tr>
<td>%Unemp***</td>
<td>DFW, IAD, SFO</td>
<td>EWR†, JFK, LGA, OAK, ONT, HOU, MIA</td>
</tr>
<tr>
<td>%Poverty***</td>
<td>BWI, DFW, IAD, ORD, SFO</td>
<td>DCA, EWR†, LGA</td>
</tr>
<tr>
<td>%Vacant</td>
<td>none</td>
<td>DCA, EWR, FLL†, IAH†, DAL</td>
</tr>
<tr>
<td>%Renter</td>
<td>BWI, IAD, MDW, ORD</td>
<td>DCA, EWR†, LGA†</td>
</tr>
</tbody>
</table>

AAC The AAC value is more extreme than the AAC’s regional value. $|AAC| >> |Region_{AAC}|$

AAC† The AAC value is more extreme than all other AACs’ value. $|AAC| >> ||AAC||$

† Data only available for years 1990, 2000, and 2010.


Figure 3.3 Boxplots summarizing total change in each population characteristic from 1970 to 2010, across 20 airport-adjacent communities. This figure shows the variation in the magnitude of change for the 20 observations. IAD was dropped from analysis due to inconsistency with the AAC's boundary. In this figure, change is represented as the total change in count for each variable from 1970 to 2010. Some variables are assessed over a slightly different timeline, as described in the notes.

Figure 3.4 Boxplots summarizing percentage point change\(^\dagger\) in each population characteristic from 1970 to 2010, across 20 airport-adjacent communities This figure shows the variation in the magnitude of change for the 20 observations. IAD was dropped from analysis due to inconsistency with the AAC’s boundary. In this figure, change is represented as the change in percent\(^\dagger\) for each variable from 1970 to 2010. Some variables are assessed over a slightly different timeline, as described in the notes.

Figure 3.5 Scatterplot of percentage point change: AAC vs Metro The metro change is on the x-axis and the AAC change is on the y-axis. See notes for Figure 3.5.
Table 3.3 Centroids for scatterplots depicted in Figure 3.5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Change in Percentage Points†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Region</td>
</tr>
<tr>
<td>%White Persons</td>
<td>-25.7</td>
</tr>
<tr>
<td>%Black Persons</td>
<td>+1.4</td>
</tr>
<tr>
<td>%Native American Persons</td>
<td>+0.35</td>
</tr>
<tr>
<td>%Asian Persons</td>
<td>+7.1</td>
</tr>
<tr>
<td>%Hispanic Persons</td>
<td>+16.7</td>
</tr>
<tr>
<td>%Youth</td>
<td>-8.7</td>
</tr>
<tr>
<td>%Senior</td>
<td>+2.4</td>
</tr>
<tr>
<td>%College-Educated Persons</td>
<td>+11.7</td>
</tr>
<tr>
<td>%Foreign-Born Persons</td>
<td>+16.5</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>+1.9</td>
</tr>
<tr>
<td>Poverty Rate</td>
<td>+1.8</td>
</tr>
<tr>
<td>%Vacant Housing Units</td>
<td>+2.5</td>
</tr>
<tr>
<td>%Renter-Occupied Housing Units</td>
<td>-3.3</td>
</tr>
</tbody>
</table>

†Example: (30% in 2010) – (20% in 1970) = 10.
*** Data only available for years 1990, 2000, and 2010.
Note: IAD dropped from analysis.
Chapter 4: Airport Expansion and Environmental Justice in the 21st Century

Introduction

Aviation scholars are questioning how the US national airport system will sustainably handle long-term air transportation demand. Currently, capacity enhancement is the default intervention, while regional and policy alternatives are overlooked (Ryerson and Woodburn, 2014). Hub airport expansion often exacerbates local environmental and health impacts because it accommodates more and larger aircraft. Even when new flight paths and procedures minimize noise per operation, the aggregate effects of new runways can substantially alter the noise profile to the benefit of some and the detriment of others. The results of Chapter 3 show that airports became increasingly surrounded by communities of color during the jet age and often fared worse than their regions with respect to socioeconomic status. The case study analysis also highlighted that airport owners employed aggressive campaigns to expand. Building on this knowledge, this chapter investigates environmental justice outcomes for airport-adjacent populations surrounding America’s expanding hub airports. This research probes into national airport expansion policy and investigates whether new runways in the 21st century were allocated equitably from the perspective of airport-adjacent communities. Thus, the second research question in this dissertation is: Were hub airports more likely to expand if historically marginalized groups surrounded them?

For this research, I employed quantitative methods to evaluate the likelihood of expansion if the airport was surrounded by historically disadvantaged groups. In essence, the goal is to understand if communities of a certain composition were more
likely to experience an airport expansion, and, consequently, receive a larger or disproportionate distribution of environmental and health impacts. The airport sample includes 50 of the largest hub airports in the US. Similar to the previous chapter, I used census data and spatial analysis to define the airport-adjacent communities’ spatial area and demographic characteristics. In addition, I used airport operations data to quantitatively assess whether an airport demonstrated a need for hub expansion. Through a quantitative method of regression analysis, I tested relationships between expansion events, the need for expansion, and the presence of historically marginalized groups. Overall, the regression model was unable to detect a consistent pattern of environmentally unjust outcomes related to airport runway expansion since 2000.

The remainder of this chapter is organized into the following sections: background, empirical framework, data collection, model specification, results, and conclusion. The background section reviews academic literature that links environmental justice and air transportation. The empirical framework outlines the conceptual model for quantitatively assessing environmental justice outcomes. The data collection section explains the data sources and spatial analysis procedure. The model specification section provides an overview of the regression model and variables. The results section summarizes contingency tables and statistical significance in the models. Finally, the conclusion summarizes the key findings and reflects on the strengths and weaknesses of the empirical model.

**Background**

Similar to highways, airport infrastructure is subject to the National Environmental Policy Act and other legislation designed to critically examine and prevent disproportionate or
significant impacts on the human and natural environment. However, particularly with respect to environmental justice, highway development has received far more scrutiny from planning scholars and practitioners than airport development. For example, urban renewal research illuminated the pattern of disproportionate displacement of minority communities and instigated a shift in the culture of highway planning (Greer, 1965; Klemek, 2012; Pritchett, 2003; Rose, 1990). Scholars have expanded their assessment of highways and environmental justice beyond displacement. Common topics include concerns about how highways contribute to or detract from environmental quality, health, access to job centers and municipal services, and segregated land use patterns (Bullard, 2004; Schweitzer and Valenzuela, 2004). Given the large investments in hub airport infrastructure since 2000, it is reasonable for planners to also turn a critical lens towards the infrastructure of the sky.

Environmental Concerns of Continued US Airport Expansion

Airports can physically increase capacity by constructing new or extended runways and terminals. From 2000 to 2015, sixteen new runways were deployed at America’s largest hub airports as part of the FAA’s federally-funded Operational Evolution Partnership. Often, total planning and construction costs exceeded $1 Billion per runway. The largest investments in capacity occurred at the primary hubs in the aviation hub-and-spoke network (Ryerson & Woodburn, 2014). Relaxed market regulations, which resulted from the Airline Deregulation Act of 1978, created a competitive airline market that favored the hub-and-spoke model as a means to capitalize on economies of scale (Reynolds-Feighan, 1998; Ryerson & Kim, 2013). In the hub-and-spoke model, airlines centralize their operations at a few key “hub” airports, which allows them to more efficiently serve a
larger number of “spoke” airports. Occasionally, hub expansion is followed by hub consolidation, resulting in vacant infrastructure and excess airport capacity. Hub airports in St Louis, Cincinnati, and Pittsburgh lost more than 50% of enplaned passengers after they were abandoned by their hub airlines, even though they had recently built new runways (Kramer & Seltz, 2011).

Aside from new runways, airports can also increase by reorienting airfields or implementing new regulatory policy. For example, runways at Chicago’s O’Hare International Airport were decommissioned and “relocated” predominately within the existing airfield, subsequently altering the noise contours in the surrounding neighborhoods. New York’s LaGuardia Airport offers an example of regulatory changes. As of 2016, officials are considering opening up LaGuardia to long haul flights greater than 1500 miles, which would attract larger aircraft and likely increase the severity of noise and emissions impacts (Sharkey, 2015; Tangel & Nicas, 2015; Tangel, 2016).

Since the airport’s noise impacts can abruptly change with new runway construction or new flight policies, Julie Cidell (2013) argues that airports must be viewed through a “relative mobility” lens. While the built environment surrounding an airport is not necessarily static, the airport’s neighboring communities operate on a much slower timescale. This mobility inequity creates serious consequences for airport-adjacent residents and business owners, as they have a reduced capacity to adapt to noise contours, demolished housing, or lowered property values. The expected pace of future hub expansion, coupled with the low “relative mobility” of the airport-adjacent built environment set the stage for contentious and adversarial relationships between airport-adjacent residents and airport owners.
Academics commonly cite noise, air quality, climate change, and the resulting community opposition as the most pressing environmental concerns for the future growth of air transportation (de Neufville & Odoni, 2013; Schafer & Waitz, 2015; Upham et al, 2003). Aviation scholars have argued that hub airports are responsible for the brunt of aviation’s noise and local air quality effects, and that expansion exacerbates harmful effects (Nero & Black, 1998; Wolfe et al., 2014). For context, consider that He et al (2014) conducted a meta-analysis of hedonic noise pricing studies and found that global annual aviation noise damages are likely greater than $36 billion (in 2005 dollars) and 95 US airports are responsible for 41% of that total. The scale of impacts will change as the areas around airports become more urbanized and affect more residents. The study also found that the number of people exposed to at least 55 decibels of day-night average sound is expected to rise from 14 million in 2005 to 24 million in 2035. Their research was published in Transport Policy’s special issue devoted to environmental issues associated with air transportation. In Schafer and Waitz’s (2014) summary editorial for the issue, they argue there is no single solution that effectively addresses noise, air quality, and climate change impacts because each impact’s burden manifests differently across local, regional, and global geographic scales.

While there may not yet (or ever) be an obvious solution to mitigate all impacts simultaneously, planners have a role in working towards community consensus and guiding long-term outcomes. As noted by aviation law scholar Scott Hamilton (1994), land use zoning is a common tool used to “protect airports from the encroachment of noise-sensitive residential developments, but also to protect residential communities from the encroachment of noise-generating airports” (Hamilton, 1994, p. 260). A central area of inquiry involves developing an understanding of whether zoning and other airport
Planning interventions are used to benefit and protect the airport or benefit and protect the residents. In an effort to inform the societal balance sheet of benefit and injury induced by airport planning interventions, this research investigates airport-adjacent populations and the pattern of airport expansion post-2000.

Framing Environmental Justice for Aviation Research

The aviation literature calls for greater study of environmental impacts of airport expansion (TRB, 2014; Upham et al. 2003). There is a need to not only study the adverse impacts, but to study the communities that bear the brunt of the impacts. This aligns with the fundamental concept in environmental justice research: to evaluate the distribution of beneficial and adverse effects and to determine if the effects are fair and equitable (Forkenbrock & Sheely, 2004). As conceptualized by Robert Bullard, a founder of the environmental justice movement, “Environmental justice embraces the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations” (Bullard, 1996).

The concept of environmental justice emerged at the turn of the 21st century and is a more recent addition to the environmental movement. The environmental movement in America started as a response to industrialization in the late nineteenth century. Tom Daniels (2009) identifies this time period as ‘Getting on the Green Path.’ Early debates between conservation and preservation, led by Gifford Pinchot and John Muir, brought resource consumption to the public consciousness. At a local planning level, Frederick Law Olmsted, Daniel Burnham, and Ebenezer Howard emphasized open space through public parks, playgrounds, and garden city developments. As suburban development increased across the US in the mid-1900s, mass production and consumption of housing
and goods led to mass pollution. The environmental movement rallied against air and water contamination in the United States. Notably, Rachel Carson’s *Silent Spring* in 1962 was influential in rousing public support for wide-scale environmental laws. Consequently, the US environmental movement generated landmark environmental policies to clean up and prevent industrial pollution in the 1970s. Environmental justice gained visibility in the 1980s after the release of two prominent studies that examined the racial and socioeconomic composition of the communities surrounding hazardous waste landfills (Bullard, 1983; GAO, 1983). By 1994, President Clinton issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (Clinton, 1994). This legislation prioritized consideration for environmental and human health impacts on minority and low-income communities. Greenberg (1993) broadly addressed inequity stemming from the location of locally unwanted land uses (LULUs), moving the conversation beyond hazardous waste facilities.

As environmental justice research developed over the subsequent decades, substantial evidence supported strong links between protected groups and exposure to environmental hazards. In Evans and Kantrowitz’s (2002) literature review, they find that the non-white poor bear a “disproportionate burden of exposure to suboptimal, unhealthy environmental conditions in the United States.” Analysis methods and tools have matured over this time, allowing for even more nuanced assessments of planning policies. Even policies with a stated intent to diminish environmental impacts can still result in heightened impacts on the most disadvantaged. For example, Schweitzer and Zhou (2010) applied environmental justice theory to dense infill development. Their research challenged the conventional wisdom that infill would improve respiratory
outcomes for urban residents simply because it would reduce overall emissions. The authors found that emissions exposure increased (especially for minority, low income, and elderly citizens) even though overall emissions decreased.

Most environmental justice literature focuses on a single piece of infrastructure or a cluster of LULUs in a region. Only a small body of work specifically addresses airports. One study evaluated fine particulate matter pollution at the Hartsfield-Jackson Atlanta International Airport in June 2002. The authors found that "populations that have less income, less education, and are more nonwhite are more likely to be located in areas that are strongly affected by aircraft emissions" (Rissman et al., 2013). Further, they found that as pollutant concentration increased, minority populations became an even stronger predictor. Another study, which focused on Boston Logan International Airport, used spatial analysis methods to evaluate the distribution of airport noise across different socio-demographic groups. They observed significant socio-demographic differences between the 'quiet' areas and 'noise-affected' areas in both 1990 and 2000 (Ognewa-Himmelberger & Cooperman, 2010). In a separate noise study of an unspecified airport, Sobotta et al (2007) found that ethnicity was a "more important predictor of exposure to aviation noise pollution than are other factors having to do with economic and political costs." Finally, Most et al (2004) used St Louis-Lambert Field Airport as a methodological case study. They illustrated that the outcome of environmental justice research is sensitive to the spatial resolution of analysis, the population selected as the reference comparison, and how the areal units of analysis are assigned to the geographic area of vulnerability.
The growing environmental justice literature not only documents inequitable outcomes associated with infrastructure planning, but also critiques methods. There is an additional component of the research that questions how to use environmental justice information to achieve more equitable planning processes and outcomes. For example, Walker (2010) questioned the usefulness of expert data analysis for environmental justice investigations. Walker highlighted the problems with a technocratic approach to analysis, seeming unable to decide whether such investigations ultimately foster conflict resolution or consensus building. Another facet of environmental justice research emphasizes the complex economic, cultural, and historic factors that shape the cityscape. Controversially, Been (1994) argued there is not enough research to identify the role of market dynamics related to disproportionate impacts of LULUs. Is it possible to know which came first - people of color or LULU? In response, Bullard (1996) asserts that siting inequities are not the only indicators of environmental injustice. Lisa Schweitzer (2007) cautioned against the common oversimplifications in environmental justice analysis and urged scholars to empirically consider the role of agglomeration economies and residential segregation.

Been’s and Walker’s apprehension highlight the need for environmental justice researchers to clarify the normative criterion to which their work can be applied. If quantitative assessments of environmental injustice are to influence policy interventions or mobilize public interest, then researchers must acknowledge the qualitative nuances of environmental justice, and, where applicable, situate these nuances in the context of racial discrimination. For example, Pulido (2000) argued that an emphasis on siting, intent, and spatial scale constrains the definition of injustice and racism, leading researchers to overlook the ways that a range of discriminatory practices manifest in
While unjust outcomes can certainly be the result of blatant unjust intent, there are a range of structural mechanisms throughout social systems that perpetuate unjust outcomes, even if there is no obvious intent to discriminate by race, income, or nationality. In this research, I acknowledge the limitations of a quantitative methodology to parse all the nuances of environmental injustice, but assert the value of data analysis to glean insight to patterns of environmental injustice phenomena.

