THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

**TECHNICAL REPORT 0-7054-1**
TxDOT PROJECT NUMBER 0-7054

# Incorporation of Stated Preference and Revealed Preference Methods in Regional Travel Survey Programs: Final Report

Katherine Asmussen
Katherine Dannemiller
Aupal Mondal
Lisa Macias
Sarah McGavick
Chandra Bhat

Published October 2022

https://library.ctr.utexas.edu/ctr-publications/0-7054-1.pdf

# Technical Report Documentation Page

| 1. Report No.<br>FHWA/TX-22/0-7054-1 | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| 4. Title and Subtitle<br>Incorporation of Stated Preference and Revealed Preference Methods in Regional Travel Survey Programs: Final Report | | 5. Report Date<br>Submitted: July 2022<br>Published: October 2022<br>6. Performing Organization Code |
| 7. Author(s)<br>Katherine Asmussen<br>Katherine Dannemiller<br>Aupal Mondal<br>Lisa Macias<br>Sarah McGavick<br>Chandra Bhat, https://orcid.org/0000-0002-0715-8121 | | 8. Performing Organization Report No.<br>0-7054-1 |
| 9. Performing Organization Name and Address<br>Center for Transportation Research<br>The University of Texas at Austin<br>3925 W. Braker Lane, 4th Floor<br>Austin, TX 78759 | | 10. Work Unit No. (TRAIS)<br>11. Contract or Grant No.<br>0-7054 |
| 12. Sponsoring Agency Name and Address<br>Texas Department of Transportation<br>Research and Technology Implementation Division<br>125 E. 11th Street<br>Austin, TX 78701 | | 13. Type of Report and Period Covered<br>Technical Report<br>January 2020 – August 2022<br>14. Sponsoring Agency Code |
| 15. Supplementary Notes<br>Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration. | | |
| 16. Abstract<br>Transportation plans must consider the inevitable introduction of new emerging technology and must be able to assess the impacts of proposed transportation policies and large-scale infrastructure projects. To address this need, it is important to incorporate SP questions within travel surveys. This project demonstrated state-of-the-art SP techniques and recommends the addition of SP experiments to existing traditional household travel surveys to enhance the surveys' use for long-term travel forecasts. It included the development of a practical methodology for creating an integrated RP-SP travel survey in the form of a guidebook. This methodology was exemplified by the design, deployment, and analysis of an RP-SP survey, which included an SP experiment on workplace location choices in scenarios where the effects of COVID-19 begin to wane. The research shows that SP experiments and RP-SP surveys are an important tool to provide information for a future that may substantially differ from today, and suggests that the hybridization of workplaces will persist into the future. | | |
| 17. Key Words<br>Transportation, Economic and Social Factors, Survey Design, Stated Preference, Revealed Preference | 18. Distribution Statement<br>No restrictions. This document is available to the public through the National Technical Information Service, Alexandria, Virginia 22312; www.ntis.gov. | |

| 19. Security Classif. (of report)<br>Unclassified | 20. Security Classif. (of this page)<br>Unclassified | 21. No. of pages<br>280 | 22. Price |
|---|---|---|---|

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

THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

# Incorporation of Stated Preference and Revealed Preference Methods in Regional Travel Survey Programs: Final Report

Katherine Asmussen
Katherine Dannemiller
Aupal Mondal
Lisa Macias
Sarah McGavick
Chandra Bhat

| | |
|---|---|
| CTR Technical Report: | 0-7054-1 |
| Report Date: | Submitted: July 2022 |
| Project: | 0-7054 |
| Project Title: | Integration of Stated Preference and Revealed Preference Methods in Regional Travel Survey Programs |
| Sponsoring Agency: | Texas Department of Transportation |
| Performing Agency: | Center for Transportation Research at The University of Texas at Austin |

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Center for Transportation Research
The University of Texas at Austin
3925 W. Braker Lane, 4th floor
Austin, TX 78759

http://ctr.utexas.edu/

## Disclaimers

**Author's Disclaimer**: The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation.

**Patent Disclaimer**: There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine manufacture, design or composition of matter, or any new useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

## Engineering Disclaimer

NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

Project Engineer: Chandra Bhat
Professional Engineer License State and Number: Texas No. 88971
P. E. Designation: Research Supervisor

## Acknowledgments

The authors gratefully acknowledge the financial support provided for this project by the Texas Department of Transportation (TxDOT). The authors would like to thank Tom Schwerdt, Christeen Pusch, Geena Maskey, Ibrahima Tembely, Janie Temple, Sonya Solinsky, and Chad Coburn of TxDOT for their support and constructive advice throughout this project.

## Products

**P1 - Excel workbook tabulating different aspects of past integrated RP-SP surveys**

**P2 – Preliminary Guidebook**

**P3 – Final Guidebook**

**P4 – Workshop materials (presentation)**

# Table of Contents

# List of Tables

## List of Figures

# Chapter 1. Synthesis of current travel survey practice and identification of Stated Preference integration into survey data collection

## 1.1. Introduction

Regional metropolitan planning organizations (MPOs) throughout Texas rely on the Texas Department of Transportation's (TxDOT's) household travel surveys to acquire data that informs travel forecasting models. As with most household travel surveys undertaken by MPOs and DOTs, TxDOT elicits travel information from respondents using Revealed Preference (RP) questions. RP questions seek information on observed activity-travel characteristics of respondents in the context of *currently available travel options*. For example, in a mode choice context, an RP question may relate to the travel mode used by a worker to travel to her or his primary workplace. While such RP questions provide important information, they do not provide information for a future that may substantially differ from today, in terms of potential new travel technologies/options or new travel policies. For example, one new travel technology/option on the horizon is autonomous vehicles (vehicles that can drive without human intervention). A new travel policy under consideration may be an area-based congestion pricing scheme that imposes a fee on individuals who drive alone in their cars as they enter a specific congested area of a city. In such cases, the emphasis is on understanding how individuals may respond to currently unavailable technologies/options or currently un-imposed policies. RP data alone are not adequate to inform travel demand patterns in these potentially new contexts. However, transportation plans must consider the inevitable introduction of new emerging technology and must be able to assess the impacts of proposed new transportation policies and large-scale infrastructure projects. In addressing this need, it becomes important to incorporate Stated Preference (SP) questions within travel surveys. SP questions record the decision made by survey respondents in the context of hypothetical scenarios that have not yet materialized, providing essential information about impacts, cost-benefit analysis and social acceptance for future transportation projects and plans. This need for integrating SP questions with RP questions in travel surveys is increasingly being recognized by the transportation demand practitioner community in the current era of rapid change. In this regard, it is critical that TxDOT surveys integrate RP as well as SP questions, so that travel

demand models (TDM) for Texas metropolitan areas are able to consider the wide gamut of future possibilities and make good travel predictions.

## 1.2. Status of travel surveys administered by TxDOT

Currently, in Texas, TxDOT's Transportation Planning and Programming Division (TxDOT-TPP) is responsible for TDM development to support the regional long-range plan update and associated long-range planning activities of 20 of the 23 Texas Urban areas. The three Texas MPOs that TxDOT-TPP does not assist with model development are the Dallas-Ft. Worth, El Paso, and Houston-Galveston MPOs. Also, TxDOT-TPP is responsible and/or deeply involved in survey data collection to support TDM development in every MPO in the state. The two types of surveys that are most important to providing inputs for urban TDMs are household travel surveys and establishment surveys (the next section expands on the survey types TxDOT administers). *Household travel surveys* are typically employed to gather travel patterns and characteristics of the residents in the area, as well as collect the information on socio-economic characteristics of a sample of individuals and households residing in the urban region. *Establishment surveys*, formerly the workplace and commercial vehicle surveys, collect information on travel generated by local establishments and commercial vehicle drivers, rather than an individual and their household's travel. TxDOT used to conduct roadside external station surveys to gather data on traffic into, out of, and through the urban region; however, now they purchase passive data for external travel information. Together, household travel surveys, the focus of this report, combined with establishment surveys, external data purchases, and travel counts, provide the means to forecast travel in urban areas, both due to the travel of urban area residents and the travel of other individuals and commercial traffic on area roadways.

As previously stated, TxDOT administers data collection programs for household travel surveys, establishment surveys, and external station surveys in each MPO—one of the strongest and most consistent programs in the United States. These programs are structured to provide updated travel survey data for each metropolitan area for each decade. Table 1.1 shows the year in which TxDOT began to deploy the latest household travel survey for each MPO. It is important to note that the years reflected in the table below are when the data collection began, not when the data was made available to the MPO. Reports take some time to finalize and are published to the TxDOT website regularly.

**Table 1.1 TxDOT household travel survey data collection year**

| MPO | Year Data Collection Began |
|---|---|
| Abilene | 2021 |
| Amarillo | 2021 |
| Austin | 2016 |
| Beaumont-Port Arthur | 2008 |
| Bryan-College Station | 2011 |
| Corpus Christi | 2009 |
| Dallas-Fort Worth | N/A |
| El Paso | 2010 |
| Houston-Galveston | 2007 |
| Killeen-Temple | 2021 |
| Laredo | 2018 |
| Longview | 2016 |
| Lubbock | 2006 |
| Midland/Odessa | 2016 |
| Rio Grande Valley | 2016 |
| San Angelo | 2014 |
| San Antonio | 2021 |
| Sherman-Denison | 2011 |
| Texarkana | 2014 |
| Tyler | 2016 |
| Victoria | 2010 |
| Waco | 2021 |
| Wichita Falls | 2021 |

Each report is used as TxDOT's reference to best respond to individuals and businesses, as the agency diligently maintains and improves transportation systems all over the state. In this context, over the past decade, new technologies and new environmental and various other policy measures have been emerging and are likely to become reality in the not-too-distant future. Though some technology and trends unimaginable in the mid-2000s are thoroughly integrated into transportation systems today, many remain only vaguely imagined for the public. Therefore, in the future, if deployed household travel surveys are limited to RP questions, TDMs would be substantially hampered in their ability to predict demand patterns in these potentially new futures. This situation may be addressed through the inclusion of SP questions into TxDOT's household travel surveys.

