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What Can COVID Tell Us About Market Definition in Air Travel?

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I. Introduction

Market definition is a key issue in many antitrust matters involving air travel, particularly when evaluating potential airline mergers or joint ventures. Antitrust authorities and economists often define geographic markets at the city-pair level. However, recent merger activity has raised the question of whether this geographic market definition is best suited for airline leisure passengers. A useful way to test this is by examining the impact of economic shocks that serve as "natural experiments." Normally, these natural experiments are rare or difficult to apply in air travel because they affect the entire industry in the same way. However, COVID may present such a rare opportunity. This article considers whether differences in COVID-related restrictions at vacation destinations can be used to determine the relative substitutability of these destinations and inform market definition analyses. Our results, which consider several measures of internal and external stringency of destination-specific COVID restrictions, do not show a clear relationship between any of these measures and travel to certain destinations. We, therefore, conclude that COVID may not be a useful natural experiment to assess market definition in air travel. We offer potential explanations for these results and propose other data for future research.

II. Market Definition in Air Travel

A relevant market in antitrust analysis has two components: a product market and a geographic market.[1] The key question regulators and academics seek to answer when defining a market in air travel is the extent to which passengers might consider substitutes to air passenger traffic between two airports if prices increased or quality decreased (*e.g.*, through poor customer service or inconvenient departure schedules).

One approach to answering this question is to define a "candidate market" around certain products in a geographic area and consider whether it would be profitable for a hypothetical monopolist of the candidate market to impose a small but significant and non-transitory increase in price, or SSNIP. This is commonly referred to as the "hypothetical monopolist test." If enough customers would substitute outside of the candidate market to make a SSNIP unprofitable, the market is expanded to include these substitute products until a SSNIP is profitable.

Antitrust authorities and academics often define relevant markets in the air travel industry as air passenger service—the product market—on a specific route with an origin and destination—the geographic market. Whether it would be profitable for a hypothetical monopolist to impose a SSNIP on a candidate market defined around a particular route therefore depends on how many passengers would be willing to substitute to a different route, substitute to a different mode of

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[1] *See* Horizontal Merger Guidelines (2010), *available at* https://www.ftc.gov/system/files/documents/public_statements/804291/100819hmg.pdf, describing the US Department of Justice's and Federal Trade Commission's analytical techniques and criteria for assessing the competitive effects of horizontal mergers.

transportation, or not travel at all in response to an increase in price. Real-world evidence is often used to assess this hypothetical scenario. In particular, natural experiments that affect the price of different options can provide insights into the substitution patterns exhibited by the aggregate demand as a response to them.

We briefly review the academic literature and legal history on these issues. As discussed above, passengers may substitute outside of the candidate market in several ways. Passengers may choose a different way to travel, such as by train or car; passengers may choose a different airport to fly *from*; or passengers may choose a different airport to fly *to*.[2]

Passengers' choices—and their willingness to substitute among these choices—are driven by several key factors. When deciding where to fly *from* or *to*, passengers will consider the price of flights from the airport, which airlines offer service from the airports, the location of the airports, access to infrastructure such as highways or public transportation, airport amenities, and even historical loyalty to a certain airport.[3]

Much of the academic literature has focused on whether the geographic market for air travel should be defined around *airport* pairs or *city* pairs. An airport pair is defined as travel between two airports. This market, for example, would include traffic from Boston Logan Airport (BOS) to LaGuardia Airport (LGA) in New York City, but would exclude traffic from BOS to Newark Airport (EWR) (also in the New York City metropolitan area). A city pair would include multiple airports within a city or metropolitan area as the origin or destination, such as LGA, EWR, John F. Kennedy Airport (JFK), in New York City. A well-known paper by Bruckner, *et al.* (2013)[4] concluded that the grouping of airports in a metropolitan area into a single origin or destination depends on the specific cities and should therefore be considered on a case-by-case basis. For example, the authors find, under their proposed method, that Regan National Airport (DCA) and Baltimore-Washington International Airport (BWI) in the Baltimore-Washington, DC area should be considered substitutes but that San Jose International Airport (SJC) and San Francisco International Airport (SFO) in the Bay Area should not, even though the two airports are only 35 miles apart.

Courts have also weighed in on issues of market definition. In its decision on the Alaska Airlines-Virgin America merger, the US District Court for the District of Columbia found that the relevant geographic market should be defined at the city-pair level and concluded that other modes of transportation—such as car, bus, or train—were not close enough substitutes because of the time savings and convenience made possible by scheduled air passenger service, which was determined to be the relevant product market.[5]

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[2] A separate question is whether non-stop or connecting flights between the same origin and destination should be in the same market. Several academic studies have concentrated on the substitutability of airports with a focus on getting from the same origin to the same destination via alternative routes that optimize for variables in the consumer's choice, such as price, driving distance, and total elapsed time, among others.