**Empirical Framework**

This research design includes a statistical test, using spatial analysis and regression modeling, to identify whether hub airport expansion in the 21st century occurred disproportionately in communities with historically marginalized groups. Ultimately, the goal is to design an empirical model that is capable of detecting environmentally unjust outcomes associated with airport infrastructure development. Alternatively stated, this study tests for outcome equity. It does not explore intent during the planning process.

The variation in just and unjust outcomes could be the result of discriminatory intent, whereby municipal airport owners are more likely to initiate a project for an additional runway when they have reason to believe that marginalized communities are less equipped to successfully resist the project. Or, on a similar note, whereby airlines are more likely to grow route markets at airports when they have reason to believe that marginalized communities are less equipped to successfully resist future expansion. In contrast to deliberate intent, unjust outcomes may be better explained by existing social structures and market dynamics. For example, if the push-pull LULU effect may explain the presence of marginalized groups near airports. Runway expansion, which often occurs at airports in the largest cities, may simply coincide with the incidence of more
diverse and disenfranchised population groups that exist in the larger cities. Since these market dynamics have internalized their own pathways for disenfranchisement and discrimination, they cannot be neatly isolated away from environmental justice inquiries. However, this work does not explore or offer evidence of these scenarios of ‘deliberate intent’ or ‘market dynamics’: it simply looks at patterns in outcomes.

The empirical framework to investigate outcomes relies on three observable and measurable phenomena. First, the incidence of hub airport expansion. Second, the demonstrated need for expansion. Third, the demographic and socioeconomic composition of communities near the airport facility. I defined hub airport expansion as the deployment of an additional runway after the year 2000. I defined the need for expansion as the extent that the airport experienced capacity strain in the year 2000. Finally, I defined the composition of airport-adjacent communities (AAC) in 2000. Specifically, I defined AAC composition in terms of the proportion (percent) and concentration (location quotient) of protected groups (race, ethnicity, nativity, and income). The proportion is the percentage of the protected group in each AAC. The concentration is the relative proportion of the population group in each AAC, with respect to the AAC’s metropolitan region. These three observable and measurable phenomena are explained in greater detail in the subsequent section.

The estimating equation takes the general form:

$$E = f (P, X; \theta) + \mu$$

Where E is the dependent variable representing airport expansion post-2000, P is the independent variable representing an AAC population characteristic in 2000, and X is an
independent exogenous variable representing capacity strain in 2000. Theta represents the parameter vector and mu represents the error term. The precise model specification is detailed in a later section.

**Data Collection and Aggregation**

This section discusses the sources I used to identify airports of interest and populations of interest. In addition, this section explains the spatial aggregation of census data. Overall, I collected US census data and airport operations data for the year 2000. I selected the year 2000 since it is the most recent decennial census year prior to the wave of major capacity enhancements at American hub airports post-2000.

*Airport sample*

I used data from the Federal Aviation Administration (FAA) to build the airport sample. The FAA ranks airports according to their total annual passenger enplanements and, separately, by their total annual landed cargo weight. Thus, I began the research with the FAA’s subset of the 31 large hubs and the 35 medium hubs in 2000 (66 total). Most of those 66 airports continued to be important hubs through to 2014. The 61 airports ranked as large or medium hubs in 2014 were also ranked as either large or medium hubs in 2000. Ultimately, I reduced the airport sample from 66 down to 50 airports. Sixteen airports were omitted due to methodological reasons stemming from the spatial analysis of population characteristics and the data analysis for airport capacity strain. Figure 4.1 shows a map of the final 50-airport sample. The omitted airports are not expected to have a substantial effect on the results because none of the sixteen omitted
airports added a runway post-2000 and most were unlikely to have a demonstrated need for an additional runway.

I referred to Airport Improvement Program reports published by the FAA to identify which airports experienced a major capacity enhancement or expansion. Fifteen out of the 66 airports that were prominent in 2000 built at least one additional runway post-2000 (ATL, BOS, CLE, CLT, CVG, DTW, FLL, IAD, IAH, MCO, MIA, MSP, ORD, SEA, and STL).

I also referred to the Aviation System Performance Metrics database to download hourly capacity and demand data for each hub airport during 2000. The ASPM ‘Efficiency’ database provides the most complete and detailed flight data for the largest US airports, but not all airports were included in the database in year 2000. Twelve airports (from the original 66) were removed due to a lack of hourly capacity data in the ASPM database (ANC, AUS, BUF, CMH, JAX, MKE, OMA, PVD, RNO, SMF, SNA, TUS). Occasionally, the ASPM database reports that the hourly percent of capacity used is greater than 100%. Runway orientations and flight procedures are often altered during the hour. Depending on the system’s hourly averaging procedure, the result may report a value 100%. However, the database also has occasional reporting errors. Figure A4.1 in the Appendix shows the % capacity used for the airports that exceeded 100% capacity used. From this figure, I determined that it was sufficient to drop the 70 observations above 150%.

I used the FAA’s Airport Reference Points (ARP) to generate a geographic shapefile of the 50 primary and secondary hub airports in the airport sample (FAA, 2015). The ARP, given as the latitude and longitude of the approximate center of the airport, is calculated as the geometric center of all usable runways. This point serves as a central point
estimate of the hypothetical ‘epicenter’ of noise and air emissions. However, the precise location pinpointed by the ARP depends on the layout of the airport’s infrastructure (eg. airfield, terminals, and other structures) and may not necessarily pinpoint a runway. Four airports were removed due to constraints in the spatial analysis procedure (DEN, OGG, RSW, and SJU). Denver International Airport (DEN) was removed because it had a negligible population surrounding the airport in 2000: only 4 people lived within a 5km radius. Kahului Airport (OGG) was removed because it does not have a corresponding metropolitan statistical area to serve as the regional comparison group. Southwest Florida International airport (RSW) was removed because the host census block group was significantly larger than the airport-adjacent community boundary. Finally, Luis Muñoz Marín International Airport (SJU) was removed because it is in Puerto Rico.

Population sample

With the airport facilities selected, the next step is to define the population sample. The samples are later used to calculate the proportion and concentration of protected population groups in the airport-adjacent community (AAC). In this work, there are two populations of interest: (1) persons living in the area with the most environmentally adverse conditions and (2) persons living in the area of direct and indirect beneficial economic impacts.

First, I defined the area of persons who live with the most environmentally adverse impacts of the airport. Noise and air pollution are broadly considered to be the most harmful effects for airport-adjacent communities, but their impacts are not static or uniform across time or space. At the local and regional level, air quality impacts may vary hourly according to wind speed and wind direction. Pollutant concentrations may be
more pronounced due to the quantity of aircraft operations, distinct land geography, local climates, or emissions from airport-related ground transportation (Yu et al., 2004). Similarly, noise impacts are not uniform across the local geography; they vary according to takeoff and landing flight paths, aircraft size, and flight frequency. In addition to day-to-day impact fluctuations, persons living near the airport are subject to long-term fluctuations. Airport capacity expansion, FAA regulation changes, or flight procedure updates can cause drastic changes in the airport’s environmental impact. These changes often take the form of residential displacement or altered emissions profiles and noise contours. For this research, it was important to identify the generic area that was facing disproportionate exposure to noise and emissions in 2000, and who would also be likely to absorb the altered or exacerbated impacts stemming from expansion. Thus, I opted for a radially-defined geographic boundary to define the AAC. Prior scholarship identified that neighborhoods within 5-kilometers of an airport bear a disproportionate environmental cost per person, particularly with respect to airport noise (Wolfe et al., 2014) All residents within that boundary are likely to experience harmful environmental impacts from airport operations, although some neighborhoods within that area will be more negatively impacted than others. Thus, the geographic area of adverse environmental impacts is defined as the subset of census block groups whose centroid falls within a 0-5km radius of one of the 50 airports in the sample.

Second, I defined the area of persons who gain economic benefits from the airport, either directly or indirectly. Multiple scholars suggest that airports are drivers for the regional economy, specifically employment and population growth. Michael Irwin and John Kasarda (1991) found that the reorganization of the airline network from 1950 to 1980 caused an increase in employment growth at 104 metropolitan areas. Geographer
Andrew Goetz (1992) found a positive relationship between air transportation passengers and the metropolitan area’s population growth and employment growth from 1950-1987, but concluded that the relationship diminished over time. Another geographer, Keith Debbage (1999), found that the counties that hosted the three largest airports in the US Carolinas experienced employment gains, particularly in the manufacturing sector, after those airports experienced significant gains in passenger volume. Transport economists Ken Button and Somik Lall (1999) also found that air traffic caused increases in employment from 1979 to 1997. Economist Jan Brueckner’s seminal study found that a high level of passenger enplanements had sweeping positive benefits for service-employment in metropolitan areas (Brueckner, 2003). Further specifying the air travel effect, economist Richard Green (2007) found that passenger activity, not cargo activity, is a powerful predictor of population and employment growth. Given the breadth of arguments that suggest airports exert a regional economic benefit, I defined the geographic boundary of beneficial effects for each airport as the subset of block groups within the airport’s host metropolitan statistical area. Ultimately, this information is embedded in the model as a location quotient, which signifies the concentration of persons who experience the adverse environmental impacts (the AAC) relative to the persons who experience the beneficial economic impact (the metro).

Lastly, I selected the demographic variables from the US Census Summary File 1 and 3 to describe the populations in year 2000. I chose demographic variables that represent the population groups protected in President Clinton’s Executive Order on environmental justice: race, ethnicity, nativity, and household income. The census data was retrieved from the 2000 decennial census package prepared by the National Historic Geographic Information System (NHGIS) (Minnesota Population Center, 2011).
Through NHGIS, I also obtained US geographic shapefiles for US census block groups and metropolitan statistical areas (MSA). All geographic data was collected and assessed using the 2000 Tiger/Line. I aggregated population characteristics at the census block group level, which have an average population between 600-3000 people. The census block group because is the smallest spatial resolution scale available to aggregate the population characteristics of interest. The spatial analysis procedure uses the centroid method over the areal weighting method since populations are not distributed uniformly over the areal units. Also, effects do not stop precisely at the 5-kilometer boundary, so it is permissible to have a fuzzy boundary. As stated previously, the AAC population characteristics were aggregated across census block groups whose centroid was within five kilometers of the airport’s ARP. The MSA population characteristics were aggregated across census block groups whose centroid was within the metropolitan statistical area boundary.

On average, AACs were composed of 68 census block groups. In the Appendix, Table A4.1 summarizes the number of block groups aggregated for each AAC. Figure 4.3 visualizes how well the aggregated block groups adhered to the 5-kilometer AAC boundary. I observed consistent adherence to the AAC border for 35 airports in the sample, suggesting that these most accurately detect and aggregate the AAC residential population. Nine airports had a slightly uneven adherence, where the selected area was slightly beyond the AAC boundary and also displayed noticeable gaps within the AAC boundary. These airports may have slight inaccuracies in representing the AAC population. I observed poor adherence to the AAC boundary for four airports (ABQ, IAD,
IND, RDU) because they each had noticeably empty regions within the AAC boundary. This is not expected to affect the results significantly because the ‘empty’ regions are generally space occupied by the airport facilities or low density residential areas. I also observed poor adherence for another three airports (IAH, MCO, PIT) because they each included population regions outside the AAC boundary. Comparatively, MCO exhibits the worst adherence.

**Model Specification**

Two constraints in framing the model specification for this quantitative research are (1) the dichotomous outcome for expansion and (2) the small airport sample size. The most appropriate regression approach for binary outcomes and small sample size is Exact Logistic Regression (ELR). Although initially proposed in the 1970s, the ELR method has recently become practical for research due to modern computing power and is most frequently used in the medical field.

In the case of separated data or small sample size, logistic regression often fails as a result of the maximum likelihood estimation procedure. Asymptotic assumptions in the maximum likelihood estimators do not hold for small sample size or highly separated data. In some cases, the likelihood maximization algorithm fails to converge due to highly separated data (where the independent variable is a perfect predictor for the dependent binary variable and the contingency table has cells with a ‘0’ value). In other cases, the estimate is just not reliable due to small sample size.

Statisticians recommend ELR as an alternative procedure because it does not rely on asymptotic estimation. Instead, the procedure efficiently considers every possible
permutation of the binary response variable across the sample. The number of vectors in
the permutation varies according to the number of observations in the sample by \(2^X\) (eg.
4 observations requires 16 vectors, 10 observations requires 1024 vectors). Then, the
permutation set is compared against the observed vectors to calculate the exact
conditional distribution. For this reason, ELR works best with contingency tables, where
all variables in the model are categorical or dichotomous. ELR will generally show poor
performance with continuous predictors. For more information on the computational
algorithms, statistical procedure, and SAS software availability of ELR, see Allison

The model specification for this research consists of 50 observations that correspond to
the 50 airports. It takes the form:

\[
\text{Logit } [P(E=1)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2
\]  

(2)

where \(P(E=1)\) is the probability of a new runway, \(E\) is the binary ‘airport expansion’
variable, \(\beta_0\) is the intercept parameter, \(X_1\) is the binary ‘AAC population characteristic’
variable, \(\beta_1\) is the ‘population” parameter, \(X_2\) is the binary ‘airport capacity strain’
variable, and \(\beta_2\) is the ‘airport capacity strain’ parameter. As with logistic regression, the
variable coefficients can be interpreted as log odds or transformed to odds ratios. The
model specification relies on the most conservative framing of dichotomous outcomes
for each variable in order to design a model that can broadly detect incidents of
environmental injustice.
**Dependent Variable: Airport expansion**

The dependent variable represents whether the airport expansion occurred after 2000, specifically in the form of an additional runway. The dependent variable takes the form of a binary variable, where 1 indicates that the airport added a runway after year 2000 and 0 indicates that the airport did not add a runway after year 2000. Fifteen airports in the sample expanded with an additional runway. The dichotomous outcome ultimately treats all ‘additional runway’ events the same. However, the precise scale of impacts from each new runway will vary on a case-by-case basis, both in terms of how much it alters daily airport operations and in terms of the severity of impact on the human and natural environment. Despite these differences, the addition of a new runway is a significant and distinct choice that greatly contrasts other forms of airport capacity expansion (i.e. new terminals, new flight procedures, extended runways, etc). Additional runways are often the most expensive and highest-impact planning interventions available to airport owners. For this reason, the dichotomous variable, while oversimplified, is still a viable means to describe significant airport expansion.

**Independent Variable: Airport capacity strain**

This independent variable represents whether the airport experienced significant capacity strain throughout 2000. If the airport experienced significant capacity strain, then a new runway would arguably have been justified. In the classic airport design textbook, *Airport systems: planning design, and management*, the authors assert that “a good rule of thumb is that runway systems should not be operated at more than 85 to 90 percent of their capacity for the duration of the consecutive busy hours of the day” (de Neufville and Odani, 2003, p. 389). For this research, I calculated the aggregate number
of hours each airport in the sample used more than 65%, 75%, 85%, and 90% of hourly capacity in 2000. Ultimately, as will be further explained in the results section, I chose 85% as the optimal threshold for evaluating capacity strain. If the airport spent at least 1098 hours at more than 85% capacity used, which amounts to 3hrs/day, then I deemed that the airport experienced strain. Just a few hours of significant capacity strain can cause disruptive delay. As noted by Churchill et al (2010), just a few hours of delay in the morning can propagate delay across the aviation system.

The independent variable takes binary form, where 1 indicates that the airport is capacity strained and 0 indicates that the airport is not capacity strained. While the binary metric captures availability of capacity, it does not necessarily reflect the flexibility of that capacity to accommodate all types of aircraft. For example, runway length is an important factor in determining how existing capacity can be used. An airport owner may wish to accommodate larger aircraft with a longer runway. Rather than simply extend an existing runway, they may opt to construct an additional runway as was seen with Fort Lauderdale-Hollywood International Airport (FLL). However, the motivation to serve larger aircraft is still open to critique. The capacity strain metric is a valuable indicator to denote the need or justification for a new runway.