It is important to note that RP questions should not be eliminated as a method to collect travel data. RP data have been collected for many decades now and serve as the building block in TDMs to forecast traffic in a region. They also serve as anchors to ensure that the SP responses (made in the context of hypothetical scenarios) are reasonably consistent with the actual RP-based travel behaviors

manifested by individuals (Loomis, 2011). That is, it is necessary to "ground" the SP data on an RP component. Most current TxDOT household and workplace surveys already include one SP question: *If passenger rail services were available to Dallas-Ft. Worth, San Antonio or to Houston, would you use rail to travel to any of these?* This is a good start on TxDOT's behalf towards addressing potential future scenarios; however, SP questions can be integrated into their surveys in countless additional scenarios. Table 1.2 summarizes RP questions currently included in TxDOT's household travel surveys that should be retained in future surveys to "ground" the SP data.

**Table 1.2 Typical RP questions in current TxDOT household travel surveys**

| ***Part Number*** **Information Type** | ***Part One*** **Instructions** | ***Part Two*** **General Information** | | ***Part Three*** **Travel Diary (For 10 trips)** | | |
|---|---|---|---|---|---|---|
| Information | • All locations beginning at 3 a.m.<br>• Age<br>• Travel day/date | *Work Information*<br>• Number of jobs<br>• Industry<br>• How many days in the last week did you work from home?<br>• Location of workplace<br>• In-home or out-of-home business | *Bike Use*<br>• How many days in the last week did you bike?<br>• Most common purpose | • Time arrived<br>• Name of location<br>• Type of place<br>• Address and intersection streets<br>• Did you walk more than a block from parking lot/bus stop<br>• Was this the primary transportation to get there? | *If car/truck/van*<br>• Driver or passenger<br>• Total people in vehicle<br>• Number of people from household in vehicle<br>• Carpool?<br>• Year and make/model of vehicle<br>• Household vehicle?<br>• Amount paid to park | • What did you do at the location?<br>• When did you leave?<br>• Last place you went today |

MPOs in Texas and all over the world rely on data collected through RP questions such as those listed in Table 1.2 to acquire travel data. As just indicated, these RP questions are important to preserve in any survey that includes SP questions. To reiterate, we summarize the nature and value of each type of question (RP and SP), and then discuss the advantage of integrating both types of questions in a single survey.

Only RP data: RP data correspond to actual travel behavior data and represent important information about preferences. Thus, models of activity-travel patterns (including travel generation, activity participation location, travel mode, time-of-day, and route choice) are typically based on RP. However, there are two limitations of RP data for predicting the impacts of new technologies/options and policies. First, if the RP data is from an environment with no current availability of a service or a policy, use of RP data implies an assumption that the behaviors and responsiveness of individuals will not change due to a dramatically changed environment. Second, it is difficult to obtain precise parameters characterizing behavior due to inadequate observed variation in, and high correlation among, exogenous variables of interest (such as times and costs).

Only SP data: SP data refer to self-stated choices in response to controlled exposures to packages of different service levels (even if non-existent today) or policies. The controlled nature of the SP experiments provides the opportunity to collect information on travel responses to future services and policies along several dimensions and also avoids multi-collinearity. However, the limitations of SP data include "setting bias" (i.e., the choice is made in a hypothetical setting") and "policy bias" (i.e., respondents may attempt to influence the outcome to favor a certain policy rather than provide objective responses).

Combined RP-SP data: RP and SP data can complement one another. Such data pooling is based on the (now) established fact that there is a common preference structure underlying RP and SP responses. This is important, because it allows the analyst to harness the advantages of each type of data where the other falls short. Thus, SP data alone is well known to provide biased forecasts if not combined with some actual indicators of observed or RP behavior that provide important information about preferences in an actual choice environment. On the other hand, because of impending changes in our travel landscape, many future environments and/or policy changes being considered may not exist currently, and so the impact cannot be modeled using only RP travel choices of individuals. It is therefore necessary to undertake SP surveys to elicit responses about different scenarios.

As previously discussed, regional travel surveys have primarily included RP questions that record the socio-demographic characteristics of individuals as well as their travel patterns on a given day. Travel forecast models abstract these travel patterns into a few attributes, such as the number of trips made by the person in a day, the value of time of the individual, and the baseline preference of individuals to use different travel modes. The abstracted travel characteristics identified for an individual are usually sufficient to predict the decision-making of the individual in a novel setting. However, these novel settings are becoming more and more unimaginable as technology advances and hypothetical scenarios become increasingly complex. The integration and linkage of RP and SP questions would provide more accurate and complete data for TDM modeling, enabling improved forecasts for a travel future that is continually changing.

## 1.3. Defining components and key terms involved in SP questions

An SP question comprises two components: alternatives and attributes. An *alternative* is a bundle of several attributes that describe a hypothetical, real-world scenario. Respondents are instructed to choose from, or rank, a set of two or more alternatives. *Attributes* are variables used to describe alternatives. There are multiple levels of an attribute, selected from a range of potential values. These levels allow for the alternatives to vary among a subset of SP questions for each individual respondent, as well as surveys across all respondents. For example, imagine that a new high-speed rail mode is being considered between two cities. The alternatives may include the current alternatives as well as the new alternative, while the attributes characterizing each alternative may include variables such as travel time, travel cost, and travel time reliability. Also, the majority of surveys integrating SP questions do not just include a single SP question, but multiple SP questions to harness as much information as possible from each respondent without causing too much respondent fatigue. The way in which the attributes of the many alternatives are developed in each SP experiment for each individual is based on a specific experimental design set-up that maximizes the value of the information obtained from respondents, while also preserving some modicum of realism in the attribute values presented. Figure 1.1 depicts a visualization of a series of four SP questions presented to a single respondent for the choice between two alternatives.

**Stated Preference *Subset:*** contains four *experiments*/questions; each experiment has two *alternatives*, with three, three-level *attributes* of varying *values* which have been selected through a certain *statistical experimental design* type and depicted by the dark rectangular outlines

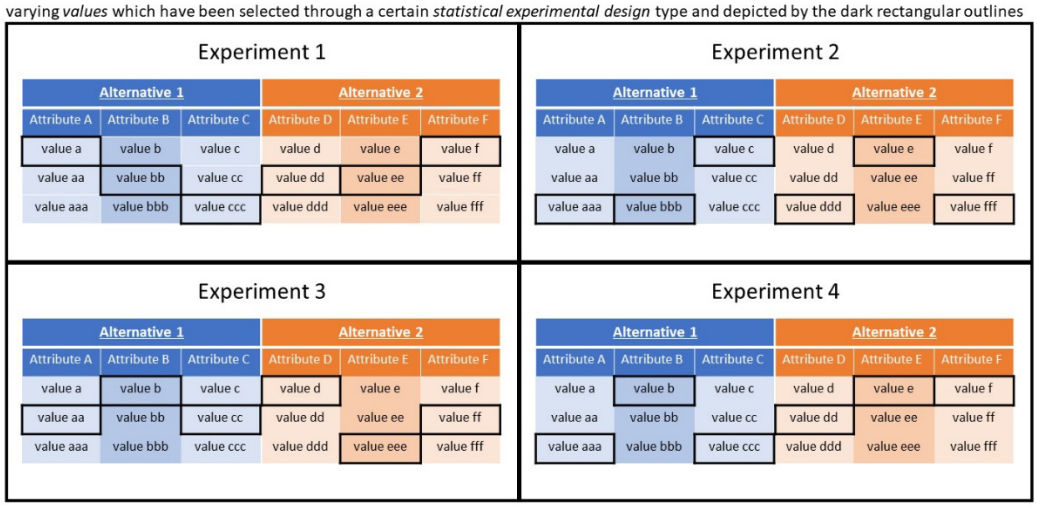



*Figure 1.1 SP subset demonstration*

Figure 1.2 exhibits a specific example of an SP question from the Connecticut I-95 Corridor Congestion Relief Study performed by CDM Smith (2017). This question presents hypothetical travel option scenarios for the respondent to decide between, presenting three alternatives: *Use the I-95 Express Lanes, Use the Express Bus Service in the I-95 Express Lanes*, and *Use the I-95 / Route 15 (Merritt Parkway) Regular (Toll Free) Lanes*. The attributes included in the SP question from Figure 1 are *Travel Time* and travel cost, listed as *Toll Cost* and *Fare Cost*. The attribute levels used for *Travel Time* vary between the values 20 to 60 minutes across the alternatives, while attribute levels for travel cost vary between values of 0 (free) to 10 dollars.

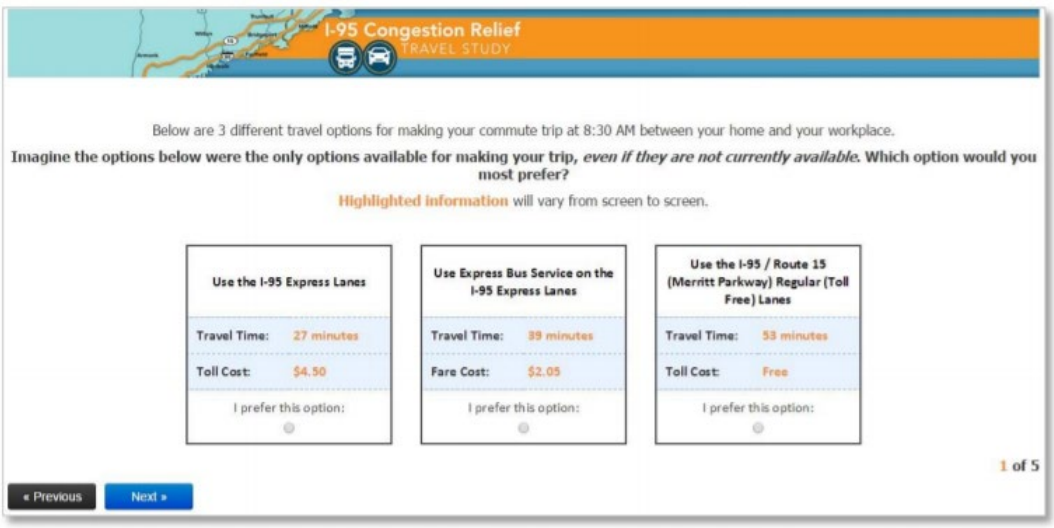



*Figure 1.2 SP question example (CDM Smith, 2017)*

As alluded to earlier, the set of SP questions must be designed in such a way that information on a wide range of possibilities within the scenario of interest, comprising the alternatives and varying attribute levels, can be obtained using a minimal number of questions or experiments. This is a critical issue, since respondent burden must always be carefully evaluated and balanced against additional information that can be elicited through SP questions. Since it may not be possible to obtain SP information on all the possible instances of a hypothetical scenario, mathematical tools for experimental survey design are employed to select an optimal subset of instances that would be most useful for predicting travel behaviour. These various experimental survey design methods are used to manage trade-offs to maximize the success of a study. Table 1.3 provides a quick and broad overview of four statistical experimental design types typically used in SP surveys.