[3] Mahoney and Wilson (2014) find evidence that airlines often attract passengers through their position as a hub and their loyalty programs. *See* Mahoney, Dan and Wilson, Wesley, (2014), "*Airport and Airline Substitution Effects in Multi-Airport Markets*," *in* THE ECONOMICS OF INTERNATIONAL AIRLINE TRANSPORT, Vol. 4, Emerald Publishing Ltd., 309–337.

[4] J. K. Brueckner, D. Lee, and E. Singer, "*City-Pairs Versus Airport-Pairs: A Market-Definition Methodology For The Airline Industry*," 1 REVIEW OF INDUSTRIAL ORGANIZATION, Vol. 44, 1–25 (2013) *available at* https://doi.org/10.1007/s11151-012-9371-7.

[5] *United States of America* v. *Alaska Air Group, Inc., et al.,* Civil Action No. 1:16-cv-02377.

In its decision on the *Air France-KLM* merger, the European Commission ("EC") found that the market definition for the relevant market should be based on the "point of origin/point of destination (O&D) pair" rather than a broader network-to-network competition, as third parties opposed to the merger had advocated.[6] The EC emphasized that passengers might consider network-related aspects such as frequent flyer programs "only to the extent that airlines or alliances serve the O&D pair between which they wish to travel." In its assessment of the O&D pair, the EC not only considered direct flights between the two main airports, but also connecting flights between the same airports, direct flights between other airports with "overlapping catchment areas," and even other means of transportation that could be considered substitutable. The EC found that the degree of substitutability depended on factors such as price, frequency, and travel time and was determined on a "route-by-route basis."

For leisure travelers to vacation destinations—in particular, "sun destinations" that are popular during winter months—it is possible that the market could be even broader than two airports in the same city. A given city or metropolitan area need not be the main decision factor determining passengers' choice of destination.[7] In this case, rather than defining a market at either the airport or the city level, a relevant market could include an origin and multiple destinations that offer similar services. For example, some passengers may view Punta Cana in the Dominican Republic, Cancun in Mexico, and Cozumel in Mexico as close substitutes because all three destinations offer similar attractions to tourists, despite Cancun and Cozumel being 56 miles apart and Punta Cana being a different country.

In the present study, we focus on the potential for COVID as a natural experiment that may illuminate broader destination substitution patterns. Specifically, we use different levels of COVID exposure and restrictions across destinations and time to evaluate whether the data are consistent with passengers substituting among sun destinations.

III. COVID as a Natural Experiment

One common approach to understand substitution patterns is to use historical evidence about how customers have reacted to "shocks" to the price or quality of a product. In air travel, such natural experiments are uncommon. Assessing passenger substitution patterns can be challenging because most shocks to prices or quality affect multiple routes in the same way. Changes in fuel costs or labor, for example, affect all routes on a network, and are therefore not ideal for measuring how customers substitute among routes. COVID, however, presents researchers with a unique opportunity to examine passenger substitution across routes, particularly travel to vacation destinations where there have been different levels of COVID exposure and policy responses.

We document changes in travel patterns in response to COVID-related restrictions—including quarantine mandates, vaccination requirements, and other policies—using destination-specific COVID travel restrictions from the US State Department and the Oxford COVID-19 Government Response Tracker (OxCGRT). We focus, in particular, on travel originating in northern US cities to southern US states, Mexico, the Caribbean, and Central America. Winter leisure travelers to

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[6] Case No COMP/M.3280. Air France/KLM Notification of 18.12.2003 pursuant to Article 4 of Council Regulation No 4064/89.

[7] Socorro *et al*. (2018) finds evidence that tourism-oriented airports compete with one another for passengers. *See* Socorro, M. Pilar, Betancor, Ofelia, and de Rus, Ginés, "*Feasibility and Desirability of Airport Competition: The Role of Product Substitutability and Airlines' Nationality*," JOURNAL OF AIR TRANSPORT MANAGEMENT, Vol. 67, Issue C, 224–231 (2018).

these destinations may be most likely to substitute across different potential destinations in response to changes in price or quality, such as COVID restrictions.

While the pandemic has of course led to changes in leisure passengers' demand for leisure travel, we find little evidence that demand was driven by destination-specific COVID travel restrictions. As this article is only an initial exploration into the potential use of the COVID shock, we also acknowledge potential limitations to this analysis and propose directions for future research.

A. Methodology

We document the relationship between destination-specific COVID restrictions and passenger volumes. Our analysis uses three different approaches to evaluate this relationship.