*Independent Variable: AAC population characteristics*

This independent variable for airport-adjacent population characteristics in the year 2000 also takes a binary form. The variables were coded such that a “1” binary outcome indicates a significant presence of a protected population group. As mentioned previously, the Executive Order for environmental justice highlights ethnicity, race, national origin, and economic status as protected groups. To represent ethnicity, I
quantified Hispanic persons. In terms of race, I quantified persons of color as the inverse of white non-Hispanic persons. For nativity, I quantified foreign-born persons. With respect to economic status, I computed the weighted median household income.

To quantify the presence of a protected population group, I considered the proportion and the concentration. First, the proportion represents the overall percentage of the population group in the AAC. For persons of color, the proportion is considered significant at 50%. Second, the concentration represents the ratio of the AAC’s percent and the metro area’s percent of the population group. This value is commonly referred to as the location quotient. For all race, ethnicity, and nativity variables, the concentration is considered significant at 1.2. This indicates the population group is at least 20% higher in the AAC than the region.

Results

This section first summarizes the AACs’ population characteristics and the airports’ capacity strain. Then, it summarizes the contingency tables of binary data and null results of the regression models.

Analysis of AAC Population Characteristics

In this section, I review the race, ethnicity, income, and nativity population characteristics of AACs in terms of aggregate data (total count), proportional data (percent), and concentration (location quotients). For perspective, I also discuss regional and national data. Table 4.2 shows the aggregated population data for all AACs, all metro areas with a hub airport, and the nation. Table A4.2, in the Appendix, reports the summary statistics
for the 50 AACs in the sample. The summary statistics are visualized as boxplots in Figure 4.4.

In 2000, more than five million people lived within 5km of the 66 largest airports. The sample of 50 airports used in this analysis accounted for 4.7 million residents. For scale, airport-adjacent residents combined to a population that would be the second largest American city – far ahead of Los Angeles and Chicago. Aggregated across all AACs, Hispanic and foreign-born populations were disproportionately concentrated near hub airports, at more than two to three times their national population proportion and their metropolitan proportion.

However, the aggregate AAC data is not the full story. Despite seemingly typical aggregate representation of Black persons, Black residents were severely overrepresented in numerous AACs. Black residents were more than 40% of the population in six AACs, and eleven AACs had two to five times the concentration of Black residents as their metro area. Memphis (MEM) had the most extreme proportional case, with 90% Black residents in the AAC.

Asian residents had some instances of disproportionate representation, but not as often or extreme as Black residents. Asian residents generally comprised less than 5% of the AAC, but six AACs were larger than 15%. Honolulu (HNL) was the extreme case with 50% Asian residents, but reflective of the metro area. Two AACs had both a substantial proportion and more than three times the metro concentration of Asian residents: New York LaGuardia (LGA, 22% Asian) and Washington Dulles (IAD, 17% Asian).
Hispanic residents were the most consistently overrepresented population group. Ten AACs were more than 40% Hispanic, with Miami (MIA) exhibiting the most extreme proportion (85%) and twice the metro area concentration. Thirteen AACs had two to four times the concentration of their metro area. Three AACs had both a substantial proportion and more than three times the metro concentration: Tampa (TPA 43%), Boston (BOS 23%), and Salt Lake City (SLC 40%). As can be expected with immigration trends, foreign-born residents exhibited a similar pattern as Hispanic residents. Three AACs were more than 40% foreign-born (MIA 70%, LGA 55%, and BUR 42%), also with a higher proportion than their metro area.

In 2000, concentrations of persons living in poverty were not consistently higher near airports, but the weighted median household income was consistently lower than the nation and the AAC’s respective region. Five AACs had more than a 20% poverty rate (PHX, ABQ, EWR, MEM, ATL) and each of the five were disproportionately higher than the metro rate. Five AACs had more than twice the concentration of poverty as their region (PHX, SLC, DCA, ATL, CLT). Median household income was both higher than the nation as well as $5K+ higher than the metro in four AACs (IAD, DFW, MCI, DAL). At the other end of the spectrum, PHX and ABQ were less than $30K (much lower than region). Another 5 AACs were $15K less than their region (ATL, EWR, PHX, LGA, HOU).

Broadly, the results show there is significant variation across AACs, particularly in terms of Black, Hispanic, and foreign-born populations. In each group, the interquartile range of proportion is at least 15 percentage points. The weighted median household income was consistently lower than the regions and the national average. Across the sample,
ten AACs were disproportionately represented by persons of color, foreign-born persons, and persons living in poverty (LQ>1.2). Phoenix (PHX) had the most pronounced disproportionate representation in terms of both concentration and proportion: 81% persons of color (LQ=2.3), 39% foreign born (LQ=2.7), 33% poverty rate (LQ=2.8). In total, 22 AACs had more than 50% persons of color. 17 AACs had at least twice the concentration and greater than 20% proportion for at least one of the population groups (i.e. Black, Asian, Hispanic, or foreign-born).

**Analysis of Airport Capacity Strain**

In this section, I review the binary variable that captured whether the airport was experiencing capacity strain in the year 2000, thus justifying capacity expansion in the form of an additional runway. I defined an airports as strained if it spent at least 1,098 hours (~3hrs/day) operating near capacity. I considered 65%, 75%, 85%, and 90% as possible thresholds for ‘percent capacity used’. In 2000, 35 airports experienced capacity strain at 65%, nineteen airports had strain at 75%, eleven airports had strain at 85%, and six airports had capacity strain at 90%.

Next, I considered the incidence of capacity strain against the incidence of expansion, as shown in the two-way contingency table in Table 4.4. Ultimately, I selected 85% as the appropriate strain threshold because (1) it has variability of outcomes in the contingency table and (2) it is recommended in the literature as the maximum level for airport operations. Capacity strain is also visualized in Figure 4.5. The figure shows the average daily capacity profile for the 50 airports. Six airports (LAX, PHX, EWR, LGA, SAN, and JFK) exhibit the most extreme capacity strain with flat lines near the 90% capacity threshold. Arguably, airports with high peaks and valleys in their capacity profile could
institute demand management policy to make more efficient use of their existing capacity before opting for an additional runway. However, airports with flat lines in their capacity profile have fewer options to manage demand.

**Three-Way Contingency Tables**

Tables 4.3 – 4.6 show the three-way contingency tables for expansion, capacity strain, and population characteristics. From the contingency tables, it appears that AACs with a disproportionately large presence of persons of color, with respect to proportion and concentration, were less likely to expand. Alternatively, a high concentration of Hispanic persons appears to be more often associated with expansion. Foreign-born persons do not have a discernable effect from the contingency table data. Nearly all AACs had a median household income that was consistently below the national median, which suggests income is a general concern across all AACs. From the contingency table, expansions appear to have occurred more often at airports whose median household income was at least $5K less than its region.

Table 4.3 presents the variation in binary outcomes for expansion, capacity strain, and persons of color in the 50-airport sample. In terms of concentration of persons of color relative to the region, nine of the fifteen airports that expanded were disproportionately concentrated near persons of color. In terms of proportion of persons of color, four out of the fifteen airports that expanded had a majority of persons of color. Of the six airports that did not expand even though they experienced strain, four were in AACs with a majority of persons of color and a high concentration of persons of color relative to the region. Five of the eleven airports that experienced strain were near communities with a
majority of persons of color. Eight of the eleven airports that experienced strain were near communities with a higher concentration of persons of color than their region.

Table 4.4 presents the variation in binary outcomes for expansion, capacity strain, and Hispanic persons in the 50-airport sample. In terms of concentration of Hispanic persons relative to the region, eleven airports expanded where the AAC was disproportionately concentrated and four airports expanded where the AAC was not disproportionately concentrated. Of the six airports that did not expand even though they experienced strain, three were in AACs that had a high concentration of Hispanic persons. Table 4.5 presents the variation in binary outcomes for expansion, capacity strain, and foreign-born persons in the 50-airport sample. Eight of the fifteen airports that expanded had a high concentration of foreign-born persons. Of the six airports that did not expand even though they experienced strain, three were in AACs had a high concentration of foreign-born persons relative to the region.

Table 4.6 presents the variation in binary outcomes for expansion, capacity strain, and weighted median household income in the 50-airport sample. In terms of the national median household income, fourteen of the fifteen airports that expanded had an AAC with a lower income than the national median income. However, only six of the AACs in the entire sample exceeded the national median income and none of them experienced capacity strain. IAD was the only high-earning AAC to add a runway. Of the six airports that did not expand even though they experienced strain, five were in AACs had an income at least $5,000 lower than the region. In total, ten of the fifteen airports that expanded had an income at least $5,000 lower than the region.
Regression Results

Although some of the three-way contingency tables seemed to indicate the potential for a relationship between population characteristics and expansion decisions, the regression models did not offer statistically significant evidence to support those indications. Numerous models were fit using only the capacity strain variable, or only one population variable at a time, or with both the strain variable and a population variable together. All models returned null findings for strain, race, ethnicity, nativity, and economic status variables. Consistently, the one- and two-variable models failed to fit better than an empty model. Additionally, the parameter statistics failed to reject the null hypothesis. A list of the tested binary variables is available in Table 4.7.

Conclusions

This chapter investigated environmental justice outcomes related to airport expansion after 2000. First, this research characterized residents in airport-adjacent communities using year 2000 data. In total, more than 5 million people lived near large- and medium-sized American hub airports. Evaluated individually, there is a pattern of high proportions and high concentrations of protected populations (race, ethnicity, nativity, income) in airport-adjacent communities. Ten of the fifty AACS had higher concentrations for persons of color, nativity, as well as poverty. Similar to the findings in Chapter 3 with the multi-airport region sample, this work shows evidence that there may be environmental justice conflicts between the beneficial economic impact area (metro) and the adverse environmental impact area (the AAC). More information is needed to understand the economic benefits of the environmental impact area to further understand the tradeoffs in residing near the airport. However, as Robert Bullard is careful to point out, all
persons “are entitled to equal protection of environmental and public health laws and regulations” and should not be forced to endure environmental blackmail due to their economic status (Bullard, 1996). More information is needed to qualitatively investigate the planning interventions deployed in AACs to ensure airport adjacent-residents have fair access to a healthy environment and equal protections under environmental law.

*Environmental justice: Interpreting null findings*

The main goal of the paper was to determine whether airports were more likely to expand if they were surrounded by historically marginalized communities. Using regression analysis, there did not appear to by a systematic or institutional pattern of adding runways at airports with high proportions or concentrations of persons of color, Black persons, Asian persons, Hispanic persons, or foreign-born persons. However, there is some concern regarding low-income populations since they consistently reside near almost all hub airports. The null findings from the regression model should not be interpreted as evidence that airports near communities with a higher incidence of persons of color are systematically avoiding expansion due to a higher incidence of persons of color. It is just as likely that these airports avoided expansion due to high nearby population density, as high proportions of persons of color are associated with AAC populations over 100,000.

Ultimately, this is only one method to scope and evaluate disproportionate impacts on airport-adjacent communities. For example, the regression model focused on expansion outcomes, not day-to-day operations outcomes. To evaluate environmental justice issues related to daily operations outcomes, the definition of the environmentally adverse area should be more specifically derived from noise contours and emissions
dispersion profiles. It is possible there is significant differentiation between populations inside and outside the noise contours and emissions profiles, such that environmental justice concerns are masked at the 5-km radial scale. Another way to scope this study could include an alternate definition of airport expansion. For example, airports may still significantly alter impacts through other forms of expansion such as land acquisition and displacement, airfield reconfiguration, revised flight procedures, or terminal expansion. Another alternative is to change the catchment area of the AAC to a smaller radius and see if results change across concentric rings of varying sizes.

In general, quantitative approaches for small samples have limitations. While the regression methodology was designed with small samples in mind, this work points to the significance in incorporating qualitative research design in environmental justice investigations. Mixed quantitative-qualitative assessments that are rooted in descriptive statistics may ultimately be more useful for detecting and rectifying environmental injustice. The subsequent chapter builds on this chapter's findings and employs a qualitative approach to investigate environmental justice outcomes in recent airport expansion.

_Justifying expansion: Delay vs Capacity strain_

In the course of evaluating airport expansion patterns in the United States, I found that actual capacity strain had little correlation with the decision to expand capacity. Often, the Federal Aviation Administration and airport owners make expansion decisions based on aircraft delays (Ryerson & Woodburn, 2014). The manner in which the value of time is injected into delay modeling has a direct effect on environmental decision-making, and arguably becomes a concern in environmental justice outcomes.
Conventional constructs regarding the ‘value of time’ result in a bias that frequently favors increased mobility. In current practice, travelers are considered to have static values of time disutility. Overemphasis on minimizing quantity of time, as opposed to quality of time, favors transport policies that center on infrastructure expansion. Givoni et al. (2013) noted an emerging recognition of time value heterogeneity; varying by mode, travel conditions, time spent in vehicle, and time spent waiting. They presented three central ideas concerning time value heterogeneity. First, is the idea of travel time budgets, where people are willing to travel an average of 60-70 minutes per day. They prefer to travel farther, faster, for the same period of time; not necessarily the same distance, faster, for a shorter period of time. Second, they discuss the idea of latent (or induced) demand for transport, where previously unmet demand is served by new infrastructure (or new trips are generated as a byproduct of new infrastructure). This indicates individual willingness to spend time traveling to previously inaccessible locations. A third idea relates to passengers’ travel time considerations, where travel is sometimes deemed a positive utility. Travel time can be utilized to conduct other activities en route, a phenomenon bolstered by the emergence of mobile technology. Given the positive utility of certain types of travel, mode and route choice is not always subject to time travel minimization. Travel options that include wireless Internet, workspace, and physical comfort offer a desirable ‘quality of time’: all of which are increasingly available in air travel. These three main ideas imply that “travel time is not empty and valueless: people use and experience it in all kinds of ways” (Givoni et al., 2013, p. 272). Consequently, planning methodologies that predominately use static values of time disutility (i.e. delay) to inform infrastructure decisions may ultimately be
exerting unjustifiable pressure for expansion, at the expense of the human and natural environment.

Current airport planning practices in aviation do not uncover these heterogeneous values of time. This oversight injects a bias for airport expansion during the cost-benefit analysis and during mode-choice modeling. While this chapter’s results do not support the assertion that there are systemic environmental justice conflicts related to airport expansion on the 21st century, there is still a substantial number of airports with high proportions and concentrations of groups protected under the Executive Order for environmental justice. A shift in the underlying value of time assumptions that inform airport decision-making may significantly alter the motivation for airport expansion and prevent airports from unnecessarily expanding into increasingly marginalized communities.
Figure 4.1 Map of 50-airport sample 49 airports are located in the continental US and 1 is located in Hawaii.
Figure 4.2 Adherence to 5km airport-adjacent community boundary This figure classifies the airport-adjacent community spatial analysis into four levels of boundary adherence. Level 1 adherence represents instances where the census block groups adhere the most to the AAC boundary and are most likely to accurately represent the population within the 5km radius.
Table 4.1 Aggregated population data for 2000. Data expressed as absolute count (Millions), followed by proportion (%).