**Table 1.3 Statistical experimental designs**

| Type of Experiment | Characteristics |
|---|---|
| ***Full Factorial Design*** | Each level of each attribute is combined with every other level of every other attribute. For example, a design with two, three-level attributes and two, two-level attributes could have 36 scenarios or subsets ($3^2 * 2^2 = 36$). This design captures all the main effects and interaction effects of attributes within the dataset (TRB, 2019). |
| ***Fractional Factorial Design*** | When not all interaction effects are statistically significant, they can be ignored. Therefore, this type of experiment allows for the reduction of extensively large volume of scenarios created by the full factorial design, while ignoring some interactions of attributes. |
| ***Orthogonal Design*** | All attributes are statistically independent of one another. Only main effects can be estimated as there is no interaction among attributes. |
| ***Efficient/Optimal Design*** | This method optimizes the amount of information obtained from a design, accomplished through multiple methods (such as D-optimal design). |

An optimal subset of SP questions is selected for each individual to respond to; however, in the majority of surveys, multiple subsets of SP questions are selected to vary across individuals in the complete respondent pool. In other words, individuals taking the same survey may be presented different optimal subsets of questions or experiments, i.e., attributes with changed values. Optimization of an SP set can be performed multiple times, resulting in numerous optimal subsets, each containing a different combination of questions or experiments. Each statistical experimental design type included in Table 1.3 can be automated through various experimental design software and programs. Alternatives, attributes, respective attribute levels, and desired number of questions or

experiments for each SP subset are input into the experiment design software by the survey designer. The program will consider all possible combinations of attribute levels for each alternative and run the preferred experimental design algorithm, outputting an optimal subset for the designer to include in their survey. The array of selected questions highly depend on which experimental design type is chosen; orthogonal design is most commonly used. Each experimental design type is basically a premeditated method to randomize the selection of attribute levels or values to be included in a set of SP questions.

## 1.4. Where TxDOT surveys will benefit from the integration of SP questions

Including SP questions within TxDOT surveys will help TDM development respond to multiple technologies/policies and options, a small sampling of which is listed below:

- Different forms of pricing mechanisms to alleviate roadway traffic congestion or to generate transportation funding
- Analysis of the impact of ridesharing, bicycle sharing, and ride-pooling, which may not have enough penetration currently but are emerging as potential important mode options in the future
- Cost-benefit analysis of new transportation projects and potential alternatives currently in the works at TxDOT for different MPOs. These may include plans for managed lanes, bridges, transit introduction such as bus systems or light rail tracks, and converting vehicle lanes to bicycle lanes
- Autonomous and connected vehicle technologies' impact on route choice or mode choice. This may be broken down into the various levels of automation depending on whether an MPO wishes to model a short-term or long-term scenario
- Impacts of electric vehicles on emission rates
- Speed limit changes
- Impacts of telecommuting options
- Changes in ecommerce trends (online shopping, grocery and other food delivery, etc.)
- Potential long-term impacts from COVID-19

Of course, the integration of SP questions within a specific MPO survey should be based on the policies and infrastructure projects currently in consideration at that specific MPO, as well as the advancing technology of most interest to the MPO. Thus, there will be a need for customization, so that the SP surveys are tailored in ways to engender an efficient and sustainable transportation system specific to each MPO region.

## 1.5. Application of SP-RP integrated surveys at MPOs

Developing travel forecasts for scenarios that differ greatly from current travel scenarios has become essential, given the rate of change in the transportation arena. As a result, MPOs all over the country and the world are increasingly integrating SP questions into their travel surveys. Table 1.4 and Table 1.5, which also serve as a knowledge base matrix (KBM), synthesize surveys deployed by MPOs and DOTs that have started integrating SP choice experiments within their travel surveys. A potential analysis of the effectiveness of SP questions and the combination of RP and SP questions will be addressed in future phases of this project; however, this information is not typically made public by institutions that develop, deploy, and analyze surveys. It is important to note that, in Table 1.5, some projects are described as having “randomized” or “presented different arrangements” of their SP question, implying that an experimental design method was employed while developing their set of SP questions, though they did not wish to report which one.

**Table 1.4 State preference choice questions included in surveys by MPOs (question and components)**

| Survey Name | SP Question | # of Experiments or Questions per Respondent | # of Alternatives | Listed Alternatives | # of Attributes for Each Alternative | Listed Attributes |
|---|---|---|---|---|---|---|
| **Atlanta Regional Managed Lane System Plan: Automobile Questionnaire (2007)** | In the nest section, you will compare the trip you just described with an alternative way of making the same trip along an improved I-85 and I-75. If these options were available for making your work commute trop on I-75 in the future, which would you choose? | 8 | 3 | Drive alone in existing lanes, drive alone in new managed lanes, carpool in new managed lanes | 2 or 3 | Travel time, toll, people in carpool |
| **Atlanta Regional Managed Lane System Plan: Commercial Vehicle Questionnaire (2007)** | The new lanes would be built as "Trick Only Lanes." These lanes will be open to heavy trucks. Tolls would vary by time of day or level of congestion. The existing lanes would still be available for all trucks and would remain toll-free. If these options were available for making your trip in the future, which would you chose? | NA | 2 | Existing lanes, new truck only lanes | 2 | Travel time, toll |
| **Utah Travel Study: Residential Choice State Preference (2013)** | Next, you will see a series of potential home locations for living in Utah. For each screen, please look closely at the option and tell us which one you most prefer. When making your decision, please assume that the only differences between the home locations are those listen on each screen. Which of the following home locations would you choose to live in if they were available to you? | 10 | 2 | Option 1 or Option 2 | 7 | Housing compositions, destinations, parking availability/cost, proximity to transit, street design/ accessibility for pedestrians and bicycles, proximity to work, home/rent prices |
| **Puget Sound Region Council: Household Activity Survey (2007): Transit Choice** | Suppose these were your transportation options for your trip from: a place for conducting personal business at 24TH NE in AUBURN to a workplace at 3401 AURBURN WAY N in AUBURN. Which of the options above would you choose? | NA | 4 | Bus service A, Bus Service B, Rail, Auto | 10 | Cost (fare, gas, parking), In-vehicle(s) time, time to get to transit, time to walk from your car or transit stop to your workplace, service frequency, transfers/transfer time, seat availability, reliability |
| **Puget Sound Region Council: Household Activity Survey (2007): Toll Choice** | Suppose these were your transportation options for your trip from: a place for conducting personal business at 24TH NE in AUBURN to a workplace at 3401 AURBURN WAY N in AUBURN. Which of the options above would you choose? | NA | 4 | Travel on free route during peak-period, travel on a tolled route during peak-period, travel on free route outside the peak-periods, travel on tolled route outside the peak-period | 4 | Toll cost, travel time, distance traveled, reliability |

| Survey Name | SP Question | # of Experiments or Questions per Respondent | # of Alternatives | Listed Alternatives | # of Attributes for Each Alternative | Listed Attributes |
|---|---|---|---|---|---|---|
| **WSDOT I-5 Columbia River Crossing Stated Preference Travel Study Report (2013): Passenger Vehicles** | Below are 5 different travel options for making your commutes to/from work trip with 1 passenger departing at 7:30 AM between your home and your workplace. Imagine the options below were the only options available for making your trip, even if they are not currently available. Which option would you most prefer? | 10 | Up to 5 at a time (definitely the first 2). | I-5 tolled, I-205 (toll-free), I-5 off-peak, I-5 HOV, Transit | 6 | Travel time, toll cost, trip departure time, additional passengers, transit mode (bus or rail), transit fare |
| **WSDOT I-5 Columbia River Crossing Stated Preference Travel Study Report (2013): Commercial Vehicles** | Below are 2 different travel options for making the trip you have just described. Imagine the options below were the only options available for making your trip. Which option would you most prefer? | 10 | 2 | Tolled I-5 bridge, Toll-free I-205 bridge | 2 | Travel time, toll cost |
| **SH 183 State Preference Travel Study (around Dallas, Texas) (2010)** | *A scenario is described for new managed lanes on SH 183.* Heartland in Motion Transit Study | NA | Up to 4 | SH 183 general purpose lanes, SH 183 managed lanes, Sh183 managed lanes in an HOV, SH 183 managed lanes at a different time of day | 4 | Travel time, toll cost, vehicle occupancy, departure time shift levels |
| **Puget Sound Regional Travel Study (2015), (2017), (2019)** | What is your level of interest in the following uses of autonomous cars? | NA | 4 in 2015 and 5 in both 2017 and 2019 | Taxi ride in autonomous vehicle with no driver present, taxi ride in autonomous vehicle with a backup driver present, owning an autonomous car, participating in an autonomous car-share system for daily travel, riding in an autonomous car for a short trip to get a vehicle (e.g., from airport to parking lot) (2017, 2019) | 6 | "Rate level of interest in the following uses of autonomous cars" (very interested, somewhat interested, neutral, somewhat uninterested, not at all interested, don't know) |
| **Heartland in Motion Transit Study (2013)** | Presented to you are three transportation options based on your travel response. Which would you choose? | 5 | 3 | Drive on trip, travel by express bus, travel by commuter rail | 4 | Travel time, travel distance, travel cost (drive, bus fare, rail fares) parking cost, frequency |
| **Dulles Toll Road State Preference Survey (2004)** | If the following options were available to you for making your trip, which would you choose? Pay close attention to travel times and tolls because they will be changing over the next few screens. | 5 | 3 | Dulles Toll Road- same time as current trip, Dulles Toll Road- different trip time, Dulles Toll Road- HOV lane, Non-Tolled Route, New Rail Service | 4 | Total time, toll/fare cost, time shift, time, plus many additional attributes for the new rail service |