First, we present summary statistics of passenger volume and shares before and after the onset of COVID. We show how changes in passenger volume relate to various COVID restrictions.

Second, we examine changes in COVID restrictions at a destination over time and evaluate whether destinations experienced a decrease in share relative to pre-pandemic conditions when they experienced more COVID restrictions.

Third, we use a regression analysis to estimate the relationship between passenger volume and COVID restrictions and the relationship between passenger share and COVID restrictions. We control for the origin, year-month, and other factors that could explain changes in passenger volume or share, such as the level of disease intensity at the destination (measured as new COVID cases relative to the previous month) and the level of economic activity at the destination (measured as the square of GDP *per capita)*. Additionally, we account for the possibility that a given destination looks at its neighbors to consider which COVID policies are potentially effective by including an average measure of external and internal COVID policy stringency among all other sun destinations. We include year-month and market (*i.e.*, US city-sun destination) fixed effects to account for overall COVID restrictions and other conditions at a given point in time and for each particular destination.

1. Data

We focus on travel between northern US cities and southern US states and territories, Mexico, Central America, the northern coast of South America, and the Caribbean from January 2017 to February 2022. Our dataset combines several sources of information on air travel, COVID-19 prevalence, policy responses, and economic indicators. Together, the dataset tracks changes in passenger volume, the risk of contracting COVID, the level of restrictions applied to travelers originating in the US, the level of restrictions applied to those moving internally within a sun destination, and other characteristics of those destinations.

2. COVID-19 Restrictions

a. OxCGRT

OxCGRT is a tool created by the University of Oxford that aims to track and compare governmental policy responses to COVID.[8] OxCGRT aggregates 21 separate components

[8] Oxford maintains the complete details of their methodology and data on their GitHub page. For more information on the OxCGRT project, see "COVID-19 Government Response Tracker," Oxford University Blavatnik School of Government, *available at* https://www.bsg.ox.ac.uk/research/research-projects/covid-19-government-response-tracker.

covering containment policies, economic policies, health system policies, vaccination policies, and miscellaneous policies into four indices. The most relevant index for this analysis is the Stringency Index, which compares the level of stringency of each destination's COVID policy response. The Stringency Index considers every containment policy component,[9] as well as the health system policies component that tracks the scope of public information campaigns.[10]

We adjust the OxCGRT Stringency Index to better reflect conditions more pertinent to leisure travelers originating outside a given destination. Specifically, we remove the components for school and workplace closings, as these do not impact leisure travelers. We then add the health system component for mask mandate stringency.[11] We also create one version of the index that removes the components for international travel controls (*hereinafter,* "C-8 component"[12]) as we will be separately controlling for measures such as screenings, quarantines, and bans. This creates our measure for internal levels of stringency that are relevant to passengers once they have already arrived at the sun destination. The index increases from 0 to 100 with the stringency of the at-issue policies. If more than one component of the scale is missing, then the value will be missing. The index is calculated at a daily level, and the simple average value is taken for a given year and month.

b. US Department of State ("DOS") COVID-19 Country–Specific Information

The DOS website includes country-specific COVID travel restrictions for US citizens. We employ the Internet Archive, which preserves webpages as digital archives, to compile historical details on travel restrictions and use the latest snapshot of each country's COVID information webpage available in each month.[13]

We construct another variable analogous to the OxCGRT C-8 component using the DOS data. The scale is defined, similarly, on a range of zero to three, with zero indicating no restrictions, one indicating some restrictions, two indicating mandatory quarantine, and three indicating a travel ban applicable to leisure passengers. Using the DOS data, which focuses on US citizens, allows us to identify policies that would apply to most passengers in our data. We also use this information and our calculation for internal stringency discussed above to create an overall stringency measure using a method similar to that of OxCGRT.

3. Passenger Volumes

We measure passenger volumes using the US Department of Transportation ("DOT") T-100 domestic and international segment data. We aggregate passenger volume by the US state or

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See also the project's GitHub page, *available at* https://github.com/OxCGRT/covid-policy-tracker.

[9] Containment policies covered by this scale include school closings, workplace closings, public event cancellations, restrictions on gatherings, closed public transport, stay at home requirements, restrictions on internal movement, and international travel controls. These are otherwise known as indices C-1 through C-8.

[10] This is otherwise referred to as the H-1 index.

[11] This is otherwise referred to as the H-6 index.

[12] The C-8 index as defined by OxCGRT ranges from zero to four. Zero indicates no restrictions on international travelers entering the country; one indicates some restrictions such as testing; two indicates a mandatory quarantine; three indicates a ban on some passengers; and four indicates a ban on all international passengers. The C-8 field as maintained by OxCGRT is not specific to US originating passengers.