<table>
<thead>
<tr>
<th>Demographic characteristic</th>
<th>Population within 5km of 50 airport sample</th>
<th>Population within 5km of 66 largest hub airports</th>
<th>Population in metro areas with hub airport</th>
<th>Population of United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population</td>
<td>4.7</td>
<td>5.4</td>
<td>156</td>
<td>281</td>
</tr>
<tr>
<td>White non-Hispanic</td>
<td>2.0</td>
<td>2.5</td>
<td>97</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td>42%</td>
<td>46%</td>
<td>62%</td>
<td>69%</td>
</tr>
<tr>
<td>Persons of Color</td>
<td>2.7</td>
<td>2.9</td>
<td>59</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>58%</td>
<td>54%</td>
<td>38%</td>
<td>31%</td>
</tr>
<tr>
<td>Black</td>
<td>0.79</td>
<td>0.84</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>16%</td>
<td>14%</td>
<td>13%</td>
</tr>
<tr>
<td>Asian</td>
<td>0.37</td>
<td>0.40</td>
<td>8.6</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>8%</td>
<td>8%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Native American Indian</td>
<td>0.03</td>
<td>0.04</td>
<td>0.9</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>0.6%</td>
<td>0.7%</td>
<td>0.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.4</td>
<td>1.5</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>30%</td>
<td>29%</td>
<td>16%</td>
<td>13%</td>
</tr>
<tr>
<td>Foreign born</td>
<td>1.4</td>
<td>1.5</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>30%</td>
<td>28%</td>
<td>16%</td>
<td>11%</td>
</tr>
<tr>
<td>Living in poverty</td>
<td>0.71</td>
<td>0.79</td>
<td>17</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>15%</td>
<td>15%</td>
<td>11%</td>
<td>12%</td>
</tr>
</tbody>
</table>
Figure 4.3 Boxplots for AAC population data The upper left plot contains boxplots for the concentration of the population group present in each AAC, with respect to the airport’s metro area. The reference lines represent the disproportionately high concentration (LQ>1.2) and low concentration (LQ<0.8). The upper right contains boxplots for the proportion of each population group within each AAC. The reference lines mark 10% and 20%. The lower left shows the weighted median household income for each AAC. The US median household income was $57,700 in 2000 (dashed line). For HHIncDiff, a difference of less than 0 indicates the AAC had a lower household income than its region. The reference lines mark ±$5,000.
Table 4.2 Two-way contingency table for expansion and capacity strain

The contingency tables show the variation in binary outcomes for expansion and capacity strain in the 50-airport sample.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 1098 hours at &gt;65% capacity used</td>
<td>No strain</td>
<td>13</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Strain</td>
<td>22</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>35</td>
<td>15</td>
<td>N=50</td>
</tr>
<tr>
<td>More than 1098 hours at &gt;75% capacity used</td>
<td>No strain</td>
<td>25</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Strain</td>
<td>10</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>35</td>
<td>15</td>
<td>N=50</td>
</tr>
<tr>
<td>More than 1098 hours at &gt;85% capacity used</td>
<td>No strain</td>
<td>29</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Strain</td>
<td>6</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>35</td>
<td>15</td>
<td>N=50</td>
</tr>
<tr>
<td>More than 1098 hours at &gt;90% capacity used</td>
<td>No strain</td>
<td>33</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Strain</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>35</td>
<td>15</td>
<td>N=50</td>
</tr>
</tbody>
</table>
Figure 4.4 Average daily capacity profile for the 50 airports (by hour) In this figure, the airports are ordered from most annual operations to fewest annual operations. The following airports have at least one average hourly peak ≥90%: ORD, ATL, LAX, PHX, STL, MSP, LAS, IAH, EWR, PHL, BOS, SEA, LGA, CVG, SAN. CLE, JFK. The following airports have a flat line near 90%: LAX, PHX, EWR, LGA, SAN, JFK.
Table 4.3 Three-way contingency table for expansion, capacity strain, and persons of color: The contingency tables show the variation in binary outcomes the 50-airport sample.

<table>
<thead>
<tr>
<th>New runway post-2000?</th>
<th>&gt;85% capacity used for &gt;1098 hours</th>
<th>Proportion</th>
<th>Frequency</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No strain</td>
<td>%POC ≤ 50</td>
<td>15</td>
<td>22 (%POC ≤ 50) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>No strain</td>
<td>%POC &gt; 50</td>
<td>14</td>
<td>17 (%POC &gt; 50) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>%POC ≤ 50</td>
<td>2</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>%POC &gt; 50</td>
<td>4</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>%POC ≤ 50</td>
<td>7</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>%POC &gt; 50</td>
<td>3</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>%POC ≤ 50</td>
<td>4</td>
<td>6 (%POC ≤ 50) &amp; (Strain)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>%POC &gt; 50</td>
<td>1</td>
<td>5 (%POC &gt; 50) &amp; (Strain)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New runway post-2000?</th>
<th>&gt;85% capacity used for &gt;1098 hours</th>
<th>Concentration</th>
<th>Frequency</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No strain</td>
<td>LQ ≤ 1.2 POC</td>
<td>15</td>
<td>20 (LQ ≤ 1.2) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>No strain</td>
<td>LQ &gt; 1.2 POC</td>
<td>14</td>
<td>19 (LQ &gt; 1.2) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>LQ ≤ 1.2 POC</td>
<td>2</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>LQ &gt; 1.2 POC</td>
<td>4</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>LQ ≤ 1.2 POC</td>
<td>5</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>LQ &gt; 1.2 POC</td>
<td>5</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>LQ ≤ 1.2 POC</td>
<td>1</td>
<td>3 (LQ ≤ 1.2) &amp; (Strain)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>LQ &gt; 1.2 POC</td>
<td>4</td>
<td>8 (LQ &gt; 1.2) &amp; (Strain)</td>
</tr>
</tbody>
</table>
Table 4.4 Three-way contingency table for expansion, capacity strain, and Hispanic persons The contingency tables show the variation in binary outcomes for expansion, capacity strain, and Hispanic persons in the 50-airport sample.

<table>
<thead>
<tr>
<th>New runway post-2000?</th>
<th>&gt;85% capacity used for &gt;1098 hours</th>
<th>Concentration</th>
<th>Frequency</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No strain</td>
<td>LQ ≤ 1.2 Hispanic</td>
<td>14</td>
<td>18 (LQ ≤ 1.2) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>No strain</td>
<td>LQ &gt; 1.2 Hispanic</td>
<td>15</td>
<td>21 (LQ &gt; 1.2) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>LQ ≤ 1.2 Hispanic</td>
<td>3</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>LQ &gt; 1.2 Hispanic</td>
<td>3</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>LQ ≤ 1.2 Hispanic</td>
<td>4</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>LQ &gt; 1.2 Hispanic</td>
<td>6</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>LQ ≤ 1.2 Hispanic</td>
<td>0</td>
<td>3 (LQ ≤ 1.2) &amp; (Strain)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>LQ &gt; 1.2 Hispanic</td>
<td>5</td>
<td>8 (LQ &gt; 1.2) &amp; (Strain)</td>
</tr>
</tbody>
</table>
Table 4.5 Three-way contingency table for expansion, capacity strain, and foreign-born persons

The contingency tables show the variation in binary outcomes for expansion, capacity strain, and foreign-born persons in the 50-airport sample.

<table>
<thead>
<tr>
<th>New runway post-2000?</th>
<th>&gt;85% capacity used for &gt;1098 hours</th>
<th>Concentration</th>
<th>Frequency</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No strain</td>
<td>LQ &lt; 1.2 Foreign-born</td>
<td>12</td>
<td>17 (LQ &lt; 1.2) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>No strain</td>
<td>LQ &gt; 1.2 Foreign-born</td>
<td>17</td>
<td>22 (LQ &gt; 1.2) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>LQ &lt; 1.2 Foreign-born</td>
<td>3</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>LQ &gt; 1.2 Foreign-born</td>
<td>3</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>LQ &lt; 1.2 Foreign-born</td>
<td>5</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>LQ &gt; 1.2 Foreign-born</td>
<td>5</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>LQ &lt; 1.2 Foreign-born</td>
<td>2</td>
<td>5 (LQ &lt; 1.2) &amp; (Strain)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>LQ &gt; 1.2 Foreign-born</td>
<td>3</td>
<td>6 (LQ &gt; 1.2) &amp; (Strain)</td>
</tr>
</tbody>
</table>
Table 4.6 Three-way contingency table for expansion, capacity strain, and weighted median household income

The contingency tables show the variation in binary outcomes for the 50-airport sample.

<table>
<thead>
<tr>
<th>New runway post-2000?</th>
<th>&gt;85% capacity used for &gt;1098 hours</th>
<th>HH Income</th>
<th>Frequency</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No strain</td>
<td>Inc ≥ $57,700</td>
<td>5</td>
<td>6 (Inc ≥ $57,700) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>No strain</td>
<td>Inc &lt; $57,700</td>
<td>24</td>
<td>33 (Inc &lt; $57,700) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>Inc ≥ $57,700</td>
<td>0</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>Inc &lt; $57,700</td>
<td>6</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>Inc ≥ $57,700</td>
<td>1</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>Inc &lt; $57,700</td>
<td>9</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>Inc ≥ $57,700</td>
<td>0</td>
<td>0 (Inc ≥ $57,700) &amp; (Strain)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>Inc &lt; $57,700</td>
<td>5</td>
<td>11 (Inc &lt; $57,700) &amp; (Strain)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New runway post-2000?</th>
<th>&gt;85% capacity used for &gt;1098 hours</th>
<th>Difference between AAC and MSA HH Income</th>
<th>Frequency</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No strain</td>
<td>Diff ≥ -$5,000</td>
<td>12</td>
<td>17 (Diff ≥ -$5,000) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>No strain</td>
<td>Diff &lt; -$5,000</td>
<td>17</td>
<td>22 (Diff &lt; -$5,000) &amp; (No strain)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>Diff ≥ -$5,000</td>
<td>1</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>No</td>
<td>Strain</td>
<td>Diff &lt; -$5,000</td>
<td>5</td>
<td>0 (If high strain, then expansion expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>Diff ≥ -$5,000</td>
<td>5</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>No strain</td>
<td>Diff &lt; -$5,000</td>
<td>5</td>
<td>0 (If no strain, then expansion not expected)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>Diff ≥ -$5,000</td>
<td>0</td>
<td>1 (Diff ≥ -$5,000) &amp; (Strain)</td>
</tr>
<tr>
<td>New runway</td>
<td>Strain</td>
<td>Diff &lt; -$5,000</td>
<td>5</td>
<td>10 (Diff &lt; -$5,000) &amp; (Strain)</td>
</tr>
</tbody>
</table>
Table 4.7 Variables tested in exact linear regression model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Format</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport expansion</td>
<td>New (additional) runway deployed after 2000</td>
<td>Binary</td>
<td>FAA Reports (ROD, AIP)</td>
</tr>
<tr>
<td></td>
<td>Hours airport spent operating at or above 85% airport capacity in year 2000</td>
<td>Binary</td>
<td>ASPM Airport Efficiency Database</td>
</tr>
<tr>
<td>Airport capacity strain</td>
<td>Persons of Color (POC); Hispanic (Hisp); Foreign-Born (FB); Median HH Income (HHInc)</td>
<td>Binary</td>
<td>Census data from NHGIS; Spatial analysis</td>
</tr>
<tr>
<td></td>
<td>- POC &gt; 31%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- POC &gt; 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- POC LQ &gt; 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Hisp &gt; 12%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Hisp LQ &gt; 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- FB &gt; 12%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- FB LQ &gt; 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HHInc &lt; $57,700</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HHInc &lt; $43,300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HHInc_{AAC} - HHInc_{metro} ≤ $5,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 5: Environmental Justice in the NEPA Process

Introduction

The third and final research question in this dissertation investigates how airport-adjacent communities are represented in the planning process, specifically the NEPA process. Due to stipulations in the National Environmental Policy Act of 1969 (NEPA), nearly all airport capacity expansion projects require an Environmental Impact Statement (EIS) and Record of Decision (ROD). Collectively, this is called the “NEPA Process” documentation. As a consequence of Executive Order 12898 (“Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations”), environmental justice became one of many environmental impacts that must be quantified and documented in the EIS and ROD. In this research, I ask: How did the Federal Aviation Administration and airport owners frame and evaluate environmental justice in the NEPA planning process for the airport expansion projects?

This chapter also serves as a follow-up to the quantitative approach to environmental justice presented in Chapter 4. I now employ a mixed-methods approach and reflect on environmental justice in planning practice. Specifically, I used a qualitative method of document review to investigate how the Federal Aviation Administration (FAA) and airport owners framed and evaluated environmental justice in the NEPA process for airport capacity projects post-2000. I looked specifically at the methods used to operationalize environmental justice impacts in practice. Then, I compared the NEPA results to the environmental justice results from Chapter 4. Finally, I consider the influence that such documentation of impacts had on the overall expansion planning
process. Ultimately, this research question probes into airport planning practice to see how airport-adjacent communities are considered through the lens of environmental justice.

The remainder of this chapter is organized into the following sections: background, methodology, results, and discussion. The background section reviews the NEPA process. The methodology section explains the qualitative document review, discussing the document sample and factors for consideration. The methodology also discusses the mixed-method approach to qualitatively conceptualize airport capacity strain and environmental justice based on the quantitative results of Chapter 4. The results section highlights the key methodological decisions used to frame environmental justice in the NEPA process and summarizes which airport projects detected environmental justice issues. The discussion section compares and contrasts the results of my Chapter 4 findings with the findings in the NEPA analyses.

**Overview of NEPA**

**History and Founders**

NEPA is the keystone piece of environmental assessment legislation in the United States and became law on January 1, 1970. This national policy mandates environmental review of all proposed federal actions significantly affecting the quality of the environment. Since nearly all highway, rail, and airfield actions involve federal funding, the NEPA process plays a dominant role in transportation planning. While the text of the NEPA legislation is quite short; the NEPA process itself requires volumes of paperwork. The Environmental Impact Statement (EIS) document is regarded as the
procedural component of the NEPA process. The EIS documents the extent of environmental impacts of a proposed project and compares the proposed project to various alternatives. In contrast to the procedural component, the substantive component of the NEPA legislation is, more or less, a statement of values to “encourage productive and enjoyable harmony between man and his environment” (National Environmental Policy Act, 1970).

Within the historical literature, one significant conversation revolves around legislative intent. Senator Henry Jackson of Washington, Senator Edmund Muskie of Maine, and Professor Lynton Caldwell are widely regarded as the NEPA architects. In developing federal environmental policy, the NEPA founders viewed the federal government as the ultimate agent of national public interest. Caldwell recognized the need to consider how public agency tasks bear upon the environment, noting that “concern for the environment is the business of almost no one in our public life” (Caldwell, 1963). Yet, the spirit of this intent is widely believed to have diminished in practice over time. Three monographs by critical proponents of NEPA assert that the environmental impact analysis has improved planning process and outcomes, but acknowledge the deterioration of the original spirit of the legislation (Caldwell, 1998; Greenberg, 2012; Lindstrom and Smith, 2001). As stated by Lindstrom & Smith:

"Originally, NEPA not only mandated a more inclusive and comprehensive planning design but also required federal projects to be developed within the environmental goals of section 101. This was the intention and philosophy of NEPA. What it is today, at least as implemented, is something else - side-stepped by agencies, courts, and presidents.” (Lindstrom & Smith, 2001, p.52)
Since environmental justice is one of the most recent additions to the NEPA procedural requirement, it is not yet clear whether NEPA’s environmental justice analysis can be characterized as just another unavailing checkbox within the bureaucratic doldrums.

**NEPA Process**

All federal actions, which includes federally funded airport projects, require an environmental impact analysis through the NEPA process. In this process, the lead federal agency must explain their purpose and need, essentially describing the current problem and what outcomes they expect to achieve. Then, the agency offers a proposed action that would presumably solve the problem. In the aviation context, the proposed action could be a new runway, an airfield reconfiguration, a runway extension, new terminals, etc. The lead federal agency must also investigate alternatives to the proposed action. This could include alternatives where the runway is configured in slightly different directions, it could include other transportation modes, or even policy interventions. Finally, the lead agency must consider a no-build (or ‘no action’) scenario. With these scenarios in mind (proposed action, alternatives, and no-build), the lead agency prepares an Environmental Impact Statement (called an EIS) that details the expected environmental impacts of the different scenarios.

All EIS documents must include the following key content: a discussion of the purpose and need for the action, a description of the proposed action and alternatives to the proposed action, analysis of the affected environment and environmental consequences, and mitigation measures. A preferred alternative is recommended by the lead agency only after environmental impacts of all feasible alternatives have been considered and properly documented. At the end of the NEPA process and after comparing all
alternative scenarios, the lead agency publishes a Record of Decision (called an ROD). The ROD identifies the final, preferred alternative and functions as an approval from the lead agency, allowing the airport owner to move forward with the project. There are a few steps between publishing the ROD and beginning construction, but an airport owner cannot break ground on a construction project without an ROD from the FAA.

