Final Project Report

Expected Change in US Air Travel after the COVID-19 Pandemic

Prepared for **Teaching Old Models New Tricks (TOMNET) Transportation Center**

By

Sara Khoeini
Email: sara.khoeini@asu.edu

Ram M. Pendyala
Email: ram.pendyala@asu.edu

Shivam Sharda
Email: ssharda@asu.edu

Denise da Silva Baker
Email: denise.silva@asu.edu

Deborah Salon
Email: dsalon@asu.edu

Laura Mirtich
Email: lmirtich@asu.edu

School of Sustainable Engineering and the Built Environment
Arizona State University
660 S. College Avenue, Tempe, AZ 85287-3005

March 2023

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. N/A	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A	
4. Title and Subtitle Expected Change in US Air Travel after the COVID-19 Pandemic		**5. Report Date** March 2023	
		6. Performing Organization Code N/A	
7. Author(s) Sara Khoeini, https://orcid.org/0000-0001-5394-6287 Ram M. Pendyala, https://orcid.org/0000-0002-1552-9447 Shivam Sharda, Denise da Silva Baker, https://orcid.org/0000-0003-1414-8439 Deborah Salon, https://orcid.org/0000-0002-2240-8408 Laura Mirtich,		**8. Performing Organization Report No.** N/A	
9. Performing Organization Name and Address School of Sustainable Engineering and the Built Environment Arizona State University 660 S. College Avenue, Tempe, AZ 85287-3005		**10. Work Unit No. (TRAIS)** N/A	
		11. Contract or Grant No. 69A3551747116	
12. Sponsoring Agency Name and Address U.S. Department of Transportation, University Transportation Centers Program, 1200 New Jersey Ave, SE, Washington, DC 20590		**13. Type of Report and Period Covered** Research Report (2021 – 2022)	
		14. Sponsoring Agency Code USDOT OST-R	
15. Supplementary Notes N/A			

16. Abstract

This report studies the expected change in post-pandemic air travel for both personal and business travel purposes. The COVID Future survey serves as the data source, with 7,593 respondents from across the US who completed the survey (wave 1) between June and October 2020. The weighted survey data indicates that 40 percent of pre-pandemic frequent business flyers are expected to decrease their air travel after the pandemic, while 20 percent are expected to increase. Similarly, 35 percent of frequent personal flyers are expected to decrease their air travel, while 19 percent are expected to increase. Among all of the expected changes in post-pandemic air travel, it is more likely that a decrease in business air travel will remain. The most frequently stated reasons for the decrease in business air travel are related to long-term COVID-related realizations such as the effectiveness of online meetings. An Integrated Choice and Latent Variable (ICLV) model structure has been developed to simultaneously model the expected change in post-pandemic personal and business air travel as a function of latent attitudinal constructs and general socioeconomic and travel behavior variables. Older people, women, and people who have positive attitudes toward telecommunication are more likely to decrease their business air travel after the pandemic compared to the rest of the sample. Long-term decrease in business air travel has potential positive sustainability impacts. However, the economic implications of less business air travel may bring about permanent changes in the aviation industry.

17. Key Words Air travel, Pandemic impacts, Travel demand, Airline industry		**18. Distribution Statement** No restrictions.	
19. Security Classif.(of this report) Unclassified	**20. Security Classif.(of this page)** Unclassified	**21. No. of Pages** 21	**22. Price** N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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ACKNOWLEDGMENTS

This study was funded by a grant from A USDOT Tier 1 University Transportation Center, supported by USDOT through the University Transportation Centers program. The authors would like to thank TOMNET and USDOT for their support of university-based research in transportation, and especially for the funding provided in support of this project. The authors would like to thank Matthew Wigginton Bhagat-Conway, Rishabh Singh Chauhan, Sybil Derrible, Ehsan Rahimi, Mohammadjavad Javadinasr, Abolfazl (Kourous) Mohammadian for their contributions to the work presented in this report.

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EXECUTIVE SUMMARY
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INTRODUCTION

Since the beginning of the pandemic, travel demand for all transportation modes has been impacted tremendously. Among the many impacts of COVID-19 on the transportation system, its impact on air travel has been the most substantial. The Transportation Security Administration (TSA) checkpoint travel numbers decreased by 95 percent during April 2020 compared to April 2019. After the initial collapse, air travel started to increase and was only 27 percent off the pre-pandemic level in June 2021 [1]. Although it is expected that air travel will keep increasing, especially when the pandemic is over, the question remains as to the extent to which the routine of making fewer trips by air for personal and business purposes is going to stick. The reasons for any long-lasting shift and how air travel recovery will differ among population subgroups is also of considerable interest as the nation recovers.

While the tourism industry has recovered from other external disruptions such as the September 11 terrorist attacks in 2001, the SARS outbreak in 2003, and the MERS outbreak in 2015, there is evidence that the COVID-19 pandemic has impacted the air travel industry in unprecedented ways [2, 3]. Despite the upward trend in the recent past, as of June 2021, airports in the U.S. were registering a 21 percent decline in departures relative to 2019 [4]. Domestic non-business travel is responsible for the majority of the recovery while international and business travel continue to lag [5]. In May 2021, US international air travel (passengers on the US and foreign airlines) fell 66 percent below 2019 levels. Bookings for business air travel is still 65 percent below the pre-pandemic compared to all segments (31 percent below) as of June 2021 [6]. Because the revenue generated by business and long-haul international travelers is significantly more than domestic regular class passengers, airline revenue loss is still very substantial. According to Airlines for America [4], during the year 2020, despite an all-time high demand for air cargo, passenger airlines suffered $35B in net losses.