[13] If an archived page is not available in a given month, we use the restrictions for that country from the previously available month.

territory (for domestic destinations) or country (for international destinations).[14] To focus on leisure travel to sun destinations, we limit the analysis data to the months of November through March in the period from January 2017 through February 2022.[15]

The data are limited to travel between northern US states and sun destinations.[16] Domestically, sun destinations are defined as the following states and US territories: Arizona, Florida, Georgia, Hawaii, Puerto Rico, South Carolina, and the US Virgin Islands. For robustness, we also examine our data excluding Arizona, Florida, and Georgia as these states contain major airline hubs where a large number of passengers connect to destinations elsewhere in the country, and, therefore, passenger volumes may not reliably track leisure travelers.[17] Internationally, sun destinations are defined as all countries in the Caribbean and Central America as well as the following countries: Brazil, Colombia, French Guiana, Guyana, Suriname, and Venezuela. For robustness, we consider excluding Mexico, Colombia, and Brazil from the analysis as these destinations also have airports that rank highly in terms of international connectivity.[18]

The data are aggregated to the non-directional US city-sun destination (country or state/territory) level for each month. We require there to be at least one carrier with eight or more departures in a given month (an average of at least one weekly roundtrip operation) to be included in the analysis. We also limit the data to US city-sun destination pairs with at least 2,000 passengers flying in 2019.[19] As a robustness check, we also examine limiting the data to US city-sun destination combinations in the 50th and, separately, the 75th percentile of all passenger volumes in 2019.

4. COVID-19 Cases Per Capita

Our measure of COVID-19 cases from January 2020 through February 2022 for each country and state is from OxCRGT, the same organization that tracks COVID policy measures. We

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[14] The T-100 data report all passengers traveling on most foreign and domestic carriers operating within the US and between the US and any foreign destination. Passengers flying on carriers with less than $20 million in annual revenue in a given year are not reported in these data.

[15] These months are consistent with the International Air Transport Association's ("IATA's") definition of winter as covering the last Sunday of October through the last Saturday of March.

[16] These states are divided into four regions. Maine, Vermont, New Hampshire, New York, Massachusetts, Connecticut, Rhode Island, New Jersey and Pennsylvania are considered the Northeast region. Illinois, Minneapolis, Michigan, and Wisconsin are considered the Upper Midwest region. Ohio, Indiana, Missouri, Iowa, Kansas, Nebraska, South Dakota, and North Dakota are considered the Other Midwest region. Washington, Oregon, Idaho, Colorado, Utah, Montana, and Wyoming are considered the West/Northwest region.

[17] For instance, Hartsfield-Jackson Atlanta International Airport (ATL) in Georgia is considered by OAG to be the second-most connected airport for domestic travelers in 2019. Pheonix Airport (PHX) airport in Arizona ranks twelfth domestically. Miami International Airport (MIA) in Florida ranks twentieth among all international hubs, while nearby Fort Lauderdale-Hollywood International Airport (FLL) ranks thirteenth among international low-cost carrier connecting airports. Note, while HNL ranks nineteenth domestically, Hawaii remains in the analysis, as we assume that most domestic connections at HNL are to or from other Hawaiian island airports. *See* "Megahubs Index 2019," OAG, *available at* https://www.oag.com/oag-megahubs-2019.

[18] *Ibid.*

[19] This restriction excludes less than six percent of US city-sun destination pairs in 2019 (January, February, March, November, and December of the calendar year). This leaves markets with an average of around 100 passengers a week. While the threshold is arbitrary, we believe it is reasonable to ensure that the data better reflect routes that have enough pre-pandemic demand to be considered for operation post-pandemic.

calculate the monthly average of new cases per month for each destination. The data are reported on a per million-person basis using 2019 estimates of population from the sources detailed below.

5. Other Measures

We use the World Bank Open Data to obtain GDP and population data for sun destination countries. In addition, we obtain the state and territory-level GDP data from the US Bureau of Economic Analysis and state-level population data from the US Census Bureau for sun destinations within the US and its territories.[20] GDP is reported in our data on an annual *per capita* bases in constant 2015 US dollars for each destination.[21]

B. Results

Following the methodology detailed above, we first examine passenger volume changes as they relate to country policies and COVID prevalence overall. We then explore in a series of graphs the potential correlation between a destination's COVID policy stringency and changes in passenger shares relative to pre-COVID months. Lastly, we develop a regression model to evaluate whether there is any consistent relationship between a destination's COVID policies and passenger volume and shares. We would expect passengers to react to increased stringency similarly to an increase in prices—shifting their choices to those destinations with lower levels of stringency and fewer travel restrictions. However, the results show no clear relationship, limiting the potential usefulness of the COVID shock as a tool to evaluate substitutability among sun destinations.