*Judicial Review*

Although NEPA is an act of the legislature, NEPA is further supplemented by case law that interprets the procedural and substantive components in NEPA. NEPA is controversial in judicial review because it contains a broad statement about values and ethics. Lindstrom and Smith (2001) suggest the broad framing was intentional on the part of NEPA's founders, citing that statutory ambiguity increases discretionary power of the administrators and agencies charged with implementing regulations.

Historically, judicial review reinforces the significance of NEPA's procedural 'EIS' component, often to the detriment of the more substantive values framed in NEPA legislation. There is a vast array of legal literature to debate the outcomes of procedural and substantive NEPA rulings in the courts (for example, see Andreen, 1989; Bartlett, 2000; Blumm, 1990; Hartmann, 1994; Karkainen, 2002; Karkainen, 2004; Lindstrom & Smith, 2001; Murchison, 1984; Yost, 1990). Overall, judicial review is an efficient tactic to ensure compliance with NEPA procedures, yet in practice lacks enforcement of NEPA's substantive environmental values.

There are ample examples of airport-related EIS litigation that highlights the disconnect between procedural and substantive NEPA. The FAA fulfills a supervisory role in the
preparation of airport EISs, which involves coordination and communication across multiple government agencies as well as the general public. The EIS documentation may be used in court in the event that the airport project is contested. Consequently, the FAA has made it a priority to exhaustively list the expected impacts of the project in the FEIS, else the whole project could be delayed on ‘procedural’ grounds. In the case of airport infrastructure, it is clear that the drive for ‘procedural’ efficiency has been pursued at the expense of meeting the ‘spirit’ of the NEPA legislation (Ryerson and Woodburn, 2014).

Multiple aviation projects have been the center of litigation concerning purpose and need and alternatives analysis. For example, Toledo Express Airport was proposed as the new hub airport for Burlington Air Express, Inc in 1989. The resulting court case Citizens Against Burlington, Inc v Busey affirmed that, in order for an alternative to the proposed action to be considered reasonable and prudent, the alternative must achieve the proposed action’s objectives as stated in the purpose and need. This becomes problematic when the FAA frames the purpose and need to explicitly require the airport sponsor to build another runway. An explicit purpose and need that essentially has a foregone conclusion favoring capacity expansion will prevent less intrusive alternatives from being evaluated in the EIS even if the alternative could functionally improve operations at the airport. The EIS alternatives analysis for the runway development at Lambert-St Louis International Airport (STL) in the late 1990s was contested in the eighth circuit court case, City of Bridgeton v FAA, in 2000. The court reviewed whether the FAA had “properly excluded detailed explanations of unreasonable alternatives” (Angel, 2002). The court upheld FAA’s exclusion of alternative Ne-1a because the alternative would not have explicitly increased simultaneous arrival capacity in bad
weather as required by the purpose and need. Even though the alternative would have offered a certain level of capacity enhancement and delay reduction without requiring any community displacement, the less adverse impact went unexplored in the environmental analysis because it did not meet the full extent of the proposal’s purpose and need.

In a comprehensive review of airport expansion case law, Wyatt (2011) finds that legal challenges to the adequacy of alternatives discussion “appears to be an especially ineffective tactic”. Expansion efforts at Oakland Airport were the only noted litigation exception, where courts ruled that there was in inadequate consideration of alternatives. In short, judicial review generally supports agency discretion in crafting the purpose and need statement, which directly influences which alternatives are retained for full environmental impact analysis. Purpose and need statements can therefore fall along a continuum from broad – allowing for a full range of alternatives – to narrow, rendering otherwise plausible alternatives infeasible and undermining the spirit of NEPA analysis.

**Methodology**

As explained in the previous section, NEPA documentation is significant in its detailed project scope, history of judicial review, and potential for policy transformation. However, it is also the subject of scholarly conversation questioning its usefulness for (1) informing infrastructure decisions, and (2) generating optimal outcomes for the human and natural environment. This research narrows in on one aspect of the NEPA process’ EIS/ROD documentation. Specifically, I look at how the Federal Aviation Administration and airport owners framed and evaluated environmental justice in the planning process for airport expansion projects.
The overall methodological approach uses mixed-methods. First, I reflected on the data analysis results from Chapter 4. Although Chapter 4 did not generate results that suggest a pattern of expansion exclusively (or more frequently) at airports near marginalized groups, it is still possible that environmental injustice exists on a case-by-case basis. I reorganized the data to generate my baseline level of ‘environmental justice concern’, where I consider how many protected populations are disproportionately represented in the AAC. The baseline serves as the expected outcome of the NEPA process: when I detect a high level of environmental justice concern, I expect that the NEPA documentation to have also detected an environmental justice impact from the proposed expansion project. In addition to the level of environmental justice concern, I also generate the level of airport strain to contextualize the operations status of the airport.

Second, I used document review to contextualize how the FAA and airport owners framed and analyzed environmental justice within the planning documents. This document review is more of a critique of the methods employed in the NEPA process, and less of a critique of language and rhetoric in the NEPA process. In my review of the documents, I first analyzed the overview of environmental justice issues presented in the Record of Decision (ROD). The ROD functions as a standardized summary of whether the airport project was found to have significant environmental impacts and outlines any mitigation intended to curb those impacts. All projects contain at least a brief mention or short section on environmental justice, as required by law. However, some RODs include great detail through which I can identify trends in methodological choices related to the comparison geography, population groups of interest, and impacts of interest to
environmental justice. For instances where the ROD documentation is vague, I turn to EIS documentation to fill in the gaps.

**NEPA Document Sample**

Environmental Impact Statements (EIS) and Records of Decision (ROD) documentation are a result of the federal NEPA process. In an airport context, the EIS and ROD are key planning documents prepared specifically to evaluate and disclose environmental tradeoffs of airport development to the public. Specifically, the NEPA documents evaluate and summarize the environmental impacts of a proposed action and compare them to the impacts of feasible alternative actions. I chose to use the EIS and ROD over other forms of documentation because they are critical documents required across all airport projects, they have a standardized expectation for alternatives analysis, and a highly detailed and analytical approach to documenting environmental impacts. The environmental justice impact analysis is summarized to varying extents within the ROD documentation and listed in detail within the EIS documentation.

The document sample is derived from the 27 airport expansion projects at the 66 largest hubs at the turn of the 21st century. These 27 projects represent the complete set of available NEPA documents. Eight of the 27 NEPA documents were excluded from analysis: two did not have corresponding data to derive airport strain (CMH, PVD), four were airport access projects for transit or roadways (DFW, HNL, LGA, and OAK), and two involved projects where the NEPA process was completed prior to the Executive Order on Environmental Justice (DTW, MCO). The other nineteen NEPA documents were retained for analysis: fourteen were airport projects for an additional runway (ATL, BOS, CLE, CLT, CVG, FLL, IAD, IAH, MIA, MSP, ORD, PHL, SEA, and STL), while five
were other types of airport expansion projects such as runway extensions and terminals (IND, LAX, PDX, PHX, and SJC).

In performing the document review, the goal was to characterize how the FAA and airport owner framed the environmental justice analysis and the frequency that they detected environmental justice impacts. Thus, I screened the EIS and ROD for the following information related to the framing of environmental justice analysis: comparison geography, population groups of interest, and impacts of interest. I screened the documents for the following information related to the detection of environmental justice impacts: environmental justice conclusion and mitigation strategies.

*Operations context: Levels of ‘Airport Capacity Strain’*

The ‘Airport Capacity Strain’ metric was designed to provide insight as to whether the expansion was justified from an operations perspective. As defined in Chapter 4, capacity strain is based on the amount of time the airport spent operating at a high percent of available capacity in the year 2000. While Chapter 4 focused only on the 85% ‘capacity used’ threshold, this Chapter considered three thresholds (Low, Medium, and High). ‘Low’ is defined as at least 1098 hours (~3hrs/day) of 65% capacity strain, ‘medium’ as at least 1098 hours of 75% capacity strain, and ‘high’ as at least 1098 hours of 85% capacity strain. Across the nineteen airports in the sample, one airport exhibited no strain, six airports exhibited low strain, three airports exhibited medium strain, and nine airports exhibited high strain.
Environmental justice criterion: Levels of ‘Environmental Justice Concern’

I designed the ‘Environmental Justice Concern’ metric to identify the extent that each AAC contained populations protected under the Executive Order for Environmental Justice. The protected populations include persons of color, foreign-born persons, and low-income persons. I devised two assignment methods, each using either proportion or concentration metrics, to assign the level of ‘Environmental Justice Concern’ for each AAC. Chapter 4 outlined the methods used to calculate the AAC characteristics for year 2000 in terms of proportion (aggregated across block groups in each airport-adjacent community) and concentration (location quotients that measure characteristics of each airport-adjacent community in the context of its metropolitan area).

The first method used metrics of proportion to identify the overall prevalence of the protected populations in the AAC. The metrics of proportion include percent of persons of color (the inverse of white non-Hispanic), percent of foreign-born persons, and difference between the weighted median household income in the AAC and in the region. The second method used metrics of concentration to identify whether the prevalence of protected populations were representative of the region. The metrics of concentration include the location quotient for persons of color, Black persons, Asian persons, Hispanic persons, foreign-born persons, and the poverty rate.

For the first method (proportion), I grouped all 50 AACs from Chapter 4 according to different combinations of the three characteristics: whether the AAC was a majority persons of color, more than a third foreign-born persons, and/or more than $10K poorer than its metro area. For the second method (concentration), I grouped the AACs according to their location quotients: whether the AAC had twice the concentration of
persons of color, Black persons, Asian persons, Hispanic persons, foreign-born persons and/or persons in poverty. Table 5.1 summarizes the variables used in each method and denotes the significance threshold (i.e. proposition) for each variable.

For both methods, I grouped AACs into one of six groups: A, B, C, D, E, or F. Each group reflects a different mix of protected populations: persons of color, foreign-born persons, and low-income persons. Group A includes AACs that did not meet any of the significance thresholds for the protected population groups, so there is not a strong indication for environmental justice concern. Group B includes AACs that only met the significance threshold for one of the population groups, indicating low environmental justice concern. Groups C, D, and E include AACs that met the significance threshold for two of the population groups, indicating medium environmental justice concern. Group F includes AACs that met the significance threshold for all three of the population groups (persons of color, foreign-born persons, and low household income), indicating high environmental justice concern. The number of AACs in each group, as determined separately by Method 1 (proportion) and Method 2 (concentration), are listed in Table 5.1. After all the AACs were grouped according to Method 1 and Method 2, I cross-examined the group membership. I consolidated the results to determine the final level of environmental justice concern (high, medium, low) for each AAC. Table 5.2 shows the details of cross-examination.
Results

Baseline environmental justice criterion and operations context

In order to evaluate the framing of environmental justice in NEPA as well as NEPA’s ability to detect environmental justice, I need a baseline expectation for comparison. The concept map (see Figure 5.1) visualizes the level of capacity strain at the airport and the level of environmental justice (EJ) concern in the airport-adjacent community. From this figure, AACs with a higher level of EJ concern create the highest expectation that NEPA analysis will detect some form of environmental injustice.

In Figure 5.1, both the level of capacity strain and the level of EJ concern are ranked on a Low-High scale. The levels of capacity strain reflect airport operations at 65%, 75%, and 85% capacity. The levels of EJ concern represent the presence of protected populations in the AAC. ‘Low’ EJ concern represents AACs that only met the significance threshold for one of the population groups, ‘moderate’ represents AACs that only met the significance threshold for two of the population groups, and ‘high’ represents AACs that met the significance threshold for all three population groups. For example, Chicago O’Hare (ORD) ranked as ‘low’ because the AAC is more than a third foreign-born residents and has at least twice the concentration of foreign-born residents as the metro area, however it does not have a high proportion or concentration of minority or low-income populations.

As shown in Figure 5.1, the capacity strain level exceeded the EJ concern level for most airports, indicating there was frequently reasonable cause to initiate a project near the protected populations. Overall, fifteen of the nineteen airport projects ranked as less
than ‘moderate’, showing that the population characteristics in most AACs did not cause EJ concern for more than one protected population group. Across those same fifteen AACs, their airports’ capacity strain was distributed across the strain spectrum.

Three of the nineteen airports ranked as ‘moderate’ to ‘high’ EJ concern: Charlotte (CLT), Atlanta (ATL), and Phoenix (PHX). Table 5.3 summarizes the AAC characteristics of these three airports ranked with the highest EJ concern. The AAC characteristics were derived as calculated in Chapter 4 and qualitatively grouped according to the preceding Methodology section. ATL and CLT ranked as ‘moderate’ EJ concern because their AACs had a large proportion and concentration of persons of color and low-income persons. PHX ranked as ‘high’ EJ concern because the AAC had a high proportion and concentration of persons of color, foreign-born, and low-income residents. Of the three airports with significant EJ concern, only CLT did not exhibit any capacity strain in year 2000 (i.e. all operating hours were below 65% capacity used). The other two airports each spent a significant portion of the year operating at more than 85% capacity. Using this dissertation’s methodology for detecting environmental justice problems, these three AACs present the most obvious cause for EJ concern: ATL, CLT, and PHX. I reflect on these critical cases during the final discussion, where the results of NEPA’s environmental justice analysis are compared to the results of this dissertation’s environmental justice analysis.

*Framing of environmental justice in NEPA process*

Within the NEPA documentation, the EJ analysis is framed according to a few key methodological choices. In this section, I identify trends in methodological choices
related to the comparison geography, population groups of interest, and impacts of interest. A summary of these trends is available in Table 5.4.

In the NEPA process, the impacts of interest for EJ analysis are defined as the environmental impacts that were deemed significant elsewhere in the EIS, Thus, those impacts are subsequently subject to review for potential environmental justice concerns. The most common significant impacts listed in the airport NEPA documents include noise due to aircraft operations and displacement due to land acquisition. In the case of PDX and IAD, there were no significant impacts affecting residential areas, so there was no in-depth review of environmental justice concerns. In the case of ATL, construction was an additional impact category under environmental justice review. FLL and LAX both contained a longer list of significant impacts beyond the typical noise and displacement impacts. Three RODs (FLL, ORD, and PHX) incorporated an additional discussion of impacts on children’s environmental health and socioeconomic impacts alongside the environmental justice discussion.

The significant impacts analysis generates the area of significant impact. However, since environmental justice is essentially a comparative analysis of proportions between at least two geographic areas, EJ analysis requires an additional comparison geography. As a standard approach, the FAA compares the demographics within the area of ‘significant impacts’ to the demographics in a larger comparison geography. All the documents reviewed in this research aggregated the demographics either by census tract or census block group. As stated previously, the typical ‘significant impacts’ related to airport projects includes noise and displacement. Thus, the ‘significant impact’ area is often the 65+ DNL contour (eg. BOS), the 3 dB increase contour (eg. CLT), or the land
acquisition area (eg. STL). With respect to the comparison geography, the FAA frequently compared the area of ‘significant impact’ to the general ‘project area’ (or ‘airport environs’). For at least ten airport projects, the persons experiencing the most significant environmental impacts of airport development were essentially compared to persons who are still near enough to experience moderate environmental impacts. For example, in the case of ORD, the comparison geography encompassed an area that was within 2-12 miles of the centerpoint of the airfield. In contrast, five airport projects used the county or metro area as the demographics comparison geography: Atlanta (ATL), Houston (IAH), Philadelphia (PHL), Fort Lauderdale (FLL), and Los Angeles (LAX).

With respect to the population groups of interest, all the NEPA documents discussed minority (by race and ethnicity) and low-income groups. Foreign-born persons were not directly addressed within the analysis at any airport, unless as a note regarding Spanish-speaking Hispanic persons. In addition, all the analyses used the most recently available census data to evaluate the demographics that would experience the most adverse impacts. For example, the analysts used population data for 1990 or 2000 to determine whether there would be a large presence of protected populations within the future 65+ noise contours (which would be perhaps 10 years in the future).