There is a good possibility that the recovery for personal and business air travel will look very different, as business travel has been historically shown to be less resilient to disruptions [7]. Additionally, it has been recognized that even a small reduction in business travel (5 to 10 percent) would have serious consequences for the aviation industry, as this type of travel is responsible for large portion of aviation profits [8]. The potential adverse long-term impacts of teleworking on business air travel has been acknowledged as a contributing factor to the pace of recovery. Industry professionals expect a longer recovery for meetings, conferences, and exhibitions, while sales-related trips may see a faster return [8, 7]. In the United States, a survey during Spring 2020 found that 34 percent of a highly educated nationwide sample expected a decrease in their post-pandemic business flying [9].

Although the impact of the pandemic on airlines' financial status is negative, the reduced air travel (especially long-haul international travel) is associated with a positive impact on emissions and the environment. COVID-19 pandemic has created some new realizations that could potentially persuade people to decrease their non-essential air travel, thanks to telecommunication technologies. A study in Canada, Russia, Switzerland, and the United States identified that there is a moderate to strong association between sustainable behaviors and sustainability attitudes among business flyers [10]. The effect of the pandemic on travel is driven by anxiety; thus as long as there is a desire to see a recovery in business travel, it can be expected that airlines will take action to reduce passengers' anxiety [10, 11]. Moreover, there is a positive correlation between high international travel frequency and COVID-19 biosecurity measures, such as wearing masks and physical distancing, in the US [12]. To restore confidence in travel, airlines have invested heavily in customer satisfaction with hygiene and enhanced-cleaning protocols as well as

contactless passenger journey stations across many platforms [13]. Two nationally recognized surveys show that customer satisfaction has reached an all-time high [5]. The question is to what extent new realizations about the effectiveness of telecommunications and the environmental benefits of reduced air travel will interact in the long-term with enhanced practices of the airline industry and the varied perspectives of employers, to shape the future of air travel.

Passenger preferences and their willingness to fly are important factors in understanding the effects of COVID-19 on human mobility behavior and air travel [14]. A study in Chicago during Spring 2020 revealed that 31 percent of respondents expected to decrease their air travel after COVID compared to their pre-pandemic levels [15]. Attitudes were significant predictors of expected air travel frequency post-pandemic. Conway et al. [9] found that extrovert flyers who enjoy working from home expected the largest decrease in air travel, both for leisure and for business. A study early in the pandemic identified that over 60 percent of passengers expected to travel by air within one year, but at a decreased frequency [16]. In a Serbian study during April 2020, researchers found that concerns about COVID-19 not only influenced vacation behavior, but also created travel anxiety [17]. The path moving forward is still unclear. There is both optimism and pessimism, with one author suggesting air travel might never get back to its pre-pandemic volumes [14]. To date, no study has thoroughly investigated the expected change in post-pandemic personal and business air travel (relative to pre-pandemic levels) on a national scale based on survey research.

This study presents an analysis of data from the COVID Future survey to extract relevant information on the stated reasons behind respondents' post-pandemic air travel expectations. Additionally, this study explores the effects of socioeconomic attributes, pre-pandemic behaviors, and lifestyle and COVID-related attitudes on expected air travel, with a view to shed light on how new realizations during the pandemic may alter people's long-term choices concerning personal and business air travel. To better understand this multivariate relationship, this study develops an Integrated Choice and Latent Variable (ICLV) model system with latent attitudinal variables. The main research question of this report is to explore the extent to which various COVID-related attitudes are responsible for the stated change in air travel while controlling for socioeconomics, current behaviors, and lifestyle attributes. This research will help provide a better understanding of the expected change in air travel demand for personal and business travel purposes after the pandemic across various segments of the population.

DATA

This study uses data from the first wave of the COVID Future Panel Survey [2,25]. The COVID Future Panel Survey is a nationwide longitudinal survey collecting information about travel-related behaviors and attitudes before, during, and after the COVID-19 pandemic. The sample includes 7,611 respondents from the entire US who completed the survey between June and October 2020. The data were weighted to replicate national distributions of age, education, gender, Hispanic status, household income, presence of children, and number of household vehicles (for details, see Chauhan et al., 2021). The survey questions cover a wide range of topics including (tele)commuting, daily travel, air travel, working from home, online learning, shopping, and COVID risk perception, along with attitudinal, socioeconomic, and demographic information. The survey is ongoing with multiple waves administered to the same respondents to monitor how behaviors and attitudes evolve during various stages of the pandemic. The dataset is publicly available with complete documentation at the ASU Dataverse (https://doi.org/10.48349/ASU/QO7BTC).

The COVID Future survey asked respondents about the frequency of their personal and

business air travel before the pandemic and their expected changes after the pandemic. Figure 1 summarizes the results of air travel frequency before and after the pandemic for personal and business purposes. In general, more than 30 percent of personal and business air travelers (with at least one air travel episode per year pre-pandemic) are expecting to decrease their frequency of air travel after the pandemic. However, 20 percent of frequent personal and business travelers are expecting to increase their air travel post-pandemic. Because of the observed variations in expectations to decrease or increase air travel after the pandemic, it is very important to see how these preferences vary across segments of the population defined by different attributes, attitudes, and behaviors.