Figure 1 below shows changes in passengers shares and COVID restriction measures among the top 15 sun destinations in both the pre-pandemic and post-pandemic periods. Several patterns are noteworthy. Some destinations with relatively less restrictive COVID policies gained share. Florida, a domestic destination widely portrayed in the news as having the most relaxed COVID measures, gained the most share during the pandemic. Mexico, the Dominican Republic, and Puerto Rico, all of which had relatively fewer restrictions to travelers, also gained share. However, there is still no clear pattern detailing the impact of COVID restrictions on US demand. Brazil, the Bahamas, Georgia, and South Carolina, for instance, lost shares despite similarly few restrictions, as well as having similar or better disease conditions as the major "winners" (*i.e.,* those sun destinations that saw an increase in the share of passengers traveling to all sun destinations).

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[20] We make the following assumptions to resolve missing data issues: (1) For foreign sun destinations with missing 2021 GDP, we project the missing GDP by adjusting the 2020 value for the change in GDP *per capita* for the World Bank region of Latin America and the Caribbean; (2) For domestic sun destinations with missing 2021 GDP, we project the missing GDP by adjusting the 2020 value for the population-weighted change in GDP *per capita* across all US states, Washington, DC, Puerto Rico, and the US Virgin Islands; and (3) Given the lack of 2022 GDP and population data, we assume all data points are the same as those of 2021.

[21] The World Bank GDP figures are maintained in constant 2015 US dollars. GDP for US states and territories is adjusted to constant 2015 US dollars using historical Consumer Price Index. *See* "Consumer Price Index, 1913-", Federal Reserve Bank of Minneapolis, *available at* https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1913-.

Figure 1: Trends in COVID Restrictions and Passenger Shares Pre- and Post-Pandemic

							COVID Measures			
	Avg. Monthly Passengers			Avg. Passenger Share to Sun Destinations			Avg. External Stringency (All Passengers)	Avg. External Stringency (US Passengers)	Avg. Mothly Internal Stringency	Avg. Monthly New COVID Cases (per million people)
Sun Destination	Pre	Post	Change	Pre	Post	Change				
Florida	6,525,178	4,457,913	-2,067,266	47.6%	50.4%	2.7%	0.0	0.0	39	15,493
Georgia	2,611,861	1,348,911	-1,262,951	19.1%	15.2%	-3.8%	0.0	0.0	43	14,313
Arizona	1,752,403	1,138,411	-613,992	12.8%	12.9%	0.1%	0.0	0.0	41	19,406
Mexico	845,200	642,775	-202,425	6.2%	7.3%	1.1%	1.1	0.0	55	2,254
Dominican Republic	342,948	285,504	-57,444	2.5%	3.2%	0.7%	1.8	0.0	56	3,025
South Carolina	211,473	131,809	-79,664	1.5%	1.5%	-0.1%	0.0	0.0	40	17,960
Puerto Rico	238,495	190,017	-48,478	1.7%	2.1%	0.4%	0.0	0.9	55	11,272
The Bahamas	52,257	22,055	-30,202	0.4%	0.2%	-0.1%	1.4	0.9	62	3,699
Hawaii	352,825	207,514	-145,311	2.6%	2.3%	-0.2%	0.0	1.2	63	11,589
Aruba	74,737	50,578	-24,159	0.5%	0.6%	0.0%	1.5	1.2	48	20,763
Costa Rica	45,186	35,987	-9,200	0.3%	0.4%	0.1%	1.2	1.2	56	6,550
Panama	64,978	31,192	-33,786	0.5%	0.4%	-0.1%	1.7	1.2	63	11,666
Brazil	99,518	32,267	-67,251	0.7%	0.4%	-0.4%	1.7	1.4	66	5,852
Colombia	52,194	38,501	-13,693	0.4%	0.4%	0.1%	2.7	1.6	62	4,772
Jamaica	123,960	72,969	-50,991	0.9%	0.8%	-0.1%	2.2	2.0	77	2,159