| Survey Name | SP Question | # of Experiments or Questions per Respondent | # of Alternatives | Listed Alternatives | # of Attributes for Each Alternative | Listed Attributes |
|---|---|---|---|---|---|---|
| **Denver-Boulder Stated Preference Survey Report (2010)** | Below are 2 different travel options for your trip with your passengers. These options include information on travel time, toll cost, and number of passengers. Please assume that all other travel costs are the same as they are now. If the options below are the only options available for your trip, which would you choose? | 8 | 3 | General purpose/non-36 current route, US 36 Managed Lanes, US36 Managed Lanes HOV | 3 | Travel time, toll cost, occupancy |
| **Capital Beltway - HOT Lanes (2010): Toll lane Use** | The following travel options are available for your trip along the Capital Beltway. Your trip is from: Exit 36 to Exit 25. Which travel option would you prefer? | NA | 4 | Drive alone on normal travel lane, SOV lanes (no passengers), HOV lane (passengers), I will not use the Beltway and use an alternative route | 5 | Average travel time, possible additional travel time due to congestion, possible additional travel time due to an accident, fuel cost, toll cost |
| **Capital Beltway - HOT Lanes (2010): Departure Time Choice** | The following travel options are available for your trip along the Capital Beltway. Your trip is from: Exit 36 to Exit 25. Which travel option would you prefer? | NA | 3 | Drive alone on normal travel lane, SOV lanes (no passengers), HOV lane (passengers), I will not use the Beltway and use an alternative route | 4 | Departure time, travel time, fuel cost, toll cost |
| **Connecticut I-95 Corridor Congestion Relief State Preference Survey (2014): Passenger Vehicle: New Express Lanes** | Below are different travel options for making your commutes trip at 8:30 AM between your home and workplace. Imagine the options below were the only options available for making your trip, even if they are not currently available. Which option would you most prefer? | 5 | 3 | Use the I-95 regular lanes, use the I-95 express lanes, use express bus service in the I-95 express lanes | 2 | Travel time, travel cost |
| **Connecticut I-95 Corridor Congestion Relief State Preference Survey (2014): Passenger Vehicle: Congestion Pricing on all Travel Lanes** | Below are different travel options for making your commutes trip at 8:30 AM between your home and workplace. Imagine the options below were the only options available for making your trip, even if they are not currently available. Which option would you most prefer? | 5 | 5 | Use I-95 and Route 15 before or after the peak for a lower toll, use alternative route to avoid a toll at 8:30, use Metro North Railroad for a lower toll at 8:30, use I-95 and route 15 at 8:30 for a toll. | 2 | Travel time, travel cost |
| **Connecticut I-95 Corridor Congestion Relief State Preference Survey (2014): Commercial Vehicle: Congestion Pricing on all Travel Lanes** | Below are 2 different travel options for making the trip that you have just described. Imagine the options below were the only options available for making your trip. Which option would you most prefer? | 10 | 2 | Use I-95 and pay toll, use an alternative route | 2 | Travel time, travel cost |

**Table 1.5 State preference choice questions included in surveys by MPOs (deployment and analysis details)**

| Survey Name | MPO/DOT | # of Responses | How SP was administered | How SP was Designed | How analysis was performed (w/ RP?) | How analysis was used for Policy |
|---|---|---|---|---|---|---|
| **Atlanta Regional Managed Lane System Plan: Automobile Questionnaire (2007)** | GDOT | 4173 | Online (2361), laptop-based administration of the survey to intercepted respondents (1812) | Orthogonal design | Preceded by RP context questions. Proceeded by RP questions dealing with tolling policies in the form of debrief questions to indicate their overall support for potential, specific tolling prices | Value of time estimates and their associated variations were analyzed, but it is not specified how it influenced policy |
| **Atlanta Regional Managed Lane System Plan: Commercial Vehicle Questionnaire (2007)** | GDOT | 413 | Online (412), laptop-based administration of the survey to intercepted respondents (1) | Orthogonal design | Preceded by RP context questions. Proceeded by debrief and background questions, including if they would obtain a transponder to get a discount on the road | Does not specify |
| **Utah Travel Study: Residential Choice State Preference (2013)** | UDOT | 2795 | Online | "Randomized across respondents" | Preceded by a separate survey that gathered travel diary and socio-demographic data. Proceeded by RP attitude/debrief questions | Used as a foundation for outreach and discussion about how cities and towns in Utah want to grow |
| **Puget Sound Region Council: Household Activity Survey (2007): Transit Choice** | WSDOT, Puget Sound Regional Council | 2151 | By mail | Does not specify | Had 3 models: only RP, only SP, and RP/SP combined. Used RP question to reveal the unbiased mode choice the respondent would pick as a function of measured network characteristics to compare data/results. Also had a RP/SP model to combine the datasets | Used to understand the market for transit services |
| **Puget Sound Region Council: Household Activity Survey (2007): Toll Choice** | WSDOT, Puget Sound Regional Council | 2862 | By mail | Does not specify | Using RP sociodemographic questions more variables were able to be calculated with the travel time and toll cost measures, as well as vehicle availability data. Proceeded by RP questions of "how likely" the respondent would be to pick additional toll options | Does not specify |
| **WSDOT I-5 Columbia River Crossing Stated Preference Travel Study Report (2013): Passenger Vehicles** | WSDOT | 1985 | Online | Orthogonal experimental design | Proceeded by RP debrief and opinion questions about additional scenario and disposition on tolls and changing travel patterns (carpooling, destination, trip chaining, reduce/eliminate trips). Also asked the likelihood of purchasing a tolling transponder | Used to decide the tolling prices on I-5 across the Colombia River between Portland, OR and Vancouver, WA |

| Survey Name | MPO/DOT | # of Responses | How SP was administered | How SP was Designed | How analysis was performed (w/ RP?) | How analysis was used for Policy |
|---|---|---|---|---|---|---|
| **WSDOT I-5 Columbia River Crossing Stated Preference Travel Study Report (2013): Commercial Vehicles** | WSDOT | 368 | In-person intercept, online | Orthogonal design | Preceding with trip detail questions, proceeded with debrief and opinion questions and company questions, all RP | Used to decide the tolling prices on I-5 across the Colombia River between Portland, OR and Vancouver, WA |
| **SH 183 State Preference Travel Study (around Dallas, Texas) (2010)** | TxDOT | 1593 | Online, intercept administration in public locations, | Orthogonal design | With R question of a travel diary and about toll transponder ownership, as well as SP debrief questions | Value of time sensitivities calculated were used to assist TxDOT's decision to increase highway capacity and reduce congestion along IH 820 and SH 183 through the addition of managed lanes and expansion of general-purpose lanes |
| **Puget Sound Regional Travel Study (2015), (2017), (2019)** | Puget Sound Regional Council | 4786, of which 1365 were usable | Online, by mail | N/A | With RP based on socio-economic factors | Help agencies determine specific markets that need to be studied and accommodated to help advancing desirable outcomes |
| **Heartland in Motion Transit Study (2013)** | Madison Country Council of Governments | 1350 | Online, on rSurvey | Randomized | Used alongside RP sociodemographic data, alongside a reveal reference trip of which the SP question was built upon from a travel diary | Used to evaluate preferred transit options between Madison county and Indianapolis |
| **Dulles Toll Road State Preference Survey (2004)** | VDOT, Metropolitan Washington Council of Governments | 1428 | Onsite fieldwork at location around Fairfax County, online | "Presented different arrangements" | Used alongside I RP sociodemographic questions (specifically smart tag acquisition questions) and to debrief questions after SP question | Used to determine the integration of tolls, and HOV lane and a new transit mode onto the Dulles Toll road |
| **Denver-Boulder Stated Preference Survey Report (2010)** | CODOT | Does not specify | Online | Does not specify | Used alongside RP sociodemographic-demographic questions and debrief question after the SP question | Does not specify |
| **Capital Beltway - HOT Lanes (2010): Toll lane Use** | SHA, MDOT | Not specified | Online | Does not specify | Used alongside RP sociodemographic-demographic questions | Determining toll pricing on the Capital Beltway |
| **Capital Beltway - HOT Lanes (2010): Departure Time Choice** | SHA, MDOT | Not Specified | Online | Does not specify | Used alongside RP sociodemographic-demographic questions | Determining toll pricing on the Capital Beltway |

| Survey Name | MPO/DOT | # of Responses | How SP was administered | How SP was Designed | How analysis was performed (w/ RP?) | How analysis was used for Policy |
|---|---|---|---|---|---|---|
| **Connecticut I-95 Corridor Congestion Relief State Preference Survey (2014): Passenger Vehicle: New Express Lanes** | Connecticut Department of Transportation | 1511 | Online with rSurvey | Orthogonal design | Preceded by trip detail RP questions and proceeded by debrief questions from the SP survey | Used to determine how many lanes should be toll on this I-95 corridor |
| **Connecticut I-95 Corridor Congestion Relief State Preference Survey (2014): Passenger Vehicle: Congestion Pricing on all Travel Lanes** | Connecticut Department of Transportation | 1511 | Online with rSurvey | Orthogonal design | Preceded by trip detail RP questions and proceeded by debrief questions from the SP survey | Used to determine how many lanes should be toll on this I-95 corridor |
| **Connecticut I-95 Corridor Congestion Relief State Preference Survey (2014): Commercial Vehicle: Congestion Pricing on all Travel Lanes** | Connecticut Department of Transportation | 291 | Online with rSurvey | Orthogonal design | Preceded by trip detail RP questions and proceeded by debrief questions from the SP survey and company information questions | Used to determine how many lanes should be toll on this I-95 corridor |

## 1.6. Conclusions

Based on Table 1.2 the general themes of topical information collected and analyzed through the SP questions may be grouped into three categories:

- Accelerating pace of technology development in the transportation industry
    - In the context of travel demand modeling, SP techniques have been extensively used to determine the level of acceptance of and interest in adopting emerging technologies. Technologies such as autonomous vehicles and micro-mobility services, such as electric scooter and electric bike rentals, have been of substantial focus of recent SP surveys.
- Determining the impact of complex government transportation (as well as other) policies
    - SP surveys, when combined with RP questions, can be used to assess the decision-making of individuals in hypothetical scenarios that would be realized if certain policies are implemented. This assessment can then be used to predict the effectiveness of the policy. Policies such as managed lanes and emission restrictions are explored by recent SP surveys.
- Determining the use case for large-scale infrastructure projects.
    - In the planning stage of any large-scale infrastructure project, detailed studies have to be conducted to determine its cost-to-benefit ratio and to finalize its design parameters. These factors would depend on the extent to which the infrastructure facilities will be utilized.