While the spatial comparison geography plays a role in deciding whether there are adverse effects to environmental justice, so does the definition of the ‘disproportionate population’ significance threshold. Across the NEPA documents, there was some variation on how to define whether minority and low-income groups were disproportionately represented. CEQ guidance and the text of the Executive Order
12898 defined low-income persons as those in poverty (as defined in the census, by household size) and minority persons as non-white and Hispanic persons. While most NEPA documents referred to these definitions, at least two of the analyses opted for a slightly different definition for low-income persons. For example, ORD included a more generous description of low-income persons, defining low-income as 150% of poverty to account for the increased cost of living in Chicago. While this is not an explicit use of the region as a comparison geography, the cutoff point reflects a regional standard for low-income persons. STL used $20,000 as the household income threshold for determining low-income persons because “it was the lowest income range contained within the Census database used throughout this study.” Although not as generous as ORD, STL’s cutoff point was still more generous than the national poverty level (FAA, 1996, p.5-47).

The text of the Executive Order also suggests vague methods to identify minority and low-income communities, stating that minority communities are geographic areas where “(a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.” Similarly, the low-income communities are “either a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect” (Clinton, 1994). PHL opted to use the ‘disproportionate’ thresholds set by their local metropolitan planning organization, the Delaware Valley Regional Planning Commission, instead of those defined in the Executive Order. PHL thresholds for populations of interest were evaluated at the census block group level and “any census block with greater than 24 percent minorities
would be considered a minority community; any census block with greater than 5 percent Hispanic population would be considered a Hispanic community; and any census block group with greater than 11 percent low-income persons would be considered a low-income community” (FAA, 2010a, p 5-77). Similar to PHL, ATL used a more generous threshold for protected populations: “census tracts that had minority or low-income populations exceeding either the state or three-county totals by 20 percent were identified as being potential environmental justice areas” (FAA, 2001c, p 14).

Indianapolis (IND) had a more broad-brush discussion of low-income representation, stating that the entirety of the airport environment was not low-income because the “median household income is $33,842, well above the national poverty level of $15,000” (FAA, 2001b, p.12). It is not clear if they required the entire airport environment to have a median household income below the national poverty level in order to derive significance.

Detecting environmental injustice in NEPA process

Across the nineteen airport projects, eighteen RODs stated that there were no significant environmental justice impacts. Two additional RODs had the caveat that there was a significant environmental justice impact, but it was cancelled out by the proposed mitigation activities. Only one of the airport projects, ATL, explicitly stated that there were significant impacts to environmental justice in the ROD documentation. They found the impact area to be 67% minority and 25% low-income across the 40,000-person population area. Given the county-based comparison, these percentages were considered significant enough to warrant disproportionate representation of minority and low-income communities. LAX and ORD, which both found significant impacts to
environmental justice in the EIS documentation, reframed the finding in the ROD. After including their proposed mitigation strategies, the airport owners and FAA claimed there was no net environmental justice impact.

At least two of the airport projects included statements that indicate no environmental justice impact simply because the impacts are not worse than the “do nothing” scenario. Both MSP and CLE claimed that there is no significant environmental justice impact since the forecasted impacts of the proposed project are not worse than the forecasted impact of the no action alternative: “No disproportionate effects on low-income or minority households were determined to exist when compared to the No Action Alternative” (FAA, 1998b, p. 33). However, CLE, which used similar language to MSP, had a Section Eight housing complex within the most adverse noise contours. The CLE analysis concluded that “the Cleveland Metropolitan Housing Authority Section Eight housing complex would continue to be impacted by noise in the 70-75 DNL and 65-70 DNL under the 2006 and 2016 No-Build/No-Action Alternatives”, so there was no significant impact if the project caused a similar adverse impact (FAA, 2000a, p. 5.3-12).

The documentation in at least two airport projects, for PHX and CLT, found large proportions of protected populations in the significant impact area, but concluded the impacts were proportional. For example, CLT’s documentation stated “while the project directly impacts minority populations and low-income households, the minority and low-income impacts are not disproportionate in comparison to the general population of the airport environment…Therefore the Proposed Federal Action will not result in environmental justice impacts and will not require additional mitigation” (FAA, 2000c, p. 22). PHX relied on a similar methodological decision, where the comparison geography
is essentially an area where impacts are already felt, but not necessarily the most adverse impacts: the comparison area “encompasses the area where social and environmental justice conditions could potentially be influenced as a result of the proposed project” (FAA, 2005a, p 3-20). The comparison geography for PHX ultimately included 24 census tracts near the airport, which contained 59% minority population and had a 38% poverty rate. Since the “racial mix of the acquisition area is consistent with that of the surrounding community”, the analysis concluded that there were no environmental justice impacts. Similarly, since CLT also had either a similar or smaller proportion of protected populations than found in the immediate airport environment, the NEPA process documentation did not report significant environmental justice impacts.

**Discussion: See the forest for the trees**

Using this dissertation’s methodology for detecting environmental justice problems, three AACs presented the most obvious cause for EJ concern: ATL, CLT, and PHX. However, the NEPA analysis only detected and mitigated environmental justice impacts in the case of ATL. The NEPA analysis for both CLT and PHX confirmed that there were large populations of minority groups and low-income individuals, but the ‘airport environs’ comparison geography gave the illusion that the impacts fell on a proportionate mix of those groups. The ‘airport environs’, as a comparative geography, essentially prevents the FAA from seeing the forest for the trees. The FAA successfully detected the large percentages within the ‘airport environs’, but failed to acknowledge that the ‘airport environs’ held a disproportionate and unusually high share of low-income and minority communities when compared to the rest of the metro area. The fact that ATL used county-level data as a comparison geography is a primary reason that the environmental
justice impacts were detected and mitigated in ATL’s NEPA analysis. Of the three airport projects where EJ impacts were detected in the NEPA analysis, all three used the county as a comparison geography and/or used a regionally-based benchmark to identify and compare protected populations near the airport (ATL, LAX, and ORD).

While the Executive Order has vague recommendations for how exactly to operationalize environmental justice, there seems to be clear evidence from practice that the county level data is an appropriate unit of geographic analysis. Projects that used the county data instead of ‘airport environs’ are more likely to live up to the spirit of NEPA and the Executive Order. The Executive Order grants freedom to federal agencies to select the unit of geographic analysis, but states the unit that is chosen should not “artificially dilute or inflate the affected minority population.” Across 50 of the largest hub airports in the US in year 2000, PHX had the most significant population of protected persons (jointly considering proportion and concentration) and CLT was in the top six. I argue that any NEPA conclusion that dismisses the large population of protected persons in these ‘significant impact’ areas, simply because there is a large population of protected persons in the ‘airport environs’ is antithetical to the purpose of environmental justice investigations and an artificial dilution of the minority and low-income populations.

The goal of environmental justice checks and balances cannot be distilled to comparisons of “those who are in a noise contour” vs “those who might have been in a noise contour.” First, noise contours are best-guess forecasts of how the airport expects air traffic to be distributed after expansion. It is possible that noise contours would manifest differently than forecasted in the NEPA process. Second, there is considerable discussion in the academic community regarding the validity of the 65+ DNL as the best
metric to fully capture adverse impacts. By choosing the ‘airport environs’ as a
comparison geography, it is still likely that portions of the ‘airport environs’ are
experiencing adverse effects, but they simply do not register at the strict significance
threshold requirements for NEPA analysis. The more fitting comparison is between
“those whose environment is likely degraded by the future airport activity” vs “those who
are most likely to gain from the future airport activity.” If there are considerable minority
and low-income groups near the airport than in the region, it should raise environmental
justice concern, not diminish it.

If environmental justice is not detected in the NEPA analysis as a significant impact, the
consequence is that it is more difficult to work towards reconciliation. Mitigation
strategies can only be proposed and executed to rectify a significant impact. As seen in
the case of LAX, ORD, and ATL, the county comparisons led to environmental justice
mitigation. Most mitigation plans incorporate relocation assistance and noise abatement
plans that exceed normal federal standards. In the case of LAX, more unusual mitigation
measures were included, such as a mobile health clinic, a nature center, a job outreach
center, an aviation academy. These ‘good neighbor’ efforts help to reconcile
environmental justice impacts, but it is not clear that those interventions are meaningful
enough to cancel out the total environmental justice impact. Nor is it clear the extent that
federal agencies are legally obligated to follow-through on mitigation promises in the
NEPA process. However, since the NEPA process thus far has a poor record of
detecting environmental justice concerns, there are not many mitigation case studies to
investigate to understand if they were successfully implemented with meaningful effect.
Chapter 5 Tables and Figures

Table 5.1 Two methodologies to determine the level of environmental justice concern for the 50 AACs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Proposition</th>
<th>Proposition Groupings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proposition</td>
<td>A</td>
</tr>
<tr>
<td><strong>Method 1, Proportion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Persons of Color</td>
<td>&gt;50%</td>
<td>~</td>
</tr>
<tr>
<td>% Foreign-born Persons</td>
<td>&gt;33%</td>
<td>~</td>
</tr>
<tr>
<td>Income_{AAC} – Income_{MSA}</td>
<td>&lt; -$10,000</td>
<td>~</td>
</tr>
<tr>
<td><strong>AAC Count</strong></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td><strong>Method 2, Concentration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LQ Persons of Color</td>
<td>&gt;2</td>
<td>~</td>
</tr>
<tr>
<td>LQ Black Persons</td>
<td>&gt;2</td>
<td>~</td>
</tr>
<tr>
<td>LQ Asian Persons</td>
<td>&gt;2</td>
<td>~</td>
</tr>
<tr>
<td>LQ Hispanic Persons</td>
<td>&gt;2</td>
<td>~</td>
</tr>
<tr>
<td>LQ Foreign-born Persons</td>
<td>&gt;2</td>
<td>~</td>
</tr>
<tr>
<td>LQ Poverty Rate</td>
<td>&gt;2</td>
<td>~</td>
</tr>
<tr>
<td><strong>AAC Count</strong></td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

~ = All propositions are false (logical nor)
v = Only one proposition is true (exclusive disjunction)
v = At least one proposition is true (logical disjunction)
& = All propositions are true (logical conjunction)
Table 5.2 Results for level of environmental justice concern

Consolidated results of Method 1 and 2 to determine the level of environmental justice concern for 50 AACs.

<table>
<thead>
<tr>
<th>Environmental justice concern</th>
<th>Method 1 (Percentage)</th>
<th>Method 2 (Concentration)</th>
<th>Consolidate methods 1 and 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>None</strong>&lt;br&gt;0 Protected populations (Group A in Table 5.1)</td>
<td>BDL, BNA, BWI, CLE, CVG, DFW, FLL, IAD, IND, LAS, MCI, MCO, MSP, MSY, PDX, PIT, RDU, SAN, SAT, SEA, SFO, STL</td>
<td>BDL, BUR, BWI, CLE, CVG, DFW, DTW, FLL, HOU, IAH, IND, LAS, LAX, MCI, MCO, MSP, ONT, PHL, PIT, RDU, SAN, SAT, SFO, SJC, STL</td>
<td>None: BDL, BWI, CLE, CVG, DFW, FLL, IND, LAS, MCI, MCO, MSP, PIT, RDU, SAN, SAT, SFO, STL&lt;br&gt;Low/: None: DTW, IAH, LAX, MSY, ONT, PDX, PHL, SEA</td>
</tr>
<tr>
<td><strong>Low</strong>&lt;br&gt;1 Protected population (Group B in Table 5.1)</td>
<td>Foreign-born only: ORD&lt;br&gt;Persons of color only: HNL, IAH, JFK, LAX, ONT, TPA&lt;br&gt;HHIncDiff only: BOS, DTW, PBI, PHL, SDF</td>
<td>Foreign-born only: ORD&lt;br&gt;Race only: ABQ, EWR, HNL, JFK, MEM, OAK, PDX&lt;br&gt;Hispanic only: MDW, MIA, MSY, PBI, SEA&lt;br&gt;Poverty only: DCA</td>
<td>Low: BNA, HNL, HOU, IAD, JFK, ORD, PBI, SJC&lt;br&gt;<strong>Moderate/: Low</strong>: ABQ, BOS, BUR, DCA, EWR, MDW, MEM, MIA, OAK, SDF, TPA</td>
</tr>
<tr>
<td><strong>Moderate</strong>&lt;br&gt;2 Protected populations (Groups C, D, and E in Table 5.1)</td>
<td>Persons of color and foreign-born: DAL, MIA, SJC&lt;br&gt;Foreign-born and income: (none)</td>
<td>Persons of color and foreign-born: BNA, BOS, DAL, IAD, LGA, SDF, TPA&lt;br&gt;Foreign-born and income: (none)</td>
<td>Moderate: ATL, CLT, DAL&lt;br&gt;High/Moderate: LGA, SLC</td>
</tr>
<tr>
<td><strong>High</strong>&lt;br&gt;3 Protected populations (Group F in Table 5.1)</td>
<td>BUR, LGA, PHX</td>
<td>PHX, SLC</td>
<td>High: PHX</td>
</tr>
</tbody>
</table>
Figure 5.1 Concept map of ‘environmental justice concern’ and ‘airport capacity strain’ In this figure, the sample includes all airports with a NEPA document for planned airport expansion of runways, terminals, and airfields completed after 1994.
Table 5.3 Characteristics of the three AACs with moderate to high level of environmental justice concern

<table>
<thead>
<tr>
<th>Variable</th>
<th>Atlanta (ATL)</th>
<th>Charlotte (CLT)</th>
<th>Phoenix (PHX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQ Concern Level</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Total Population</td>
<td>62,000</td>
<td>18,000</td>
<td>91,000</td>
</tr>
<tr>
<td>Minority</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons of color (%)</td>
<td>87%</td>
<td>63%</td>
<td>81%</td>
</tr>
<tr>
<td>Persons of color (LQ)</td>
<td>2.1</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Black persons (LQ)</td>
<td>2.5</td>
<td>2.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Asian persons (LQ)</td>
<td>0.9</td>
<td>2.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Hispanic persons (LQ)</td>
<td>1.43</td>
<td>1.3</td>
<td>2.6</td>
</tr>
<tr>
<td>National Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign-born persons (%)</td>
<td>12%</td>
<td>11%</td>
<td>39%</td>
</tr>
<tr>
<td>Foreign-born persons (LQ)</td>
<td>1.1</td>
<td>1.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Low-income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted median HH income</td>
<td>$32,000</td>
<td>$35,000</td>
<td>$26,000</td>
</tr>
<tr>
<td>Difference between AAC and MSA</td>
<td>-$24,000</td>
<td>-$14,000</td>
<td>-$22,000</td>
</tr>
<tr>
<td>weighted median HH income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons in poverty (%)</td>
<td>20%</td>
<td>19%</td>
<td>33%</td>
</tr>
<tr>
<td>Persons in poverty (LQ)</td>
<td>2.1</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>Airport</td>
<td>Publication Year (ROD)</td>
<td>Comparison Geography</td>
<td>Population Groups</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------</td>
<td>----------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>ATL</td>
<td>2001</td>
<td>State, county, project area</td>
<td>Race, ethnicity, &lt;$15K HH Income in 1990</td>
</tr>
<tr>
<td>BOS</td>
<td>2002</td>
<td>Project area</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>CLE</td>
<td>2000</td>
<td>Airport environs</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>CLT</td>
<td>2000</td>
<td>Immediate airport environment</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>CVG</td>
<td>2001</td>
<td>n/a</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>FLL</td>
<td>2011</td>
<td>County</td>
<td>Race, ethnicity, poverty</td>
</tr>
<tr>
<td>IAD</td>
<td>2005</td>
<td>[no residential impacts]</td>
<td>Minority, ethnic groups, low-income</td>
</tr>
<tr>
<td>IAH</td>
<td>2002</td>
<td>County, project area</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>IND</td>
<td>2001</td>
<td>Airport environment</td>
<td>Minority, &lt;$15K median HH Income</td>
</tr>
<tr>
<td>LAX</td>
<td>2005</td>
<td>County, airport environment</td>
<td>Minority, poverty</td>
</tr>
<tr>
<td>Jurisdiction</td>
<td>Year</td>
<td>Project Area</td>
<td>Most Likely to Have Impacts</td>
</tr>
<tr>
<td>--------------</td>
<td>------</td>
<td>--------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>MIA</td>
<td>1998</td>
<td>Project area</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>MSP</td>
<td>1998</td>
<td>Jurisdictions in project area</td>
<td>Minority, poverty</td>
</tr>
<tr>
<td>ORD</td>
<td>2005</td>
<td>Project area</td>
<td>Race, ethnicity, &lt;$30,768 HH income</td>
</tr>
<tr>
<td>PDX</td>
<td>2008 (FONSI)</td>
<td>[no residential impacts]</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>PHL</td>
<td>2010</td>
<td>General population, defined by DVRPC</td>
<td>Minority, low-income</td>
</tr>
<tr>
<td>PHX</td>
<td>2006</td>
<td>Project area</td>
<td>Minority, low-income, Native-American tribe</td>
</tr>
<tr>
<td>SEA</td>
<td>1997</td>
<td>n/a</td>
<td>Minority, age, and income groups</td>
</tr>
<tr>
<td>STL</td>
<td>1998</td>
<td>Municipalities in study area</td>
<td>Minority, &lt;$20K household income</td>
</tr>
<tr>
<td>SJC</td>
<td>1999</td>
<td>n/a</td>
<td>Minority, low-income</td>
</tr>
</tbody>
</table>
CHAPTER 6 Conclusions and Policy Implications

Introduction

Functioning as the nexus of global and local economies, airports have emerged as a critical piece of transportation infrastructure in global cities. The experimental era of the early aviators, which coincided with the dawn of urban planning at the start of the 20th century, has given way to a commercial era of mass global transportation, which now coincides with unprecedented levels of dense, urban settlement at the start of the 21st century. Around the globe, airports are faced with an increasing level of pushback tension. Airport owners who seek sustainable and just development must reconsider how they manage airport infrastructure in the context of air transportation demand and in the context of airport-adjacent community impacts.