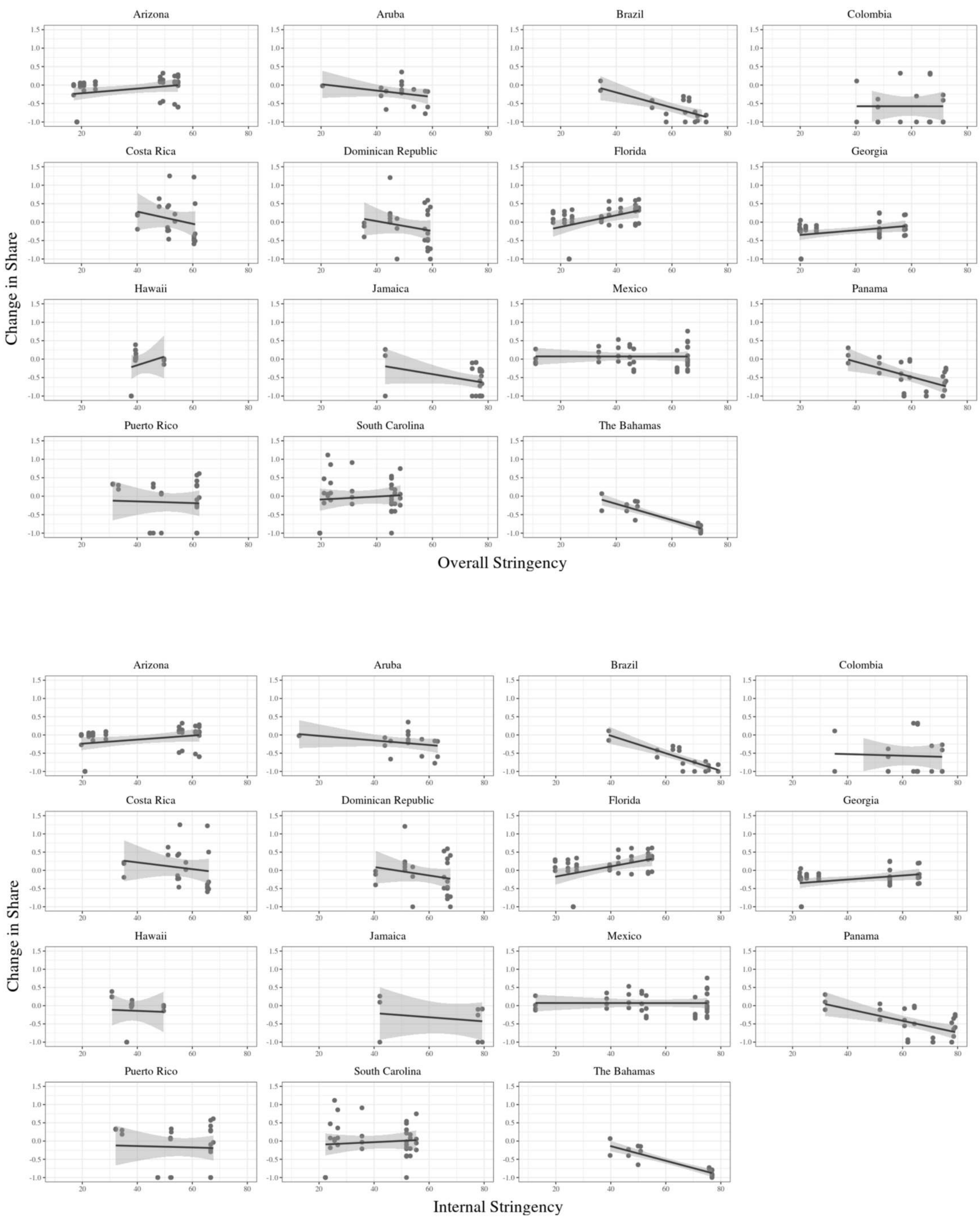
Sources: US DOT T-100; OxCGRT; US Department of State.