In summary, integrated RP-SP data can be valuable to MPOs and TxDOT to model future travel demand. The integration can be streamlined to focus on specific issues of concern or emerging considerations at each MPO. Further, surveys across different MPOs can be combined in appropriate ways to obtain a larger picture of the travel future for Texas as a whole. The need for keeping surveys simple and efficient (from a response time perspective) is important too—but presenting different attributes and scenarios to different individuals within a single survey enables inclusion of SP questions while not substantially increasing survey respondent burden. Specifically, through orthogonal design procedures, varying configurations of SP questions can be easily generated, once the alternatives and attributes of importance have been identified. Then, once paired with RP questions, an integrated RP-SP survey can be deployed through the same

online and in-person methods that TxDOT has been using for decades. The resulting integrated RP-SP survey will be valuable to TDMs in every MPO in Texas, providing important insights for planning the transportation systems of the future.

# Chapter 2. Identification of key areas of SP experimental needs and application

## 2.1. Introduction

Stated preference (SP) surveys evaluate a respondent's attitude or preference toward hypothetical scenarios yet to exist in one's normal, everyday life. An agency, such as a metropolitan planning organization (MPO) or department of transportation (DOTs), poses such scenarios in surveys to assess how residents of their region may react if certain decisions and investments were implemented into transportation infrastructure. Whether the MPO or DOT is considering constructing a new tolled highway as an alternative to a congested existing freeway, or studying the smart infrastructure required for their region's intersections as the market penetration of autonomous vehicles increases, an informed prediction of the potential viability and economic success is essential to the agency's decision. These scenarios or conditions may be entirely futuristic, with no existing implementation to refer to either locally or elsewhere in the world; therefore, the potential return on investment and the response of the population is difficult to determine through simulation or analysis of only revealed preference (RP) questions. In this context, the attitudes and preferences revealed through hypothetical scenarios posed in SP questions are extremely valuable to the MPO or DOT, as the agency strives to determine which investments they will pursue, and to what degree. Given the hypothetical nature of these scenarios, a certain level of uncertainty accompanies the data collected—and thus varying levels of potential risk are also in play when assessing the viability and economic success of future ventures. These levels of risk will be addressed and categorized for each example survey provided in the Product 1 (P1) document, alongside our tabulated categorization of hypothetical scenario topics of highest importance to MPOs and DOTs.

## 2.2. Categorization of hypothetical scenarios

In reviewing the hypothetical scenarios of most concern to transportation engineers and planners over the past two decades, several categories reveal themselves. Agencies both across the United States and worldwide, attempting to keep pace with rapidly advancing technology and sizable shifts in travel behavior, use such scenarios to forecast future adaptation and development of their transportation systems and infrastructure. Hypothetical scenarios proposed in SP questions by MPOs and DOTs tend to fall into the following categories:

- Autonomous Vehicles

- Congestion Pricing
- Managed Lanes
- Facility Improvement
- Freight Transportation
- Public Transit/Mode Choice
- Miscellaneous – anything tangentially related to transportation planning (such as residential development placement as seen in the Utah Travel Study)

The P1 document's analysis of the example SP survey questions uses these categories. Each scenario category presents its own set of primary concerns and potential uncertainties. The responses to SP survey questions about these topics provide MPOs and DOTs with the insight needed to answer policy and investment questions related to potential concerns and risks. Following is a brief discussion of the primary concerns and potential uncertainties identified for each hypothetical scenario category.

### 2.2.1. Autonomous vehicles (AVs)

Though AVs are not fully integrated on our roadways currently, their arrival is inevitable. MPOs and other entities ponder a broad range of questions concerning the unavoidable and emerging technology, including:

- Will the market accept a shared AV fleet service?
- What level of market penetration will AVs attain, and in what time frame?
- Depending on the market acceptance and penetration of AVs, what type of sensors and other smart technology must be integrated into transportation infrastructure and systems?
- What data privacy concerns surround the use of AVs?
- What are the major concerns regarding the safety of AVs that regulatory authorities need to address?

To answer these questions, MPOs and other organizations need to obtain a measure of their residents' attitudes towards and preferences for AV technology; SP-only surveys are one of the limited methods available for gathering society's attitudes about and preferences for such emerging technologies.

The P1 includes only one MPO SP survey devoted to addressing AVs; however, analysis of attitudes toward and preferences for AV technology is of extreme

importance to research institutions and frequently the topic of questions in other entities' SP surveys. The MPOs' lack of focus on hypothetical scenarios involving AVs may stem from the long lead time facing this technology's full adoption on roadways, which also creates high uncertainty levels in this area. AVs still represent an unimaginable future for many, making it difficult for transportation engineers and planners to develop questions and analyze responses, and for respondents to answer questions about a reality they must conjure up based on hypothetical AV technology scenarios. MPOs are in the difficult position of balancing the uncertainty inherent in exploring such hypothetical scenarios with limited data collection methods, while determining how best to integrate AV technology into their transportation systems.

Primary concerns or important issues in MPOs' hypothetical AV scenarios mainly revolve around acceptance of the technology. For example, the AV-specific survey provided in the P1 asks the respondent to *Rate level of interest in the following uses of autonomous cars*. Respondents select from these options: *very interested, somewhat interested, neutral, somewhat uninterested, not at all interested, don't know*. This *direct preference-elicitation* format is a different format than an SP *"experimental game"-type* format that presents a choice situation with attributes and attribute levels, and asks respondents to select a preferred alternative (as discussed in detail in Chapter 1). *Direct preference-elicitation* questions are typically used when the technology under investigation is not a part of society's current reality, and therefore it may be difficult for respondents to consider an imagined alternative with specific attributes and attribute levels. In many cases, both of the above SP formats are used in tandem, with the *direct preference-elicitation* questions preceding the *experimental game* questions. The combination of the data collected from the assorted formats of SP questions assists the modeler to later paint a well-developed picture in predicting future levels of AV technology's acceptance and adoption into society and transportation systems.

### 2.2.2. Congestion pricing

Usually tangentially addressed alongside the managed lane category, SP questions about congestion pricing are designed to determine a region's evaluation of value of travel time. Other questions MPOs and other entities ask concerning congestion pricing hypothetical scenarios include the following:

- Will the public accept the congestion pricing policy?
- Will vehicle miles travelled (VMT) reduce with the implementation of a congestion pricing policy?

- How can the congestion pricing policy be equitably implemented?

The concept of congestion pricing can be easily grasped by most respondents, even if not currently practiced on specific roadways considered in the survey. At some point, a non-insignificant fraction of our population has driven roads with dynamic tolling systems. Rates of familiarity and experience with congestion pricing are much higher than for AVs, creating significantly less uncertainty in data collected from the congestion-pricing SP survey responses.

Two considerations for MPO and DOTs' hypothetical congestion pricing scenarios are travel time and toll cost. Based on these two attributes, and accounting for their varying levels and the ultimate alternative chosen by a respondent, planners can model the value of travel time or perceived travel cost for an entire region's population, or for specific segments of the region's population. Additional insights that can be gained from SP surveys on congestion pricing include the potential for a respondent to shift departure time to avoid high tolls, the role of fuel costs during higher congestion and travel times, and the possibility that higher tolls will cause the respondent to shift travel modes to high-occupancy vehicles (HOVs) or public transit.

### 2.2.3. Managed lanes

Similar to the congestion pricing category, SP questions about managed lanes are designed to determine a region's perception of the value of travel time. Questions of interest for MPOs and DOTs deploying SP surveys about managed lanes include:

- How will HOV travel impact toll revenue?
- How can tolls be implemented on these managed lanes? Should a dynamic tolling structure be implemented?
- What is public response to HOV2+ versus HOV3+ lanes?

The concept of managed lanes is typically already familiar to many respondents. HOV lanes are found on roadways all over the country and it is rather rare that a respondent has not interacted with these lanes. High-occupancy trips for both work and recreational travel are a weekly, even daily, occurrence for drivers in cities such as Dallas and Houston in Texas; the inclusion of managed lanes on roadways is an accepted and adopted infrastructure engineering practice.

The primary concerns or important issues for hypothetical managed lanes scenarios are identical to those of the congestion pricing category. SP questions

about managed lanes have an additional emphasis on HOV formation while evaluating value of travel time.

### 2.2.4. Facility improvements

Improving or constructing a new facility is continually on the minds of transportation planners. The scenarios in this category compare existing facilities with a proposed facility, asking the respondent to choose between multiple alternatives. The alternatives selected will reveal key preferences, such as those concerning travel time, travel cost, travel distance, and the number of people in the vehicle. Once again, the region's value of travel time is modeled to evaluate the potential viability and economic success of the proposed facility. The new facility may be tolled or include managed lanes, thus combining scenario categories and their respective concerns. MPOs and DOTs may consider the following questions in hypothetical facility improvement scenario surveys:

- What is the trade-off between travel time and distance for a driver?
- How many people will shift from the existing facilities to the new one?
- Will the revenue from potential tolls on the facility equal or exceed the cost of facility improvement or construction?

The level of uncertainty in facility improvement greatly depends on whether the facility is an upgrade or new construction. An upgrade to an existing facility involves lower levels of uncertainty because the respondent can better imagine the changes. For example, the geometric design of a road may be altered, resulting in appropriate speed limit increases on the facility and decreases in travel time. The respondent can easily imagine traveling on the same road, just faster. For new construction, such as a proposed tolled highway to run parallel to an existing congested freeway, the respondent may be able to imagine driving on this new road. However, a significant amount of uncertainty remains as to whether the driver would actually choose to pay a toll on their commute rather than use the congested freeway to which they are accustomed. In addition, perhaps the old facility presents a particular advantage, such as an entrance ramp being closer to the respondent's home or work, which may outweigh the lower travel times on the new facility.

### 2.2.5. Freight transportation

The category of freight transportation is a high priority for many MPOs and DOTs, especially ones managing sprawling and high-speed highways and freeways. These facilities are commonly traveled by commerce companies,

transporting heavy and large shipments of cargo across multiple states or the country. MPOs and DOTs target these surveys to the commerce market segment, in effort to answer these questions:

- What is the trade-off between shipment reliability and shipment cost?
- What truck weight limits should be in place to preserve road quality?
- Would building a railroad be a valued investment?

The commerce market segment can easily imagine the hypothetical freight transportation scenarios most frequently proposed. Respondents of these surveys tend to be freight company representatives or truck drivers. The SP portion of the survey is usually preceded by RP questions about the frequency, value, weight, size, and cost of the company's freight shipments.

As with managed lanes and congestion pricing, the primary concerns or important issues for hypothetical freight transportation scenarios involve travel time and travel cost. However, freight transportation deals with a high quantity of high-valued goods, which are not owned by the driver. The risk of delay, service flexibility, and risk of damage to the shipment are significant considerations when presenting the freight market segment respondents with route and mode choice alternatives. Additionally, departure time is a crucial attribute, as it is vital to know whether the respondent's answer changes depending on the time of day (or night) the majority of travel will occur.