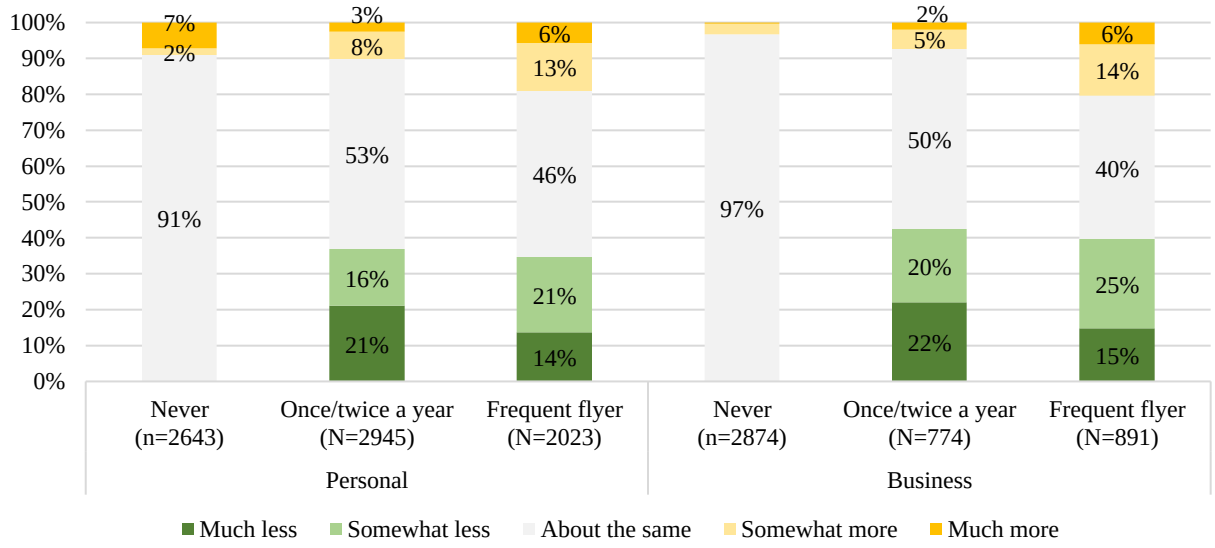

Figure 1 Expected Change in Air Travel after the Pandemic Among Flyers

Table 1 depicts the socioeconomic attributes of respondents based on their willingness to change their air travel frequency after the pandemic. Younger respondents are more inclined to increase their air travel while older people are more inclined to decrease or not change their air travel after the pandemic. This trend is observed for both air travel purposes but considerably more for business air travel. Males are more inclined to increase their personal and business air travel. The relationship between education and willingness to change post-pandemic air travel is also very interesting. People who completed high school are more inclined to increase personal and business air travel; the same is found for people with a graduate degree or higher. However, people with mid-level education are more inclined to decrease their air travel after the pandemic. Relationship between income and expected change in air travel after the pandemic is different between personal and business air travel. While higher-income people are more inclined to decrease their business air travel, they are more inclined to increase their post-pandemic personal air travel. On the other hand, lower-income people are more inclined to increase their business air travel and decrease their personal air travel after the pandemic. The vehicle ownership pattern is also similar to income. Lastly, expectation to decrease both personal and business air travel is more dominant among households with children present in the households. The impacts of socioeconomic attributes and attitudes will be explored in later sections of this report through a multivariate statistical model estimation effort.

Table 1 Demographic Characteristics of the Sample (Weighted Sample of Air Travelers)

		Personal Travel after COVID			Business Travel after COVID		
		Decrease	**No change**	**Increase**	**Decrease**	**No change**	**Increase**
Total sample size		1787	2493	688	682	744	239
Age	18-34 years	26%	26%	41%	21%	23%	46%
	35-49 years	25%	22%	28%	37%	36%	44%
	50-64 years	28%	32%	22%	32%	33%	9%
	65+ years	21%	21%	10%	10%	7%	1%
Gender	Female	49%	49%	39%	38%	31%	18%
	Male	51%	51%	61%	62%	69%	82%
Education	High school or Less	30%	27%	35%	10%	16%	26%
	Some college	30%	34%	24%	22%	25%	10%
	Bachelor's degree(s)	22%	23%	16%	35%	29%	18%
	Graduate degree(s)	19%	17%	25%	33%	29%	46%
Household annual income in 2019	Less than $25,000	5%	4%	5%	1%	2%	4%
	$25,000 to $74,999	20%	19%	17%	12%	14%	14%
	$75,000 to $124,999	36%	31%	34%	28%	28%	31%
	$125,000 or more	39%	45%	44%	59%	56%	51%
Household vehicles	0	6%	4%	6%	4%	3%	2%
	1	25%	19%	23%	23%	23%	31%
	2	40%	41%	41%	46%	46%	49%
	3	20%	25%	22%	22%	20%	13%
	4 or more	9%	10%	8%	6%	8%	5%
Presence of children	Not present	65%	64%	57%	49%	46%	34%
	Present	35%	36%	43%	51%	54%	66%

The COVID Future survey also asked about the reasons behind respondents' expectations to decrease or increase their post-pandemic air travel. Respondents could select up to three reasons for their selected choice in a multiple-choice question format. Table 2 summarizes the frequency of the selected reasons for the stated change in post-pandemic air travel. Some of the stated reasons are short-term including the lingering anxiety about the coronavirus (leading to an expectation of decrease in air travel) or compensation for the stay-at-home period (leading to an expectation of increase in air travel). Some other reasons are more long-term and related to new realizations due to the pandemic such as the effectiveness of online business meetings. There are also other reasons, such as changes in commitments or financial situations.