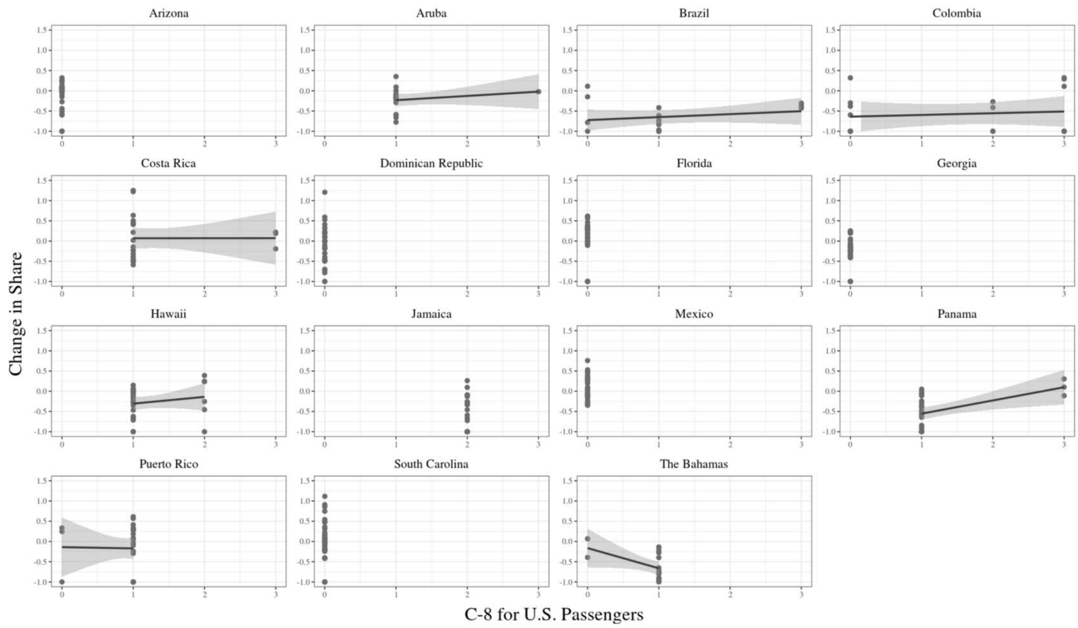
Notes:
1) Pre-pandemic period covers January 2017 through February 2020. Post-pandemic period covers March 2020 through January 2022.
2) Passenger shares are based on all passengers flying to all sun destinations from northern US states in the relevant periods.
3) Only the union of the 15 destinations by passengers in both pre- and post-pandemic periods are included.

Figure 2 below shows the relationship between COVID restrictions and the change in the destination's passenger share relative to its pre-pandemic share for each destination. The change in share is the percentage difference between passenger shares in each pandemic year-month period and the average passenger share in the same region and calendar month pre-pandemic.[22] The figures show separately how changes in passenger shares relate to the destination's overall stringency measures, internal stringency measures, and external stringency measures. Again, we see no consistent correlation between changes in COVID restrictions and passenger shares. While several destinations' passenger shares decreased as internal or external restrictions for travelers increased, the correlation appears to be weak.

22 For example, travel to Aruba from the Northeast accounts for 0.39% of all sun destination passengers from northern US cities in March 2021 and an average of 0.48% of sun destination passengers from northern US cities in March 2017, 2018, and 2019, for a change of -17.6%.

Figure 2: Changes in Passenger Shares Relative to Pre-Pandemic Among Top 15 Sun Destinations





Sources: U.S. DOT T-100; OxCGRT; U.S. Department of State.
Notes: Observations with a passenger share change greater than 1.5 times pre-pandemic averages are excluded from the charts.

Figure 3 below shows the results of our regression analysis. These initial difference-in-differences-style regression results show no clear pattern of decreasing passenger volumes as policies become increasingly stringent. Most specifications yield a coefficient on external stringency controls that is economically small and not statistically different from zero.

We have further evaluated the robustness of these regressions by limiting the data to following separate samples: limiting to top destinations examined in Figures 1 and 2 above, excluding destinations containing hubs that rank highly in terms of connectivity, excluding US city-sun destination pairs that rank below the bottom 50th percentile of winter passengers in 2019, and excluding US city-sun destination pairs that rank below the bottom 75th percentile of winter passengers in 2019.[23] Additionally, these findings hold if we focus on external restrictions applied to vaccinated travelers.

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[23] Again, the sun destinations with high-connectivity hubs are Arizona, Georgia, Hawaii, Brazil, Colombia, and Mexico. The 50th percentile of winter passenger volumes by US city-sun destination in 2019 was 41,476, while the 75th percentile was 129,999.

Figure 3: Regression of Passengers and Passenger Shares on COVID Restrictions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Passengers	Passengers	Passengers	Passengers	Passenger Share	Passenger Share	Passenger Share	Passenger Share
Sample	All	All	Hubs Origins	Hubs Origins	All	All	Hubs Origins	Hubs Origins
COVID Stringency (C-8)	1,065		4,498^		-0.000577		-0.000998	
	(1,403)		(2,216)		(0.000441)		(0.000809)	
External COVID Restrictions: Closed		2,244		10,182*		-0.00112		-0.00230
		(4,008)		(4,914)		(0.000957)		(0.00209)
External COVID Restrictions: Quarantine		3,199		15,475^		-0.00184		-0.00343
		(3,270)		(7,743)		(0.00131)		(0.00250)
External COVID Restrictions: Other Restrictions		3,814		13,048^		-0.00159		-0.00314
		(3,253)		(6,529)		(0.00132)		(0.00246)
Internal COVID Stringency	-13.61	-16.56	-336.1	-348.9	1.06e-05	1.24e-05	1.26e-05	1.51e-05
	(83.97)	(88.51)	(245.9)	(263.7)	(1.52e-05)	(1.63e-05)	(2.24e-05)	(2.25e-05)
Avg. External COVID Stringency in Region (C-8)	8,491*	7,722^	42,679*	39,458*	0.000514	0.000803	0.000901	0.00171
	(3,788)	(4,023)	(18,396)	(18,533)	(0.000527)	(0.000778)	(0.00139)	(0.00202)
Avg. Internal COVID Stringency in Region	-255.3	-297.6	386.1*	313.5	-3.59e-05	-2.09e-05	-4.07e-05^	-2.20e-05
	(187.7)	(210.3)	(159.3)	(200.3)	(2.22e-05)	(2.64e-05)	(2.18e-05)	(3.16e-05)
Observations	8,804	8,804	2,992	2,992	8,804	8,804	2,992	2,992
Adjusted R-Squared	0.907	0.907	0.912	0.912	0.899	0.900	0.892	0.893