### 2.2.6. Public transit/mode choice

In many MPOs, travelers commute to their work or recreational activities by car. Public transit is an available alternative in some regions, though underused. In other MPOs and DOTs, traveling on public transit is common, but changes to the system or infrastructure are proposed. Many MPOs and DOTs must determine whether certain public transportation systems and improvements would be supported and utilized by the public. When considering these changes and evaluating the public's attitudes and preferences through SP surveys, MPOs and DOTs ask the following questions:

- Will the proposed public transit have public acceptance?
- Which mode of public transit will be most highly utilized? High-speed rail? Buses? Bikeshare?
- What market segments are most likely to use high-speed rail, and on which corridors?

- From which current travel model will high-speed rail draw riders, and how many trips not made earlier may be made with a new high-speed rail mode?
- What features of a high-speed rail (such as power ports, Wi-Fi connections restaurant cars, etc.) will entice more riders?
- What is the trade-off between speed, comfort, safety, cost, proximity, timeliness, and directness in taking public transit?

Similar to the facility improvement category, the ability of the respondents to visualize the changes to public transit (and the related level of uncertainty in data results) depends on whether the survey posits an improvement to an existing system or the development of a completely new system. Most people have traveled by some sort of public transit in their life, so they are somewhat familiar with the context. The level of uncertainty is lower than that of AV scenarios, but higher than road facility improvements. In some regions, fewer people regularly use or trust public transit and are therefore less familiar with this mode choice, creating higher uncertainty in their survey response and their actual mode choice. Perhaps in practice they would love the freedom from driving and the associated potential for car crashes, and would happily depend on public transit to travel—although while taking the survey they were unfamiliar with the hypothetical scenario and indicated that they would not choose the transit mode choice. However, a significant number of people would never give up their ability to drive alone and will respond accordingly in the survey, decreasing the amount of uncertainty because there is little risk that their response will contradict their actual mode choice.

### 2.2.7. Miscellaneous

The miscellaneous category includes any topics tangentially related to transportation planning, such as the residential development placement investigated in the Utah Travel Study. Hypothetical scenarios in this category have been of less significance for MPOs and DOTs in the past two decades, but these topics may find increasing importance in the future. Other research entities are releasing SP surveys that heavily focus on topics such as micro-mobility services, shared vehicles, impacts of COVID on travel behavior, impacts of telecommuting options, changes in e-commerce trends, and impacts of electric vehicles. Evaluation of the uncertainty involved with each of these hypothetical scenario contexts can be qualitatively evaluated along the same guidelines as for the other categories. The next section will outline how to assess potential risks in the data collected by SP surveys; this method of assessing risk can be applied to

transportation-related surveys falling into the miscellaneous category, as well as surveys concerning the other specified categories.

## 2.3. Potential risks

The hypothetical nature of proposed SP scenarios is accompanied by a certain level of uncertainty. This uncertainty arises from two main sources:

- Study Design: whether the study combines RP-SP questions or employs only SP questions in its design and analysis
- Topic and Context of Study: whether the hypothetical scenario exists in other regions but not in the area of interest to the survey (such as congestion pricing), or if the scenario involves advancing technology or other situations unfamiliar to most, such as AVs

The combination of these two issues qualitatively defines the risk associated with each SP survey for the hypothetical scenarios in consideration. Each example survey included in the P1 document is assessed for potential risks.

### 2.3.1. Study design

Surveys can incorporate SP questions through two different methods: SP-only and RP-SP. Further details on the quality and value of data collected for both can be found in Chapter 1. Of main concern is the difference in the amount of potential risk between these two methods. SP-only surveys reveal considerably higher risk than RP-SP surveys. If only SP questions are used, the study might not expose actual behavior that will manifest in the future. On the other hand, RP data corresponds to the actual travel behavior of respondents, guaranteeing more confidence in the RP-SP combined analysis.

### 2.3.2. Topic and context of study

The risk level inherent to each of the hypothetical scenario categories (as covered in a previous section) will significantly influence the overall risk associated with the data collected from a survey. The degree to which respondents can envision and are willing to adopt the service or facility proposed influences the level of risk associated with the survey results: the less familiar or popular the scenarios (with an emphasis on familiarity), the less reliable the answers, resulting in more uncertainty and potential risk for the MPO or DOT conducting the survey. An MPO or DOT can be more confident in decisions and investments based on data analysis from surveys about topics and contexts more familiar to their region's residents.

### 2.3.3. Assessing risk of study

Based on a combination of whether the study used only SP or combination RP-SP, as well as the topic and context of the study, the potential risk of relying on that study's results can be assessed and slotted into one of three categories. It is essential to note that this three-level categorization of risk is a subjective and qualitative determination based on previous experience with survey design and modeling of results. Following is a description and example of each risk level:

- *Need to be cautious*
  - This survey posits unfamiliar scenarios and asks only SP questions, and thus presents a high level of risk in terms of relying on responses; the modeler "needs to be cautious" in their analysis of the data. An example would be a survey assessing potential usage of AVs, which can be presented only in an SP format, because the majority of respondents have never experienced or interacted with AVs on a regular basis and on standard roadways.
- *Medium confidence*
  - This survey presents more familiar scenarios, using both RP and SP questions. For example, if congestion pricing is being considered for a currently untolled roadway, but the survey contains RP-SP formatted questions, there may be "medium confidence" in this survey and its analysis. Respondents know the facility, and are familiar with the concept of congestion pricing, but it is not already implemented on this specific roadway. Thus, this scenario presents some potential risk and the survey results cannot be analyzed with "high confidence."
- *High confidence*
  - This survey references a well-established technology, practice, or facility, using both RP and SP questions. An example would be the question of raising existing parking fees. Using a familiar context and a combined RP-SP survey creates a "high confidence" in the results and analysis. Parking fees already exist, and respondents are just being asked to decide between either paying an increased fee or parking elsewhere. There is "high confidence" that the response will align with the actual choice individuals would make in this situation, and therefore low potential risk in the question.

## 2.4. Conclusion

To make informed transportation infrastructure planning decisions, planners and engineers have to be able to forecast changes in the attributes of the transportation

system and changes in the attitudes of the people using that system. MPOs and DOTs are increasingly looking to apply SP-styled surveys to hypothetical scenarios to determine the attitudes and preferences of the public, the potential reward of investment in infrastructure developments, and the impacts of emerging technology. With any hypothetical simulation comes a level of uncertainty and risk. It is essential to recognize the dangers of accepting a survey's responses and a model's results as unassailable truth. Yet so few methods are available to gather the public's response to hypothetical scenarios, and SP surveys provide one of the most impartial and applicable techniques to do so. If an SP question is phrased, designed, specified by attribute levels, and administered correctly, the responses can provide valuable information and insights as an MPO or DOT forecasts trends in a region and analysts measure the impact of policy decisions. The technical components of developing an SP survey, associated RP questions, and experimental design process will be further defined and explained in the next chapter, according to the scope of Task 4 as established in the signed work plan.

# Chapter 3. Guidelines for SP survey design[1]

## 3.1. Introduction

The coronavirus, or COVID-19, was declared a threat in the United States in March 2020. One major challenge related to COVID-19 has been creating best practices for risk mitigation in order to slow the spread. Some cities took action at the municipal level, placing restrictions on gatherings in public and common spaces; precautions at the individual level have also become routine over the last six months. A few common measures have been to self-quarantine, create social or physical distance between other people, and practice adequate hygiene by more frequently washing hands and wearing masks in public (Bruinen de Bruin et al., 2020).

The immediate impact of COVID-19 was a shutdown of institutions and spaces in which many people gathered. This included most workplace settings, schools, universities, restaurants, and other such venues (Wu and McGoogan, 2020). Many adjustments had to be made to accommodate the long-term impacts on daily operations, such as conducting work, continuing studies, and maintaining some connection to the world in general. Teleworking, or working from home, was a transition many employees had to make. Travel behaviors changed dramatically and rapidly in response to the pandemic. While it may be expected that many of these travel behavior changes are transient, and some return to pre-COVID travel behavior is to be expected after the pandemic "calms" down, the nature and length of the new activity-travel experiences during the pandemic may carry over (at least to some extent) as we move into the post-COVID period. For example, as just indicated above, teleworking has become the norm during the pandemic, and these experiences may continue into a post-COVID future for workers in some employment sectors (even if very unlikely to be at the same intensity as currently). This, and other activity-travel pattern carryovers, are of substantial interest to transportation planning agencies as they plan for the future. At the same time, because of a changed environment in a post-COVID future compared to today, it would obviously be inappropriate for agencies to simply extrapolate current (COVID-era) revealed preference (RP) activity-travel trends into the future. There is a need to elicit stated preferences (SP) and intentions of individuals in a post-COVID future, and use that information to inform future activity-travel projections.

[1] This chapter was written during the peak of COVID (June 2020 to the end of October 2020). Major changes occurred between the writing of this chapter and completion of the report in fall 2022.

The importance of understanding and forecasting post-COVID activity-travel patterns led to a decision in the current TxDOT project to develop guidelines for SP survey data collection procedures and protocols in the context of examining COVID-19 effects.