The previous four chapters investigated the relationship between airport infrastructure in the United States and the residents that live nearby. Chapter 2 framed the state of academic conversation that links airport infrastructure to cities. From this literature review, I framed three research questions:

(1) How has the population of historically marginalized groups living near airports changed with the rise of the jet age?

(2) Were hub airports more likely to expand if historically marginalized groups surrounded them?

(3) How did the Federal Aviation Administration and airport owners frame and evaluate environmental justice in the planning process for the airport expansion projects?

Chapter 3 investigated the demographic changes in airport-adjacent communities over time. The airport sample included the 21 major hub airports in multi-airport regions.
Chapter 4 investigated whether runway expansion projects were allocated equitably across airports, specifically from an environmental justice perspective. The airport sample included 50 major hub airports, of which, 15 had deployed an additional runway since year 2000. Chapter 5 investigated the methodologies and outcomes for environmental justice in the NEPA process. The sample included nineteen airport expansion projects planned after the 1994 Executive Order that mandated environmental justice analysis for all federal actions. In this concluding chapter, I summarize the key findings and contributions of each chapter. I also propose policy implications and research directions that stem from the collective results.

**Summary of Findings and Contributions**

Towards integrating aviation and urban planning scholarship, Chapter 2 proposed and framed three foundations of ‘airport urbanism’: Form, Growth, and Environment. Within the three foundations, I synthesized the existing literature into thematic topics and key concepts. I also identified key scholars of aviation urbanism. The synthesis revealed that, with respect to the planner’s triangle, aviation urbanism research has offered significantly more coverage of economic sustainability than equitable or environmental sustainability. The literature review contributed an overview of the academic research that investigated airports in an urban planning context. It can stand alone as an educational tool or support the motivation for future work that addresses gaps in the aviation and urban planning literature.

Towards understanding the relationship between airport-adjacent communities and airport-centric activity centers, Chapter 3 tested three hypotheses that could describe the relationship between airports and nearby residents over time: the “power to resist” effect,
the “push-pull LULU” effect, and the “airport-centric activity center” effect. Each of the three tests relied on an analysis of the change in demographic and socio-economic status in airport-adjacent communities since the rise of the jet age. The demographic and socio-economic trends offered (1) no support for the hypothesis that the largest hub airports grew as a function of the local communities lack of ‘power to resist’, (2) some support for the hypothesis that airports exert a “push-pull LULU” effect on the nearby population, but no causal evidence, and (3) no support for the hypothesis that “airport-centric activity centers” offer overwhelming economic benefit to the nearby residents, but the results are not definitive. This analysis contributes new knowledge about the changes in airport-adjacent communities over time, defines a methodological approach to define the airport-adjacent community, and offers a basis for further inquiries into the relationship between airport infrastructure, airport-adjacent communities, and airport-centric activity centers.

Towards investigating systemic environmental injustice, Chapter 4 investigated the demographic and socioeconomic characteristics at 50 major hub airports and tested which were more likely to expand. I found that more than 5 million people lived near large- and medium-sized American hub airports in 2000. I also found a pattern of high proportions and high concentrations of protected populations (race, ethnicity, nativity, income) in airport-adjacent communities. Ten of the fifty airport-adjacent communities had higher concentrations than the metro areas for persons of color, foreign-born persons, as well as persons living in poverty. However, the regression model, which was designed to be suitable for binary outcomes and small sample sizes, did not offer any statistical evidence that environmental injustice is a concern at a systemic, institutional level. However, this does not indicate that the inverse is true. In other words, the finding
does not mean that airport expansion outcomes were systemically just. The analysis contributes to the growing body of applied work using exact logistic regression, but in a context outside of the traditional medical research applications. The analysis also contributes new knowledge and a new form of environmental sustainability analysis for aviation, where airports are considered in an aggregated group rather than as individual case studies. This demonstrates that it is possible to investigate airports in aggregate, and such results lend nuance to guide qualitative inquiry. When the tested phenomenon in this research was framed at a national scale (patterns of environmental injustice related to airport expansion, framed according to which US hub airports opted to add a runway), the phenomenon was not detected. As revealed in the subsequent chapter, when the tested phenomenon was reframed on a case-by-case basis, (patterns of environmental injustice related to airport expansion, framed according to how environmental injustice was addressed during the NEPA planning process) the phenomenon was detected. The null results of the quantitative model are not necessarily an indication that broad, aggregate investigations are uninformative, just that such investigations are most useful for detecting more egregious and systemically unjust outcomes.

Towards investigating the FAA’s ability to detect environmental injustice on a case-by-case basis, Chapter 5 investigated the methodological framing of environmental justice in the NEPA process. I found that the slight variation in comparison geography prevented the FAA and airport owners from recognizing and mitigating disproportionate impacts at two of three airports with the most obvious and egregious levels of environmental justice concern. The only airports that recognized and mitigated environmental injustice were the three (of five) airports that used the county as a
comparison geography. This work contributes to the broader critique of the NEPA process as a tool for disclosing and mitigating adverse impacts to the environment. Solutions to improve NEPA analysis for environmental justice include methodological standards in the FAA’s official guidance, engagement with regional planning agencies, and evidence from practice to understand which mitigation strategies reduce or reconcile the negative effects of environmental injustice. In addition, this work contributes to the need for more environmental and equity research in aviation urbanism.

Research and Policy Implications

In this section, I explore the research and policy implications stemming from the dissertation’s research findings. With respect to research implications, I reflect on the future of aviation urbanism: the need for scholars with a key focus area in aviation urbanism, the value of mixed-methods research to answer questions related to equity and environment, and the challenges of operationalizing environmental justice.

This work highlights the need for aviation urbanism scholars to investigate the sustainability of airport development, especially in terms of environment and equity. Airports have dynamic stakeholders participating in planning processes, both driving and inhibiting growth. These planning processes occur at federal, state, local, and corporate levels. Additionally, airport management is a highly complex, technical operation with a data-rich research environment. Scholars with mixed expertise in urban planning and air transportation can evaluate airport development from the various stakeholder perspectives and concurrently appreciate the nuance of technical airport operations. Currently, airport planning research systematically favors single case study airport analysis over aggregate narratives of the broader hub network. This is partially due to
the prevalence of scholarship from scholars whose primary field occasionally overlaps with aviation systems. There is no doubt that these scholars make significant and important contributions to aviation urbanism when they use airport case studies as a means to also advance their primary field. However, scholars of aviation urbanism, whose key focus area is the urban interface with the air transportation system, are needed to broadly synthesize the disparate scholarship and generate new questions and new knowledge that informs airport development. While it is useful for multidisciplinary scholars to engage with aviation, the aviation urbanism subfield needs specialized airport planners to strengthen the research foundations and work towards building theories and concepts that explain the relationship between airport infrastructure and the urban fabric. Such scholars are also more likely to regularly interface with airport planning practitioners and translate planning scholarship to practice.

This work also highlights the value of mixed-methods research to answer questions related to equity and environment. As seen in Chapter 4, there are limitations to the quantitative methodology’s ability to parse all the nuances of environmental injustice. Yet, I assert the value of data analysis to glean insight that guides qualitative inquiries into patterns of environmental injustice. When quantitative and qualitative inquiry are pursued jointly, the researcher can assess different scales of a phenomena. The quantitative method is useful to broadly assess outcomes, just as it was used to investigate patterns of airport expansion throughout the US. Even though local nuance is lost in this method, it is useful to identify whether unjust outcomes are pervasive and obvious at the national scale. Additionally, even in the form of simple descriptive statistics, data analysis offers an efficient and justifiable method for selecting case studies that represent the extreme and typical outcomes from the studied phenomenon.
In contrast, the qualitative method is useful to gain insights into the planning process details and urban nuances that are significant to urban planning scholarship. Mixed-methods is a strategy to generate results that are grounded in both contextual and empirical evidence. The differing nuance of the quantitative and qualitative analysis results, offers more complete and ‘triangulated’ explanations.

Throughout this dissertation, I also explored the challenges of operationalizing environmental justice. Environmental justice inquiry requires a background in the nuanced histories of place; such as the original owner of the airport or the regional propensity for segregated settlement patterns set in to place via America’s systemic racism and discrimination. As a preliminary step to investigating environmental justice related to airport development, I used data analysis and case studies to contextualize the change in airport-adjacent communities over time. Next, I used a quantitative method to operationalize environmental justice and explore airport expansion outcomes at the national level. While it is true that we should be concerned about environmental injustice even if it only occurs once, it is important to understand if current policy is structurally and consistently failing to identify, acknowledge, and rectify patterns of environmental injustice. To look broadly across the US, I used the location quotient metric as an indicator for environmental injustice. This required selection of the appropriate local and regional comparison geographies, as well as selection of spatial analysis methods to investigate populations within those geographies. Finally, I looked to a mixed-method to operationalize the level of environmental justice concern and investigate the treatment of environmental justice during the NEPA planning process.
With respect to policy implications, I now reflect on the way ahead for airports to adopt ‘Good Neighbor’ policies: the need for regional planning engagement, acknowledging the limitations of NEPA, and the need for metrics beyond operations and passenger delay to motivate and justify capacity expansion policy.

Throughout the dissertation, I investigated airport planning in the context of their residential neighbors. Through situating modern airport planning in an urban context, I am able to provide insight on how the next century of airport development can sustainably integrate with urban regions. The general demographic and socioeconomic trends suggest a vulnerable power dynamic, where airport-adjacent communities are increasingly surrounded by historically marginalized groups over time. Airport-adjacent communities seem to retain their own power when they are a densely populated community capable of resisting expansion. Good neighbor policies will acknowledge the population dynamics inherent to the AAC, while also acknowledging the regional context. Metropolitan planning organizations (MPOs) are key stakeholders trained to consider a range of regional transportation goals, recognize the benefits and limitations of airport-centric development at a neighborhood and regional scale, and address the environmental and health concerns of local residents. If airport owners build existing relationships with MPOs, this could also strengthen the likelihood of more just incomes from the NEPA planning process.

There is much opportunity to strengthen NEPA at the federal guidance level. For example, the Federal Aviation Administration (FAA) guidance could specify a requirement for environmental justice analysis at varying geographic scales. Additionally, the FAA could recommend that EIS preparers consult with MPOs to determine the
appropriate levels of significance, such that the most appropriate threshold for detecting disproportionate concentrations of protected populations (persons of color, low-income, and foreign-born). A final opportunity for improvement, as well as a subject for further research, is the efficacy and ethics of environmental justice mitigation. Given the lack of legal accountability to follow through with NEPA mitigation promises, more research is needed to understand who well the NEPA mitigation interventions work to minimize or avert environmental injustice. Further, the fundamental ethics of mitigation could be questioned. If impacted residents are offered some compensation to noise-proof their own home or move to a new location, what is considered ethical and sufficient compensation? If an impacted resident is not offered compensation because their home is technically not in the computer-generated noise contour, is it ethical to refuse any sort of compensation? While ‘good neighbor’ policies surely require some degree of bureaucratic standardization, there must be some flexibility to respond to residents in the grey who experience environmental and health consequences of airport operations. ‘Good neighbor’ policies might include asthma testing centers within the AAC and funded by airport revenue; or broadened eligibility to upgrade residential windows for noise mitigation; or permanent jobs training programs specifically to prepare and train residents for airport-centric employment. Another ‘good neighbor’ policy could include an airport-revenue stream that supports local community planning coalitions. Some of these tactics have been proposed in mitigation plans as short term solutions to mitigate environmental justice, but they may have more impact if they are instituted as permanent ‘good neighbor’ policies.

A final critique for ‘good neighbor’ policy is related to the justification for imposing a nuisance. A major and unexpected finding in Chapter 4 is the notion that airport capacity
strain had no correlation with the decision to expand. Airports that have capacity should first be expected to make efficient use of that capacity before opting to pursue projects that severely displace and disrupt nearby communities. Regional airport planning, improved technology, demand management policy, and multimodal investment are alternatives to runway expansion that can meet regional transportation needs without incurring the same environmental costs. Regional planners must be critical contributors to this dialogue of alternatives analysis to ensure that regional-level concerns are addressed in addition to the municipal-level concerns of airport owners.

Closing Thought

Overall, this work contributed to the broader narrative of airport planning, transportation mega-projects, and environmental justice outcomes. This work builds toward foundational theory to understand how airport planning processes influence and are influenced by community and place. This work also emphasized a new way to think about sustainable planning for air transportation: in aggregate. This is an important departure from earlier work which has consistently considered airport operations in aggregate, but only evaluated airport policy and airport impacts in singular case studies.