The most frequent reason, which was selected by 66 percent of people, stated for an expectation of decrease in post-pandemic personal air travel is related to COVID-19 risk perception ("I will not feel safe or comfortable sharing close space with strangers"). While this reason seems short-term and people are expected to eventually transition to a new norm after the pandemic, it is not yet known when people will truly feel safe even when COVID-19 is not considered a threat. The other selected reasons for the decrease in personal air travel after the pandemic exhibit considerably lower frequencies. On the contrary, among the respondents who stated that they are going to increase their personal air travel (post-pandemic), 47 percent chose

short-term reasons such as “After having been cooped up at home for so long, I want to travel more than I did before” and similarly 47 percent chose “I will need/want to take trips that were canceled during the COVID-19 pandemic”. It is expected that these reasons will fade over time when society reaches a new norm and people compensate for the lack of travel during the pandemic.

Among the people who indicated an expectation to decrease their post-pandemic business air travel, the top two reasons are very much related to long-term new realizations in the wake of the pandemic. Close to one-half (47 percent) of the business flyers have selected “Those I meet with have realized that we can conduct meetings by conference call” and similarly 45 percent have selected “I realized I could conduct my meetings by conference call/video conference”. Among the respondents who indicated an expectation to increase business air travel after the pandemic, the top reason selected by more than three-quarters is due to a need to compensate for reduce air travel during the pandemic (“I want/need to take trips that were canceled during the COVID-19 pandemic”). Additionally, 59 percent of business flyers selected change in job responsibilities as one reason for their expected increase in business air travel.

In summary, while the top reasons for the decrease and increase in personal air travel and increase in business air travel are more short-term in nature, the top reasons for the *decrease* in business air travel are more *long-term* and more likely to stick in the future.

Table 2 Reasons for Increase and Decrease in Air Travel after the Pandemic

	Reasons	Percent
Decrease in Personal Air Travel (n=1787)	I will not feel safe or comfortable sharing close space with strangers	66%
	I anticipate taking more of my long-distance trips by car	29%
	My financial circumstances changed and I can no longer afford to travel in the same way	22%
	I want to spend more time at home	18%
	I am able to use technology to meaningfully engage with long-distance connections	12%
	I want to fly less for environmental reasons	9%
	I anticipate taking more of my long-distance trips by train or bus	3%
Increase in Personal Air Travel (n=687)	After having been cooped up at home for so long, I want to travel more than I did before	47%
	I will need/want to take trips that were canceled during the COVID-19 pandemic	47%
	My financial circumstances changed and I can now afford more air travel	25%
Decrease in Business Air Travel (n=682)	Those I meet with have realized that we can conduct meetings by conference call	45%
	I realized I could conduct my meetings by conference call/video conference	43%
	I don't feel safe or comfortable sharing close space with strangers.	36%
	I expect a reduced budget for travel	35%
	My employer adopted a commitment to reduce travel by airplane	20%
	My job responsibilities have changed	16%
	I want to spend more time at home	10%
	I anticipate taking more of my long-distance trips by car	10%
	I want to fly less for environmental reasons	9%
	I anticipate taking more of my long-distance trips by train or bus	3%
Increase in Business Air Travel (n=239)	I want/need to take trips that were canceled during the COVID-19 pandemic	79%
	My job responsibilities have changed	59%

METHODOLOGY

The COVID Future survey was tailored to collect multi-wave nationwide data about travel behavior choices before, during, and after the pandemic [25]. Two subsets of the sample were selected for studying personal and business air travel trends. To understand personal air travel changes, the first subsample included respondents who traveled by air for leisure at least once a year pre-pandemic and did not travel for business purposes before the pandemic (n=2677**)**. This subsample includes both non-workers, as well as workers who did not fly for work but did so for leisure. To better understand business air travel changes, only workers who traveled by air (prior to the pandemic) for work at least once a year were considered (n=1158). As the interrelationship between personal and business travel was of interest to this study, only workers who also traveled by plane for leisure were included in the analysis. The number of business travelers who did not travel for leisure in the pre-pandemic era is extremely small (n=20), and hence excluded from the analysis.

Model Formulation

To simultaneously model the relationships between the response variables (change in personal and business air travel in the ordered form of decrease, no change, and increase), explanatory socioeconomic and pre-pandemic travel behavior variables, and latent attitudinal constructs, the integrated choice and latent variable (ICLV) model structure has been applied with some modifications. The ICLV model structure which has been proposed and applied for an unordered choice variable in the literature [26, 27] has been modified to accommodate multiple correlated ordered choices as needed for this study [18]. Suppose there are "I" correlated ordered choice variables "c_i" (i = 1, 2, …, I) and their latent utility functions u_i^* are formulated as:

$$u_i^* = x_i\beta_i + z^*\gamma_i + e_i. \quad (1)$$

In the above formula, x_i is a row vector of observed explanatory variables and z^* is a row vector of latent psychological factors while β_i and γ_i are two column vectors of coefficients in the respective utility function. e_i is a random component in each utility function and assumed to follow a standard multivariate normal distribution associated with a symmetric correlation matrix as:

$$cr = \begin{bmatrix} 1 & cr_{12} & \dots & cr_{1I} \\ cr_{12} & 1 & \dots & \dots \\ \dots & \dots & 1 & cr_{I-1,I} \\ cr_{1I} & \dots & cr_{I-1,I} & 1 \end{bmatrix}. \quad (2)$$