## 3.2. Selection of COVID-19 transportation-related SP surveys already conducted

Public agencies have already focused attention on COVID-19's immediate and potentially continuing activity-travel impacts by undertaking SP-based surveys. A large collection of existing SP experiments included in deployed surveys were identified and used as examples for designing this project's SP experiment, which will be presented and design process reviewed during the later chapters of this report (especially the choice analysis process found in Chapter 11). For this project, the research team selected nine surveys for review, all of which included SP experiments. Target respondents were in either the U.S., Canada, or Switzerland. These surveys asked respondents to report how their lives have changed and how they predict their lives will remain changed in the wake of COVID-19. All nine surveys focused on a respondent's travel behavior, as well as other activity trends, such as online shopping. These surveys are identified to provide a sense of the range of travel behavior dimensions that may be studied using SP surveys, including post-COVID behaviors related to teleworking, e-commerce, public transportation demand, ride-hailing use and air travel demand. Details of the specific framing of SP questions and the experimental design are provided in Appendices E, F, and G, some of which are also invoked as examples in the next section. However, to our knowledge, from a substantive standpoint, the current study is the first to design and develop an SP experiment to analyze how individuals may split up their monthly workdays across three different workplace locations: home, in-person work office, and a third workplace location (such as a coffee shop or a hotel room). The following nine surveys were reviewed:

1. *Investigating the impacts of the COVID-19 pandemic on travel behaviors*
   - Deployed by The University of Illinois at Chicago
   - Focuses on the Chicago Area
2. *Impacts of COVID-19 pandemic on mobility, telecommuting, and e-shopping patterns in the United States*
   - Deployed by the University of California, Davis (UC Davis)
   - Focuses on the entire United States
3. *COVID-19 transport choices*
   - Deployed by Arizona State University
   - Focuses on the entire United States

4. *COVID-19 impact on residential location choice in the Greater Toronto Area*
    - Deployed by the University of Toronto
    - Focuses on the Greater Toronto Area
5. *Investigating the impact of COVID-19 on transit demand in the Greater Toronto Area*
    - Deployed by the University of Toronto
    - Focuses on the Greater Toronto Area
6. *SiSTM COVID-19 survey*
    - Deployed by the University of Toronto
    - Focuses on the Greater Toronto Area
7. *COVID-19 impact on workplace choice and shopping method*
    - Deployed by the University of Toronto
    - Focuses on the Greater Toronto Area
8. *COVID-19 survey #1**
    - Deployed by ETH Zurich
    - Focuses on Switzerland
9. *COVID-19 survey #2**
    - Deployed by ETH Zurich
    - Focuses on Switzerland

*It is important to note that the two surveys by ETH Zurich are written in German and their actual titles are not available.

The nine surveys are outlined and analyzed in the tables in Appendix A. Each survey contains both RP and SP questions. SP questions are particularly suited to forming an analysis of the future impacts of COVID-19 on transportation and planning systems, as the pandemic's spread is unprecedented in modern times, and most respondents have never experienced anything like it before. Therefore, it is vital that, when asking a respondent to report how they may act in a future scenario, with or without lingering COVID-19 effects, the question is framed as a hypothetical scenario. The hypothetical scenario must have clearly defined conditions to create a realistic setting in the respondent's mind, which is done through proper wording, positioning, and general SP question design. This ensures that the analysis of data collected will lead to valuable insights that are relevant to policy decisions.

## 3.3. Use and design of SP questions

The following sections provide a detailed analysis of the use and design of SP questions in the nine COVID-19 surveys reviewed, focusing on the following characteristics:

1. Survey format
2. Survey content
3. Methods used to convey the characteristics of the hypothetical scenario
4. Experimental design of the SP survey
5. Linkage between the RP and SP components
6. Survey administration

### 3.3.1. SP survey format/type

When beginning to design an SP survey, the format or type of SP question must be decided. In the tables in Appendix A detailing the nine reviewed surveys, the question format of each survey is provided in the column *SP elicitation mechanism*, found in each survey's introductory table of information. The surveys reviewed used either the choice experiment or contingent behavior elicitation mechanisms, with the exception of Survey 6 and 7, which used both types. Both formats are employed to obtain information on potential future travel behavior in hypothetical scenarios. This section defines those two SP elicitation mechanisms as well as other elicitation types frequently used in travel surveys.

- Choice Experiment
  - In this format, respondents are presented a set of SP questions and are instructed to choose from, or rank, a set of two or more alternatives with varying attributes levels across the SP question set.

    Examples:

    - Figure 3.1 provides an example of a specific SP question from the Connecticut I-95 Corridor Congestion Relief Study performed by CDM Smith (2017). This hypothetical scenario was also presented and discussed as an example in earlier chapters of this project. This question presents three hypothetical travel option scenarios for the respondent to decide between: *Use the I-95 Express Lanes, Use the Express Bus Service in the I-95 Express Lanes*, and *Use the I-95 / Route 15 (Merritt Parkway) Regular (Toll Free) Lanes*. The attributes included in the SP question in Figure 3.1 are travel time (indicated simply as *Travel Time*) and travel cost (listed as either

*Toll Cost* or *Fare Cost)*. Across all possible SP scenarios, the attribute levels used for *Travel Time* range from 20 to 60 minutes across the alternatives, while attribute levels for travel cost vary between values of 0 (free) to 10 dollars.

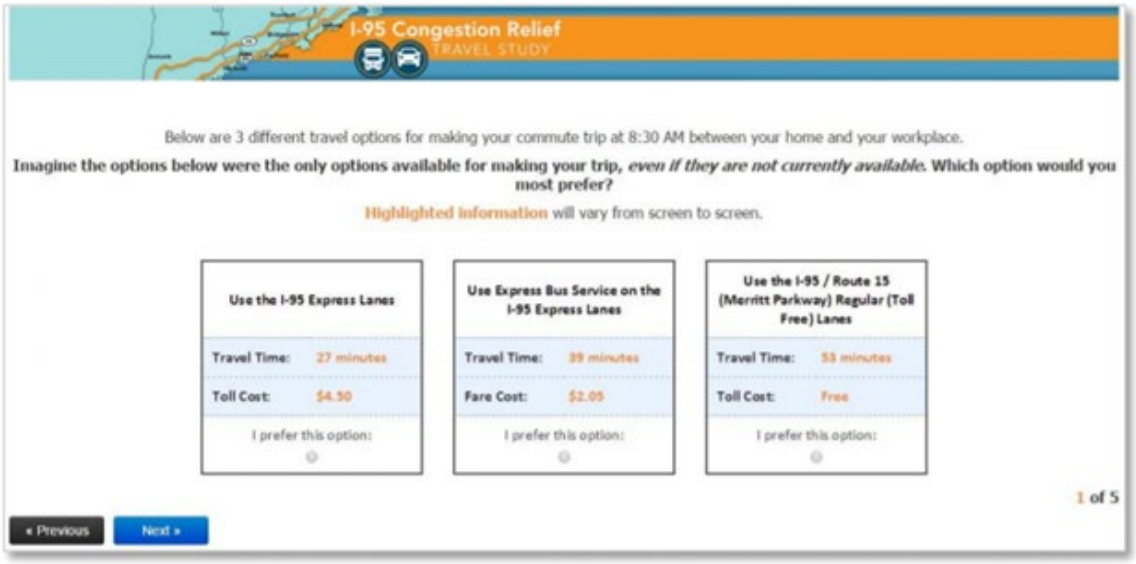



*Figure 3.1 Choice experiment example 1 (CDM Smith, 2017)*

- Figure 3.2 provides an example of a specific SP question from Survey 7. This question presents three hypothetical workplace choice scenarios for the respondent to decide between: *Work from home, Hybrid workplace (2-3 days teleworking),* and *Work at workplace.* The attributes included in the SP question are *Covid risk level, Technologies at home, Furniture at home, Shifting work hour, Splitting work hour, One-way travel time from home to workplace, Level of crowding at workplace,* and *Child caring.* Each of these attributes are described in Figure 3.2. Across all possible SP scenarios, the levels for the attributes are listed in Table 3.1.

Let's begin with the **workplace choice**.

Please take a minute to read the description of attributes, which are important factors you should take into consideration when making your decision.

In each scenario for workplace choice, you will face 2 different alternatives, **working from home** and **working at the workplace**. Each alternative has its own attributes, which have different values across the scenarios. These attributes are listed below:

**Work from home attributes:**

- **Technologies at home:** This attribute indicates your access to different technological services and supplies in home which you need for teleworking like internet, computer, etc.
- **Furniture at home:** This attribute indicates the furniture you have and use for working at home like work chair and desk.
- **Shifting work hour:** This attribute indicates if you are allowed to shift the time you begin working.
- **Splitting work hour:** This attribute indicates if you are allowed to split the work hours into separate intervals during the day.

**Work at workplace attributes:**

- **Shifting work hour:** This attribute indicates if you are allowed to shift the time you begin working.
- **One way travel time from home to the workplace:** This attribute indicates an interval in which your travel time from home to the workplace will fall into.
- **Level of crowding at the workplace:** This attribute indicates the crowding level in your workplace and the reachable social distance to others.

**General attributes:**

- **Child caring:** This attribute indicates whether you can send your child(ren) to child-care or have to take care of his/her (them) in home. Note that if you do not have any child this attributes will not be displayed to you.
- **COVID-19 risk level:** This attribute indicates to what level the COVID-19 assumed to be a threat by defining what percentage of people got vaccinated.

| ***COVID risk level*** | ***Everyone has been vaccinated*** | | |
|---|---|---|---|
| **Attributes** | **Work from home** | **Hybrid workplace (2-3 days teleworking)** | **Work in the workplace** |
| Technologies at home | Internet + Laptop | Internet + Laptop | - |
| Furniture at home | Work desk + Chair | Work desk + Chair | - |
| Shifting work hour | Allowed | Allowed | Allowed |
| Splitting work hour | Not allowed | Not allowed | - |
| One-way travel time from home to workplace | - | More than 60 minutes | More than 60 minutes |
| Level of crowding at workplace | - | Normal crowding, 6 feet distance is achievable | Normal crowding, 6 feet distance is achievable |
| Child caring | In-home without nanny | In-home without nanny | Child care |

In **this scenario**, you have two different options for your workplace. Please carefully review your options:

Please choose your preferred option for workplace choice based on the information given in the table. *

**Work from home** | **Hybrid workplace (2-3 days teleworking)** | **Work at workplace**

*Figure 3.2 Choice experiment example 2 (survey 7)*

**Table 3.1 Attribute levels for choice experiment example 2 (survey 7)**

| Alternative | Attribute | Level |
|---|---|---|
| ***Work from home*** | *Facilities* | Laptop |
| | | Internet + Laptop |
| | | Internet + Laptop + Secondary monitor/Printer |
| | *Workplace* | Dining table |
| | | Work desk + Chair |
| | | Fully furnished office room |
| | *Shifting work hour* | Shifting the start time is possible |
| | | Shifting the start time is not possible |
| | *Splitting work hour* | Splitting the working hours is possible |
| | | Splitting the working hours is not possible |
| ***Work from workplace*** | *One-way travel* | Less than 10 minutes |
| | | 10 to 30 minutes |
| | | 30 to 60 minutes |
| | | More than 60 minutes |
| | *Shifting work hour* | Shifting the start time is possible |
| | | Shifting the start time is not possible |
| | *Level of crowding* | No crowding, there are more than 6 feet distance |
| | | Normal crowding, 6 feet distance is achievable |
| | | High crowding, 6 feet distance is not achievable |
| ***General variable*** | *Child caring* | In-home without nanny |
| | | In-home with nanny |
| | | Child care |
| | | No child |
| | *COVID risk* | No vaccine has been found yet |
| | | 40% of people have been vaccinated |
| | | 80% of people have been vaccinated |
| | | Everyone has been vaccinated |

- **Contingent Behavior**
  - This format asks the respondent what they would do in a hypothetical scenario. These questions do not have varying attribute levels and instead ask a respondent to answer what they would do **if** a situation occurred. The answer options tend to be presented as alternatives on a Likert scale, such as:
    - Highly likely; Likely; Somewhat Likely; Neutral; Somewhat unlikely; Unlikely; Highly Unlikely

- Significantly less; Somewhat less; Around the same; Somewhat more; Significantly more

o Answer options may also include choosing between multiple alternatives, similar to a choice experiment; however, the alternatives will not have varying attribute levels.