Regional planners and urban transportation specialists should anticipate more opportunity to engage with air transportation in the coming century. From the first flight of the Wright brothers in 1903 to the SpaceX rocket landing in 2015, we have seen tremendous achievement in aviation and aerospace. It is unlikely that airports will remain as the only transportation interface between sky and earth. The rise of commercial space technology and unmanned aerial systems open new possibilities for transportation systems, and new concerns regarding the extent that these systems will integrate into
the urban landscape. As we see new airside and landside interactions develop, it is important to anticipate how the connecting interfaces will affect the urban environment and plan interventions that acknowledge and reconcile pushback tension. Regional planners, through graduate education and professional training, must be equipped to anticipate and respond to this high-tech transportation system in the 21st century.
APPENDIX

List of Figures and Tables (in order of appearance)

Table A3.1 Glossary of Airport Acronyms

Figure A3.1 Airport Operations from 1998 to 2015

Figure A3.2 Geographic Area of Airport-Adjacent Communities, 1970-2010

Figure A3.3 Total Population, 1970-2010

Figure A3.4 White Population (%), 1970-2010

Figure A3.5 African American Population (%), 1970-2010

Figure A3.6 Asian Population (%), 1970-2010

Figure A3.7 Native American Indian Population (%), 1970-2010

Figure A3.8 Hispanic Population (%), 1970-2010

Figure A3.9 Children Population (%), 1970-2010

Figure A3.10 Elderly Population (%), 1970-2010

Figure A3.11 Foreign-Born Population (%), 1970-2000

Figure A3.12 College-Educated Population (%), 1970-2000

Figure A3.13 Civilian Unemployment Rate, 1970-2000

Figure A3.14 Poverty Rate, 1970-2000

Figure A3.15 Total Housing, 1970-2010

Figure A3.16 Vacant Housing (%), 1970-2010

Figure A3.17 Renter-Occupied Housing (%), 1970-2010

Table A3.2 Change in Percent for Regions and AACs, Population Characteristics 1970-2010

Table A3.3 Change in Percent for Regions and AACs, Socioeconomic Characteristics 1970-2010
Figure A4.1 Local hours where ASPM reports ‘Percent of capacity used’ >100

Table A4.1 Summary statistics for airport-adjacent census block

Table A4.2 Summary statistics for 50 airport-adjacent communities

Figure A4.2 Concentration of Persons of Color in AAC vs Airport Strain, by Expansion Outcomes

Figure A4.3 Percent of Persons of Color in AAC vs Airport Strain, by Expansion

Figure A4.4 Concentration of Hispanic Persons in AAC vs Airport Strain, by Expansion

Figure A4.5 Percent of Hispanic Persons vs Airport Strain, by Expansion Outcomes

Figure A4.6 Concentration of Foreign-Born Persons in AAC vs Airport Strain, by Expansion

Figure A4.7 Percent of Foreign-Born Persons in AAC vs Airport Strain, by Expansion Outcomes

Figure A4.8 Difference Between AAC and metro Median Household Income vs Strain, by Expansion Outcome

Figure A4.9 Weighted Median Household Income in AAC vs Strain, by Expansion Outcome
Table A3.1 Glossary of Airport Acronyms

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Figure A3.1 Airport Operations from 1998 to 2015 The plots show which airports had the most annual scheduled flights (top) and which had the longest average block delay per flight (bottom) in their multi-airport region from 1998-2015.
Figure A3.2 Geographic Area of Airport-Adjacent Communities, 1970-2010

The plots show the geographic area of the airport-adjacent communities (AAC), defined as census tracts whose centroid is within 5 kilometers of the airport. The dashed line represents the expected area of the AAC (a circle with a radius of 5 km = 78 km²). In the San Francisco and New York City regions, some AAC areas are smaller due to overlap with nearby water bodies. In the Washington D.C. region, IAD is not suitable for time series analysis because the AAC’s area is significantly larger than the expected area. In the Dallas region, DFW is questionable because the AAC area is nearly double the expected area. All other airports are suitable for time series analysis since their AAC’s area is close to the expected area and each remains relatively stable from 1970 to 2010.
Figure A3.3 Total Population, 1970-2010

Population near airport

Population in metro area
Figure A3.4 White Population (%), 1970-2010
Figure A3.5 African American Population (%), 1970-2010
Figure A3.6 Asian Population (%), 1970-2010
Figure A3.7 Native American Indian Population (%), 1970-2010
Figure A3.8 Hispanic Population (%), 1970-2010
Figure A3.9 Children Population (%), 1970-2010
Figure A3.10 Elderly Population (%), 1970-2010
### Foreign-born population near airport, (% of AAC)

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### Foreign-born population in metro area, (% of MSA)

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**Figure A3.11 Foreign-Born Population (%), 1970-2000**
Figure A3.12 College-Educated Population (%), 1970-2000
Civilian unemployment rate near airport

Chicago | Dallas | Houston | Los Angeles
---|---|---|---

Miami | New York City | San Francisco | Washington DC

Civilian unemployment rate in metro area

Chicago | Dallas | Houston | Los Angeles
---|---|---|---

Miami | New York City | San Francisco | Washington DC

Figure A3.13 Civilian Unemployment Rate, 1970-2000
Figure A3.14 Poverty Rate, 1970-2000
Figure A3.15 Total Housing, 1970-2010
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<td>0.4 0.4 0.0</td>
<td>17.2 10.9 -6.3</td>
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<tr>
<td>New York City</td>
<td>LGA (4)</td>
<td>-47.7 -26.2 21.5</td>
<td>-1.5 4.1 5.6</td>
<td>12.7 7.7 -5.0</td>
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<td>15.7 10.9 -4.8</td>
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<td>6.2 7.7 1.5</td>
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<td>-22.5 -1.1 21.4</td>
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<tr>
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</tr>
<tr>
<td>Washington DC</td>
<td>DCA (20)</td>
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<td>3.5 8.0 4.5</td>
<td>0.3 0.3 0.0</td>
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Table A3.3 Change in Percent for Regions and AACs, Socioeconomic Characteristics 1970-2010

<table>
<thead>
<tr>
<th>Metro Region</th>
<th>Airport</th>
<th>%Foreign-Born</th>
<th>%College-Educated</th>
<th>Unemployment Rate</th>
<th>Poverty Rate</th>
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<tbody>
<tr>
<td></td>
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<td>ΔAAC</td>
<td>ΔMSA</td>
<td>Diff</td>
<td>ΔAAC</td>
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<td>MDW</td>
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<td>8.9</td>
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<tr>
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<td>ORD</td>
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<td>8.9</td>
<td>-16.9</td>
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<td>13.3</td>
<td>-4.9</td>
<td>4.5</td>
</tr>
<tr>
<td>New York City</td>
<td>JFK</td>
<td>19.1</td>
<td>13.3</td>
<td>-5.8</td>
<td>7.5</td>
</tr>
<tr>
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</tr>
<tr>
<td>San Francisco</td>
<td>OAK</td>
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<td>San Francisco</td>
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<td>San Francisco</td>
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<td>-8.9</td>
<td>18.6</td>
</tr>
<tr>
<td>Washington DC</td>
<td>BWI</td>
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<td>11.2</td>
<td>8.1</td>
<td>6.9</td>
</tr>
<tr>
<td>Washington DC</td>
<td>DCA</td>
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<td>11.2</td>
<td>-0.1</td>
<td>18.5</td>
</tr>
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</table>
Table A3.4 Change in Percent for Regions and AACs, Housing Characteristics 1970-2010

<table>
<thead>
<tr>
<th>Metro Region</th>
<th>Airport</th>
<th>%Vacant Units</th>
<th>%Renter-Occupied Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ΔAAC</td>
<td>ΔMSA</td>
</tr>
<tr>
<td>Chicago</td>
<td>MDW</td>
<td>6.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Chicago</td>
<td>ORD</td>
<td>3.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Dallas</td>
<td>DAL</td>
<td>4.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Dallas</td>
<td>DFW</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Houston</td>
<td>HOU</td>
<td>3.3</td>
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<td>LAX</td>
<td>2.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>ONT</td>
<td>2.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>SNA</td>
<td>0.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Miami</td>
<td>FLL</td>
<td>10.1</td>
<td>4.4</td>
</tr>
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<td>JFK</td>
<td>4.4</td>
<td>3.6</td>
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<tr>
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<td>OAK</td>
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<tr>
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<td>1.8</td>
</tr>
<tr>
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<td>2.2</td>
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</tr>
<tr>
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<td>BWI</td>
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<tr>
<td>Washington DC</td>
<td>DCA</td>
<td>4.3</td>
<td>2.4</td>
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Figure A3.18 AAC vs MSA (%), 1970-2010 Characteristics: White, Black, Youth, Renter-Occupied Homes, Native American, Senior, Vacant Housing Units
Figure A3.19 AAC vs MSA (%), 1970-2010  Characteristics: Unemployment, Poverty, Foreign Born, College Educated, Asian, Hispanic
Figure A4.1 Local hours where ASPM reports 'Percent of capacity used' >100% Hours with more than 150% 'capacity used' are dropped from analysis. They are suspected to be reporting errors and often fall outside the most critical operations hours (8AM-8PM). In total, only 70 observations out of 400,000 were screened out of the analysis. (Total observations = 366 days * 24 hours * 50 airports).
Table A4.1 Summary statistics for airport-adjacent census block groups This table shows summary statistics pertaining to the number of block groups whose centroid is within 5km of the hub airport in year 2000 (n=50 airports).

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Number of block groups</th>
<th>Example airport</th>
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<tbody>
<tr>
<td>Minimum</td>
<td>2</td>
<td>Kansas City (MCI)</td>
</tr>
<tr>
<td>First quartile</td>
<td>23</td>
<td>Detroit (DTW)</td>
</tr>
<tr>
<td>Second quartile</td>
<td>56</td>
<td>Houston (HOU)</td>
</tr>
<tr>
<td>Average</td>
<td>68</td>
<td>St Louis (STL)</td>
</tr>
<tr>
<td>Third quartile</td>
<td>84</td>
<td>Seattle (SEA)</td>
</tr>
<tr>
<td>Maximum</td>
<td>418</td>
<td>New York (LGA)</td>
</tr>
</tbody>
</table>
Table A4.2 Summary statistics for 50 airport-adjacent communities Data expressed as absolute count, followed by proportion (%), and concentration (location quotient).

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Min</th>
<th>First Quartile</th>
<th>Second Quartile</th>
<th>Average</th>
<th>Third Quartile</th>
<th>Max</th>
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<tbody>
<tr>
<td>Total Population</td>
<td>2,212</td>
<td>33,717</td>
<td>75,411</td>
<td>94,162</td>
<td>113,292</td>
<td>745,961</td>
</tr>
<tr>
<td>Weighted Median HH Income</td>
<td>$26,496</td>
<td>$37,259</td>
<td>$43,347</td>
<td>$44,745</td>
<td>$50,876</td>
<td>$76,665</td>
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<td>White NonHispanic</td>
<td>1,971</td>
<td>15,216</td>
<td>32,344</td>
<td>39,887</td>
<td>57,031</td>
<td>177,743</td>
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<td>Persons of Color</td>
<td>241</td>
<td>9,439</td>
<td>31,592</td>
<td>54,276</td>
<td>69,159</td>
<td>568,218</td>
</tr>
<tr>
<td>Black</td>
<td>61</td>
<td>2,500</td>
<td>6,725</td>
<td>15,868</td>
<td>15,528</td>
<td>133,200</td>
</tr>
<tr>
<td>Asian</td>
<td>46</td>
<td>819</td>
<td>1,928</td>
<td>7,397</td>
<td>4,754</td>
<td>162,112</td>
</tr>
<tr>
<td>Hispanic</td>
<td>58</td>
<td>1,713</td>
<td>10,802</td>
<td>28,498</td>
<td>32,209</td>
<td>310,006</td>
</tr>
<tr>
<td>Foreign Born</td>
<td>70</td>
<td>2,519</td>
<td>9,830</td>
<td>28,354</td>
<td>31,307</td>
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<tr>
<td>Living in Poverty</td>
<td>88</td>
<td>3,461</td>
<td>9,258</td>
<td>14,324</td>
<td>17,944</td>
<td>144,551</td>
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</table>
Figure A4.2 Concentration of Persons of Color in AAC vs Airport Strain, by Expansion Outcomes

The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the threshold for a disproportionately high concentration of persons of color (>1.2).
The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the threshold for a majority proportion of persons of color (>50%).
Figure A4.4 Concentration of Hispanic Persons in AAC vs Airport Strain, by Expansion Outcomes

The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the threshold for a disproportionately high concentration of Hispanic persons (>1.2).
Figure A4.5 Percent of Hispanic Persons vs Airport Strain, by Expansion Outcomes

The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the national average proportion of Hispanic persons (12.5%).
Figure A4.6 Concentration of Foreign-Born Persons in AAC vs Airport Strain, by Expansion Outcomes

The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the threshold for a disproportionately high concentration of foreign-born persons (>1.2).
Figure A4.7 Percent of Foreign-Born Persons in AAC vs Airport Strain, by Expansion Outcomes  The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the national average proportion of foreign-born persons (11%).
Figure A4.8 Difference Between AAC and metro Median Household Income vs Strain, by Expansion Outcome

The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks where the AAC’s weighted median household income is $5,000 less than the metro area’s household income.
Figure A4.9 Weighted Median Household Income in AAC vs Strain, by Expansion Outcome The horizontal reference line marks the threshold of capacity strain (>1098 hours). The vertical reference line marks the national median household income ($57,700
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**Chapter 2**


233


Index entry ideas... (n.d.).


**Chapter 3**


246


**Chapter 4**


252


Index entry ideas... (n.d.).


**Chapter 5**


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Index entry ideas... (n.d.).


### INDEX

**A**

Aerial shows, 21
Air quality, 45-47, 69-70
Air travel demand, 29
Airline competition, 30
Airports...
  ...Atlanta (Hartsfield-Jackson Atlanta International Airport), 4, 6, 15, 42, 47, 154, 160
  ...Boston (Boston Logan International Airport), 38, 48
  ...Burbank (Burbank Bob Hope Airport), 6, 17, 86-88
  ...Charlotte (Charlotte Douglas International Airport), 154, 160-162
  ...Chicago (Chicago O'Hare International Airport), 21-22, 34, 44, 47, 104, 153
  ...Cincinnati (Cincinnati/Northern Kentucky International Airport), 40, 103
  ....Denver (Stapleton International Airport and Denver International Airport), 5, 6, 16
  ...Fort Lauderdale (Fort Lauderdale/Hollywood International Airport), 82-84
  ...Houston (George Bush Intercontinental Airport), 84-86
  ...Los Angeles (Los Angeles International Airport), 45, 47, 160-162
  ...Memphis (Memphis International Airport), 32
  ...Minneapolis (Minneapolis-St Paul International Airport), 44
  ...New York airports (John F. Kennedy International Airport, LaGuardia Airport), 47, 104
  ...Phoenix (Phoenix Sky Harbor International Airport), 154, 160-162
  ...St Louis (Lambert St. Louis International Airport), 3, 6, 13, 14, 103, 108, 147
Airport architecture, 20-21
Airport-centric activity centers, 32, 56, 62, 64, 73, 80-82
Airport expansion, 40-41, 101, 111-113, 118-119, 129-130, 150
Airport metropolis, 28
Airport system, 2
Aviation urbanism, 18

**C**

---

265
Capacity strain, 110, 119-120, 123, 148, 151

D

Dehubbing, 40-41
Demand management, 38-39
Deregulation, 29
Discrimination, 58, 60
Displacement, 3, 4, 83

E

Ecological airport urbanism, 28
Economic development, 26-27, 114-115
Environmental impacts, 19, 42, 43-47, 53, 69-70
Environmental Impact Statements, 142, 145
Environmental justice, 101, 105-109, 110, 127-128, 142, 151-152, 160-162
Exact logistic regression, 117-118
Executive order 12898, 106, 115, 157

F

Flight delay, 37
Form, 18, 19, 51

G

Global city, 24, 30
Governance, 6, 17, 41, 85, 86-88
Growth, 19, 28, 52

H

266
High speed rail, 38
Hub-and-spoke, 29, 31, 48

I

Inequity, 57-62
Interurban competition, 30

J

Jet age, 67

L

Locally-unwanted land use, 56, 62, 63, 73, 76-79, 107, 110

M

MAP-21, 33
Multi-airport regions, 67
Multimodal, 38

N

National Environmental Policy Act, 102, 142-148
Noise, 43-45, 69-70, 83, 104-105

P

Planning airport capacity, 36-42, 101, 103-105
Power to resist, 56, 62, 72, 75-76
Record of Decision, 142, 145
Regional airport systems, 38, 40
Rural airports, 34

Space of flows, 24
Spatial theories, 24-26...
...Aerotropolis (see spatial theories), 25-26, 32, 49, 56
...Airea (see spatial theories), 24-25, 56
...Airfront (see spatial theories), 25-26
...Airport city (see spatial theories), 24-25
...Airport corridor (see spatial theories), 24-25, 56
...Airport region (see spatial theories), 24
...Decoplex (see spatial theories), 24-25
Sustainability, 25, 28, 38, 42, 48-50

Urban economy, 31-36
US Census, 71-72