The utility function value of u_i^* will determine an ordered choice variable, denoted as c_i, based on comparisons against a number of ordinal thresholds, denoted as $\psi_{i,0}, \psi_{i,1}, \dots \psi_{i,M_i}$ ($\psi_{i,0} < \psi_{i,1} \dots < \psi_{i,M_i}$). Among those $(M_i + 1)$ thresholds, $\psi_{i,0} = -\infty$ and $\psi_{i,M_i} = +\infty$. When $\psi_{i,m-1} < u_i^* < \psi_{i,m}$, the ordered choice variable c_i takes the value "m" from the choice set {1,2,…, M_i}. Note that a binary choice can be considered as a special case of ordered choices, where M_i takes the value of "2" and the choice set is {1, 2}. In Equation (1), the row vector of latent psychological factors z^* contains "J" elements, each of which can be denoted as z_j^* (j = 1, 2, …, J) and formulated as:

$$z_j^* = w_j\alpha_j + \eta_j. \quad (3)$$

In the above formula, w_j is a row vector of observed variables to explain z_j^* and α_j is a column vector of coefficients. η_j is a random component in the model and assumed to follow a standard multivariate normal distribution associated with a symmetric correlation matrix as:

$$zr = \begin{bmatrix} 1 & zr_{12} & \dots & zr_{1J} \\ zr_{12} & 1 & \dots & \dots \\ \dots & \dots & 1 & zr_{J-1,J} \\ zr_{1J} & \dots & zr_{J-1,J} & 1 \end{bmatrix}. \quad (4)$$

Each latent psychological factor z_j^* can influence one or more latent propensity function values, which in turn determine the same number of observed ordinal indicators (e.g., the extent to which one agrees with a certain statement). In total, there are "K" such latent propensity function values, which are denoted as $y_1^*, y_2^*, \dots, y_K^*$ and laterally combined to form a row vector y^*. The relation between z^* and y^* can be expressed as:

$$y^* = z^* \cdot \mathrm{z2y} \cdot d + \xi. \quad (5)$$

In the above formula, "$z2y$" is a dummy matrix of J rows and K columns, indicating whether a factor in z^* influences a latent propensity value in y^*. When an element in jth row and kth column of the matrix takes the value of "1", the jth factor in z^* does influence the kth propensity value in y^*. When it takes the value of "0", there is no influence. For example, $z2y = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, indicating that there are two psychological factors and three ordinal indicators, where the first factor influences the first and second propensity values and the second factor influences the third value. Then, d is a column vector of K loading factors while ξ is a row vector of random components following an independent standard normal distribution. The propensity function values of y_k^* will determine an observed ordinal indicator, denoted as y_k, based on comparisons against a number of ordinal thresholds, denoted as $\theta_{k,0}, \theta_{k,1}, \dots \theta_{k,N_k}$ ($\theta_{k,0} < \theta_{k,1} \dots < \theta_{k,N_k}$). Among those $(N_k + 1)$ thresholds, $\theta_{k,0} = -\infty$ and $\theta_{k,N_k} = +\infty$. When $\theta_{k,n-1} < y_i^* < \theta_{k,n}$, the ordinal indicator takes the value "n" from the set $\{1,2,\dots, N_k\}$.

The latent variables in Equations (3) can be substituted into Equations (1) and (5) to obtain new equations suitable for model estimation. In the interest of brevity, further details on the mathematical formulation are suppressed. The composite log-likelihood function and its analytical gradient are coded in Gauss matrix programming platform, where the composite log-likelihood function can be maximized to consistently estimate coefficients and a sandwich robust covariance matrix can be computed for drawing inferences on estimators.

ICLV Modeling Structure: Business and Personal Travel

Figure 1 depicts the ICLV modeling framework for business and personal air travel expectations. The endogenous variables are post-COVID expectations about change in personal and business air travel in the ordered format of decrease, no change, and increase. The exogenous variables consist of respondents' socioeconomic variables and general attitudes, location (Urban, Suburban, Rural), and pre-COVID behaviors. The impacts of the exogenous variables on the response variables are modeled directly and indirectly through the two intermediate latent attitudinal constructs which are labeled as "COVID New Work Modality", and "COVID Response".

The latent attitudinal constructs' role is to reflect contributing factors that are not included in the exogenous set of variables. The first latent attitudinal construct labeled "COVID New Work Modality" relates to the new realizations of work from home [18]. The most transformative long-term change identified in the COVID Future data is a large increase in telecommuting. The fraction of workers who expect to telecommute at least a few times each week has doubled from that of the pre-pandemic period, increasing from 13% to 26% (Salon et al., 2021). This increased work-from-home trend can impact business travel significantly in the long-term when employers and employees embrace online meetings in place of in-person meetings. In this study "COVID New Work Modality" latent construct has been measured by the level of agreement with two statements: "I like working from home"; and, "Video calling is a good alternative to in-person meeting".
The second attitudinal latent construct "COVID Response" is related to people's attitudes toward the mitigation policies aimed at curbing the spread of the virus [19]. COVID-19 has led to decreased air travel as well as other types of travel due to policies and guidelines such as prohibited interstate or international travel, masking requirements, and proof of negative COVID test before boarding an aircraft (besides anxiety among the public about health effects). The proposed modeling framework includes perceptions about pandemic mitigation strategies; the latent construct is labeled "COVID Response". It is expected that people who have followed COVID protocols and did not travel during the pandemic may have a greater inclination to increase their post-pandemic air travel, especially for personal reasons. The "COVID-response" latent construct is based on the level of agreement with three statements: "Community is well prepared for the disaster", "Shutting down businesses due to the COVID-19 is not worth the economic damage", and "Society is overreacting to the virus". Relationships between the exogenous, latent, and endogenous variables are shown with arrows in Figure 2. The two latent constructs are related to each other via an error correlation.