Notes: Robust standard errors clustered on market and year-month are in parentheses (*** $p<0.001$, ** $p<0.01$, * $p<0.05$, ^ $p<0.10$). The regressions also include controls for GDP per capital as the sun destination country (linear and quadratic), new COVID cases per million people (linear and quadratic), US city and sun destination combination fixed effects, year-month fixed effects, and a constant term.

Together, these results indicate that COVID restrictions alone may not be useful to evaluate substitutability among sun destinations. First, summary statistics reveal that many countries' shares of passengers to sun destinations remained stable despite differing conditions for COVID and COVID policy stringency. Some countries gained share despite strict COVID policy restrictions, and others lost share despite less stringent policies. Second, correlation plots show an inconsistent and often weak negative correlation between a COVID policy stringency and change in passengers' shares compared to pre-pandemic shares. Lastly, a regression analysis controlling for various factors, including unique market and period characteristic, generally shows no economically or statistically significant relationship between COVID policy stringency and passenger volumes, share, or change.

IV. Discussion

We conclude that COVID may not be a useful natural experiment to evaluate the market definition question in the case of airline winter leisure travel. In this section, we offer possible explanations for this finding. We also propose other data useful for future research.

It is possible that passengers sensitive to COVID restrictions simply chose not to travel for much of the pandemic period. In this scenario, the data reflect the behavior of travelers still willing to travel during COVID, which may reflect non-leisure passengers or those traveling to visit friends and family for the holidays. Our approach does not allow us to distinguish between customers not traveling to a particular destination during COVID because those passengers are particularly sensitive to COVID (relative to passengers traveling to other destinations) or because those passengers view other destinations as close substitutes. Differences in passenger sensitivity to COVID may explain, for example, why Mexico and the Dominican Republic gained passenger share in the pandemic era. Broken down by US region, Mexico gained share in the Upper

Midwest, and the Dominican Republic gained share in the Northeast. These respective areas in the US have large immigrant populations from these countries, according to US Census data.[24]

The differences in COVID restrictions across countries during the pandemic, while meaningful, may not have been large enough to induce a response among passengers. The implementation and reaction to the restrictions was highly correlated over time. In the early period, when most non-US destinations introduced restrictions, there were large decreases in passenger volumes across all countries relative to levels in the winter months in calendar year 2019. Later in the data period—after most restrictions were relaxed, uncertainty declined, and potential travelers became accustomed to measures such as mask mandates—passengers may have been eager to return to travel regardless of COVID restrictions. While some differences emerged later in the pandemic, passengers traveling may have been less sensitive to these policies. A lack of variation in COVID policies at the time of passenger demand increases would mitigate the usefulness of COVID for examining destination substitutability.

An important limitation to this analysis is that we do not have detailed information on prices. While we have detailed data on COVID restrictions and passenger volume, both prices and price changes during COVID are of course necessary to better understand passengers' decisions and their willingness to substitute to different destinations. We also lack information on passengers' true origin and destination. This information would allow researchers to better isolate leisure market travel when involving larger destinations with hubs like Georgia, Colombia, and Mexico. Adding such data to a difference-in-differences model could allow researchers to better parse the impact of COVID restrictions on passenger choices and identify the relevant geographic market for winter leisure travel.

[24] For example, Cook County, Illinois, has the largest total immigrant population from Mexico of any northern area in our sample, while counties in New York, New Jersey, Massachusetts, and Rhode Island make up 13 of the top 15 counties by number of Dominican immigrants. *See* Migration Policy Institute, "U.S. Immigration Population by State and County," *available at* https://www.migrationpolicy.org/programs/data-hub/charts/us-immigrant-population-state-and-county.