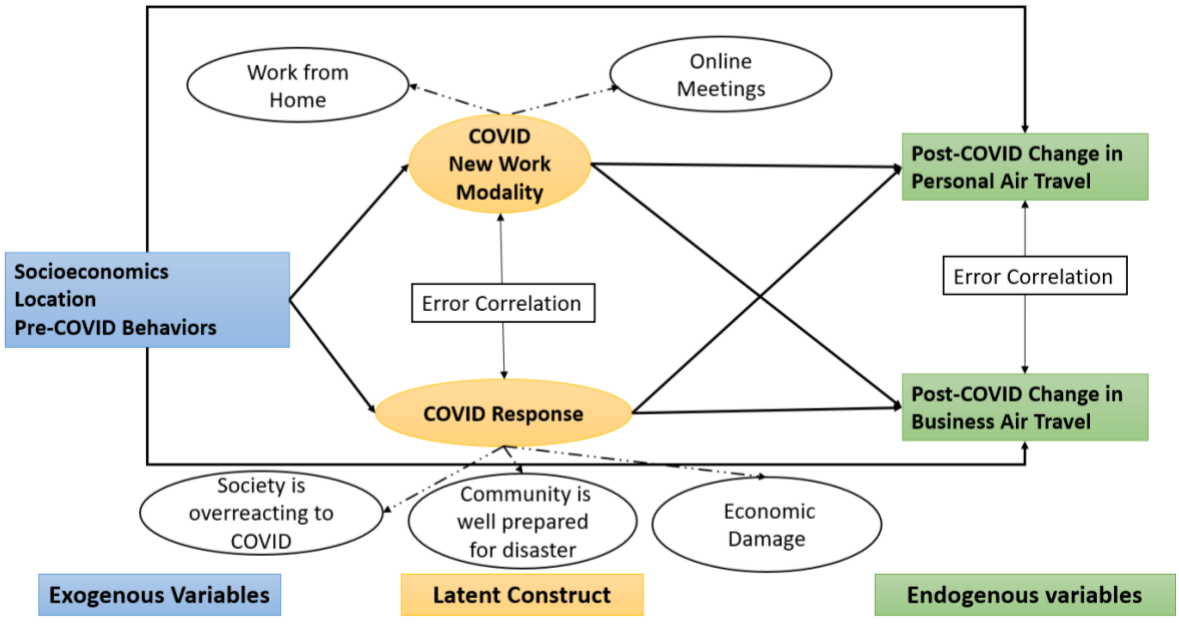

Figure 2 Proposed ICLV Modeling Framework for Business and Personal Air Travel

ICLV Modeling Structure: Personal-only Travel

A similar modeling framework is adopted to model personal air travel expectations for the subsample with zero business travel before the pandemic (n=2677). The framework is shown in Figure 3. Compared to the model framework in Figure 2, the response variable is limited to only personal air travel change. This model also has two latent constructs. The "COVID Response" latent construct is the same as that explained previously. The other latent construct is labeled "Virtual Connection" which is capturing the extent to which people rely on technology to connect with their family and friends in place of in-person traveling. "Virtual Connection" latent construct is based on responses to two statements: "Using new technologies is often frustrating for me"; and "Video calling is a good alternative to visiting friends and family".

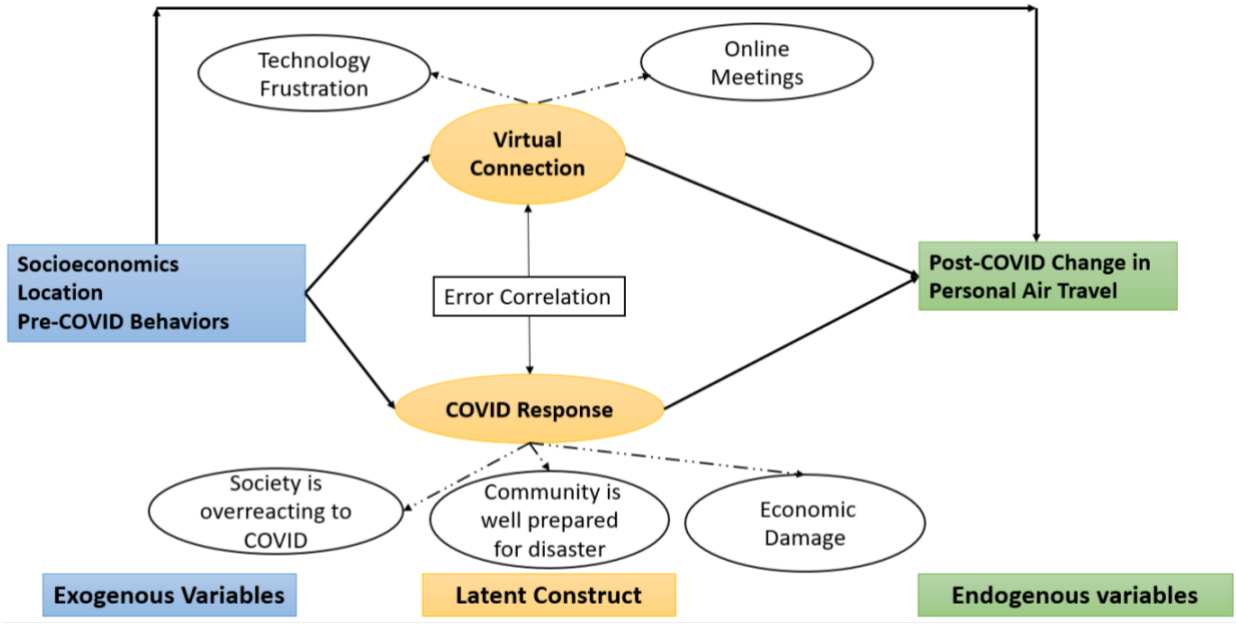

Figure 3 Proposed ICLV Modeling Framework for Personal Air Travel

MODEL ESTIMATION RESULTS

This section presents model estimation results for the two frameworks.

Business and Personal Travel Model

The ICLV model estimation results for 1152 workers who have at least one personal and one business air trip before the pandemic are presented here. The latent constructs measurement model estimation results depicting factor loadings and the effects of socioeconomic attributes on latent attitudinal constructs are suppressed in the interest of brevity. In general, the latent construct model component yielded results consistent with expectations and significant factor loadings. A brief discussion is presented below.

"COVID New Work Modality", and "COVID Response" are the two latent constructs hypothesized to significantly impact the expected change in air travel. "COVID New Work Modality" captures the amplified trend of work from home that started during the pandemic but is expected to stay at elevated levels even after the pandemic. "I like working from home", and "Video calling is a good alternative to in-person meetings" exhibit positive factor loadings on "COVID New Work Modality". Being female and/or frequent business traveler both positively

impact the "COVID New Work Modality" construct while being young (18-29 years old) negatively impacts this factor. This implies that younger workers are not as interested as older generations to work from home. Younger individuals may not have the flexibility to work remotely and may desire socialization that comes with working on-site. Women and frequent travelers are clearly more inclined to take advantage of telecommunication to gain work-life balance.

The other latent construct "COVID Response" deals with how people perceive COVID response strategies including staying at home. "Society is overreacting to the virus"; "Shutting down business due to COVID-19 is not worth the economic damage"; and "Community is well prepared for disaster" are all loading positively on the "COVID Response" construct. This definition implies that a higher score for the factor is associated with negative perceptions of COVID response strategies that emphasize lockdowns and stay-at-home orders. Females, people with zero vehicles, and people who experienced a decrease in income during the pandemic are associated more negatively towards the "COVID Response" factor, which means that these groups are more inclined to travel less and stay at home during the pandemic. However, people with negative COVID test and frequent pre-pandemic personal travel depict a higher level of the "COVID Response" latent factor, which means that they are more inclined to travel and not stay at home.

The direct effects of explanatory variables and latent constructs on the response variables of interest are presented in Table 3. The "COVID New Work Modality" latent construct significantly increases the likelihood of a decrease in post-pandemic business air travel. However, the "COVID Response" latent construct significantly increased the likelihood of higher post-pandemic business as well as personal air travel. People with higher scores on the "COVID Response" factor essentially disagree with stay-at-home policies and are more inclined to travel for both business and personal reasons. The expected changes in personal and business air travel exhibit a positive error correlation, implying that people are more likely to change air travel for both purposes in the same direction.

It is found that older people (45+ years) are more likely to decrease their post-pandemic business and personal travel. Those who were infrequent travelers prior to the pandemic are more likely to decrease air travel in the respective purposes (relative to those who were frequent pre-pandemic air travelers). White people, graduate degree holders, and people whose income has gone up during the pandemic are more likely to increase their post-pandemic personal and business air travel. While urban dwellers are more likely to increase their post-pandemic business air travel, high-income people are more likely to increase their personal air travel after the pandemic (although the effect is statistically insignificant).

Table 3 Business and Personal Travel ICLV Model Estimation Results (Direct Effects)

	Change in Personal Air Travel (Less/Same/More)		Change in Business Air Travel (Less/Same/More)	
Explanatory Variable	**Coef**	**t-stat**	**Coef**	**t-stat**
Graduate Degree	0.13	1.80	0.11	1.40
Age 45-59 years	-0.15	-1.94	-0.29	-3.52
Age 60+ years	-0.25	-2.55	-0.43	-3.99
Household Income Gone up	0.34	3.61	0.47	4.63
White	0.19	2.00	0.12	1.30
Infrequent Personal Travel Pre-Pandemic	-0.13	-1.97		
Infrequent Business Travel Pre-Pandemic			-0.10	-1.45
Urban Resident			0.06	1.85
Household Income: $100,000 and above	0.08	1.06		
General Attitudes				
I like seeing people and having people around me	0.19	2.25		
Learning new technology is frustrating for me			0.16	2.13
Attitudinal Latent Constructs				
COVID New Work Modality			-0.29	-2.67
COVID Response	0.14	1.94	0.38	5.52
Error Correlation				
Change in Personal Air Travel	NA		0.64	19.74
Thresholds				
Threshold 1-1	-0.11	-0.90		
Threshold 1-2	1.29	9.96		
Threshold 2-1			-0.23	-1.97
Threshold 2-2			1.31	10.94

Goodness-of-fit Statistic: pseudo R-squared = 0.1025 (N=1152)

Personal Travel Only Model

The ICLV model estimation results for 2677 respondents (workers and nonworkers) who have at least one personal air trip before the pandemic, *but no business air travel*, are presented in Table 4. The results of the latent constructs measurement model estimation depicting factor loadings and effects of socioeconomic attributes on latent constructs have been suppressed in the interest of brevity. A brief discussion of the results for the latent factor components of the model system is presented below.

The two latent constructs that were hypothesized to significantly impact post-pandemic personal air travel are “Virtual Connection” and “Covid Response”. Intuitively, people who agree with the effectiveness of video calling get higher scores for this latent construct. However, people who are not very technology-savvy also are getting high scores for the “Virtual Connection” latent construct. This implies that the barrier to using video-meeting technology is not high at all; individuals who are not tech-savvy are quite comfortable using such technology to connect with family and friends. In fact, older people (60+ years old) and low-income people ($50,000 and less) – who are generally considered less tech-savvy – exhibit higher “Virtual Connection” latent factor scores.

Similar to the previous model, people with higher scores corresponding to “COVID Response” are less in favor of stay-at-home policies. They do not believe that society is prepared for disasters. While low-income households ($50,000 and less) are positively associated with

"COVID Response" (and hence not in favor of staying home), older (60+ years old) and highly educated individuals are more in favor of staying home and cautionary COVID response policies. Intuitively, the two latent constructs "Virtual Connection" and "COVID Response" are significantly and negatively correlated through the error covariance. This implies that people who take advantage of virtual connections are more agreeable with cautionary COVID response and stay-at-home policies.

The direct effects of explanatory variables and latent constructs on the response variables are presented in Table 4. "Virtual Connection" negatively impacts post-pandemic personal air travel (although the effect is statistically insignificant). In line with the expressed hypothesis, people who are taking advantage of telecommunication platforms are more likely to decrease their personal air travel after the pandemic. However, "COVID Response" has a positive impact on the response variable. Again, consistent with expectations, people who are less favorable towards stay-at-home policies are more likely to engage in travel post-pandemic.

Model estimation results reveal that younger people (18-29 years old), high-income ($100,000 and above) individuals, frequent pre-pandemic air travelers, and people with zero vehicle ownership are less likely to decrease their post-pandemic personal air travel. However, respondents who have kids, workers (no pre-pandemic business travel), and people whose income has gone down during the pandemic, are more likely to decrease their post-pandemic personal air travel. People who like being outside are more inclined to increase their personal post-pandemic air travel (although the effect is statistically insignificant). People who engaged in online shopping during the pandemic and are interested in continuing to do so after the pandemic are less likely to increase their post-pandemic air travel. This finding once again highlights the significant effects of new realizations (regarding substitution of virtual for physical activities) on people's expectations regarding air travel in the post-pandemic period.

Table 4 Personal-only Travel ICLV Model Estimation Results (Direct Effects)

	Change in Personal Air Travel (Less/Same/More)	
Explanatory Variable	**Estimate**	**t-stat**
Age 18-29 years	0.16	2.44
Household Income: $100,000 and above	0.13	2.53
Presence of Household Kid(s)	-0.08	-1.58
Worker (no pre-pandemic business travel)	-0.07	-1.48
Frequent Personal Traveler Pre-Pandemic	0.38	1.89
Zero Vehicle Ownership	0.25	1.77
Income Gone Down	-0.11	1.75
Continue to Shop Online More after the Pandemic	-0.18	-2.87
I Like Being Outside (Attitudinal Statement)	0.07	1.26
Attitudinal Latent Construct		
Virtual Connection	-0.04	-1.33
COVID Response	0.15	2.07
Thresholds		
Threshold 1-1	-0.40	-5.48
Threshold 1-2	1.24	17.17

Goodness-of-fit Statistic: pseudo R-squared = 0.14 (N=2676)

STUDY IMPLICATIONS AND CONCLUSIONS

This report studied the expected change in post-pandemic personal and business air travel using the first wave of COVID Future longitudinal survey data from across the US [20]. The survey data indicates that 40 percent of pre-pandemic frequent business flyers are expected to decrease their air travel after the pandemic, while 20 percent are expected to increase. Similarly, 35 percent of frequent personal flyers are expected to decrease their air travel after the pandemic, while 19 percent are expected to increase. Among the air travel trends, the decreasing trend in business air travel seems to be more substantial and long-term based on the airline industry data as well as the COVID Future survey data. This is likely to hold true because close to half of the people who stated that they are going to decrease their business air travel selected reasons that are related to new work modality realizations. The reasons for a change in post-pandemic personal air travel are more short term in nature (e.g., compensate for not traveling during the pandemic or lingering safety concerns about the virus), and unlikely to affect air travel in the long term.

To better understand the underlying factors impacting respondents' expectations about post-pandemic air travel, two separate econometric model structures were estimated to simultaneously model the expected change in post-pandemic personal and business air travel as a function of latent attitudinal constructs and general socioeconomic and demographic variables. The model formulation can accommodate multiple dependent variables and latent constructs. Three latent constructs representing "COVID New Work Modality", "COVID Response", and "Virtual Connection" were defined and incorporated in the model systems. Positive attitudes toward the new remote work modality increase the likelihood of engaging in less business air travel after the pandemic (for workers). For personal travel, positive attitudes toward "virtual connection" increase the likelihood of lower post-pandemic personal air travel. However, negative attitudes toward cautionary COVID-19 response strategies decrease the likelihood of engaging in less personal and business air travel after the pandemic.

Socioeconomic variables and general attitudes also directly or indirectly impact expected post-pandemic air travel. The model estimation results can be used to identify population subgroups who are likely to increase or decrease air travel in the post-pandemic era. In general, young and higher income individuals who also traveled prior to the onset of the pandemic expect to engage in more post-pandemic travel. The existing and expected-to-continue switch from business travel to online teleworking and video communication can result in tremendous savings in time, energy, emissions, and monetary costs of travel. This is very promising for the environment and addressing climate change. On the other hand, a long-term decrease in business air travel can severely impact airline revenue. Business-class travelers account for 12% of airline passengers, but a much higher percent of profits. In fact, on some flights, business passengers represent 75% of an airline's revenue. However, this decrease in revenue may be partially made up through a significant increase in freight transportation during the pandemic. Before the pandemic, cargo typically made up around 12 percent of the sector's total revenue; that percentage tripled last year [McKinsey Study]. The findings of this study suggest that airlines will need to seek alternative revenue sources to make up for the loss of business air travel, which is likely to persist over the long-term.

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