Examples:

- How much do you expect your airplane travel for leisure/personal purposes to change once COVID-19 is no longer a threat?
  - The respondent is presented with five answer options/alternatives and must pick one:
    - Significantly less than before the COVID-19 outbreak
    - Somewhat less than before the COVID-19 outbreak
    - Around the same as before the COVID-19 outbreak
    - Somewhat more than before the COVID-19 outbreak
    - Significantly more than before the COVID-19 outbreak
- Once the pandemic is no longer considered a threat, which method of transportation will you choose to travel to visit a friend within your own city?
  - The respondent is presented with multiple mode choice alternatives and must pick one.

- **Contingent Valuation**

o This format asks a respondent to consider the value that an option holds for them. They may be asked whether or not they would choose an option given its value, or asked how much they are willing to pay for an option. The respondent will see a set of these SP questions, with varying attributes levels across the set; these attribute levels are presented either in the question or in the answer. The varying attribute levels would be the value or the cost of the option.

Examples:

- Would you be willing to pay $X for good Y?
  - X is the varying attribute
- How much are you willing to pay for X?
  - The respondent will be presented a range of values to choose from, which vary among the set of SP questions and are the varying attribute levels

- What is the maximum amount you will pay?
    - The respondent will be presented a range of values to choose from, which vary among the set of SP questions (varying attributes)

Both contingent behavior and contingent valuation mechanisms are primarily used to obtain more general behavior intentions in a hypothetical context. This helps to forecast broad future trends for more general policy insight. Contingent behavior SP questions are easier for a respondent to understand, as the hypothetical scenario presented to them appears less complex. Contingent valuation SP questions help to put a price or monetary value on a specific change to a system, activity, or commodity. A choice experiment, on the other hand, offers a complex hypothetical scenario, with exact values and conditions, used to analyze specific behavioral response for quantitative statistical models. Though a choice experiment with multiple questions, alternatives, and attribute levels may seem a bit cumbersome to a respondent, the data gathered from such a set of SP questions is extremely rich and valuable for projecting a wide range of future travel behaviors and demands. Overall, each SP question format offers an efficient method to collect responses on predicted future behavior in a situation that may be unknown, such as the evolution of lifestyles and attitudes in a post-COVID world.

### 3.3.2. Survey content

The results of the survey data collection and analysis efforts should lead to insightful conclusions that are relevant to policy actions. The goal is to inform decision-making, and not for the data collection effort to serve solely as a basis for statistical modeling. Additionally, the results should lead to exploration of the kind of travel model forecasts that are to be developed from the additional information obtained through the SP questions. Therefore, the framing and content of the SP questions must be relatively specific. In later chapters of this project, an example SP question will be designed with a focus on COVID-19's impact on commuting. However, other travel behaviors have also been impacted by COVID-19 and the nine surveys reviewed attempt to address them. In the tables in Appendix A outlining those surveys' composition, the SP questions' framing can be found in the column *Sub-categorization of hypothetical scenario*. These areas include:

- Teleworking
- School
- Air travel

- E-commerce
- Public transit/mode choice
- Transportation network companies (TNCs)
- Long distance travel
- Miscellaneous

Each of these areas of study have their own impacts on future policy decisions and trends regarding COVID-19. These impacts are briefly outlined below.

#### 3.3.2.1. Teleworking

As stated above, many businesses were forced to send their employees home due to COVID-19, instead of continuing their work at the traditional workplace. As a result, teleworking has become the new norm for office-based culture, with meetings held over Zoom or Microsoft Teams and daily communication occurring via phone call, chat software, or email. As many no longer make the daily commute to work, congestion has decreased during the morning and afternoon rush hours, and toll companies are seeing a resulting decrease in revenue. The future of the "work-from-home" culture that has accompanied COVID-19 is uncertain at this point. Whether many people will return to their office is unknown, and ultimately new traffic patterns may emerge. If the trend of fewer work trips continues in a post-COVID era, peak-hour commuting traffic volumes will reduce and transportation infrastructure will degrade at slower rates, which may imply a need to revisit the priorities for large infrastructure projects to mitigate congestion or maintain roads and other associated infrastructure. Of course, it is also possible that the claustrophobia and family-related challenges that some experience while working from home may motivate a significant cohort to return to their office spaces after normalcy is restored.

#### 3.3.2.2. School

Since COVID-19 has prevented the gathering of large groups, schools have been forced to turn to virtual learning. Instead of attending in-person classes, students with the resources to do so learn from the comfort of their own homes using video communication and online resources, while parents facilitate the schooling environment. The lack of student commutes has further helped decrease the early morning and afternoon traffic peaks—but also has adversely affected transit system usage and revenue levels. While teachers who teach core curriculum can transition more easily to a remote classroom, those who teach subjects reliant on the physical presence of both students and the relevant equipment (such as used in science labs, art classes, and many extracurricular activities) face greater

challenges in teaching virtually. Administration roles are not as prevalent in an online school environment either, as there are no students to administer at the schools themselves. Additionally, school district bus drivers are simply out of work. This lack of need for additional educational faculty has the potential to change policy in terms of funding. If fewer people are needed on the school district's payroll, then the funding for their paychecks could be redirected.

#### 3.3.2.3. Air travel

One of the primary forms of risk mitigation during the pandemic has been slowing the spread by simply staying home, refraining not only from typical daily activities but also travel plans. The air travel market has taken a massive hit, leading to the bankruptcy and collapse of several airlines. Policy changes have already provided a cushion for many airlines who almost saw the end of their days. The 2020 stimulus bill provided $58 billion dollars in aid for airlines (Slotnick, 2020).

#### 3.3.2.4. E-commerce

Especially during the early months of COVID-19, when most businesses had shut down and only a few "essential" stores kept their doors open, consumers began to, more than ever, stock up on essentials using online purchases. Specifically, e-commerce became the most efficient way for consumers to remain safely at home while acquiring essential supplies. As a result, the roads have seen an increase in delivery truck movement, even as consumers are not making as many shopping trips. This increase in e-commerce has generated an increase in freight and delivery vehicle traffic, congestion, and emissions; it is predicted that emissions could increase more than 30% in the next 10 years if serious change is not affected (Toussaint, 2020). Policy initiatives could potentially combat this increase by requiring carbon testing on every vehicle during their inspections, increasing taxes on gasoline products, or providing additional funding to public transportation infrastructure.

#### 3.3.2.5. Public transit/mode choice

The question of how people will choose to travel and commute when the pandemic is over is a topic of great interest. Many people are currently opting out of using public transportation due to the risk of exposure to COVID-19. For those who are considered "captive riders"—those with little to no choice of using a personal vehicle —transit is their only option. For those who have the option of using a personal vehicle, the existing benefits of flexibility and privacy is augmented by the lack of  exposure to the virus. Public transportation is currently

funded mainly by various levels of government; rider fares provide little revenue in comparison. Although transit is vital for captive riders, if mainstream ridership levels do not rebound post-pandemic, the funds supporting transit systems might be decreased or redistributed.

#### 3.3.2.6. Transportation Network Companies (TNC)

TNCs provide app-based ride-share services for consumers; commonly known companies are Uber and Lyft (TTI, n.d.). As many consumers are tending to remain at home now, TNC usage has plummeted. Uber saw an 80% decline in bookings in April of 2020, compared to April of 2019, while Lyft's ride volumes decreased by 70% during the first week of May 2020, compared to May of 2019 (Urbanism Next, n.d.). As a result, both companies have laid off many of their employees, leading to fewer TNC vehicles on the roads. Additionally, fewer people are willing to share rides with strangers, which may lead to a decrease in usage of high-occupancy lanes, as been seen already amidst the pandemic and may continue post-pandemic as well. The investment that departments of transportation make in infrastructure to support both high passenger-per-vehicle travel or shared rides may shift, as both these modes have seen a decline in use due to COVID-19. However, as of now, it is unclear if this shift away will continue post-pandemic. The trend away from rideshare might well reverse itself quickly after the pandemic ends, given the pre-pandemic popularity of ridesharing.

#### 3.3.2.7. Long distance travel

Long distance travel for both business and leisure has of course greatly decreased since March. Some essential workers must commute long distances to their workplaces, but, for the most part, long distance travel is associated with the risk of transmission of COVID-19 and avoided by many people.

#### 3.3.2.8. Miscellaneous

Other miscellaneous questions are asked as well, each of which relate to certain policy changes and transportation effects.

### 3.3.3. Methods used to convey the characteristics of the hypothetical scenario

As discussed earlier, it is extremely important for every respondent to understand the framing of an SP question. Given the hypothetical nature of the scenarios posed in SP surveys, a level of uncertainty accompanies the question. Therefore, it is vital that the survey designer clearly and uniformly convey the idea behind

the hypothetical scenario to all survey respondents. The specific words and description used to frame the question is critical. Similarly, the wording used in the SP questions must be carefully crafted to ensure that the respondent comprehends the question presented in the context of the specific scenario envisioned by the researcher. For example, if the hypothetical scenario involves autonomous vehicles (AVs), every respondent must have a clear idea of the different characteristics of AVs, such as the level of automation, cost, availability, use cases, acceptance, and safety record of such vehicles. In the instance of COVID-19, the question must clearly communicate the specific stage of the pandemic the SP question is addressing—e.g., few first months of the pandemic, current state, in six months, as well as issues related to vaccination presence and potential effectiveness.

Within an SP survey, specific introductions to each question set the scene for the respondent, framing the hypothetical scenario with the intent to obtain reasonable responses. The framing used in the nine surveys reviewed reveals both advantages and weaknesses; in the tables in Appendix A, the column labeled *Specific wording to set up hypothetical scenario* provides the specific introductions used for each survey. For example, the hypothetical scenario in Survey 1 is as follows: *COVID-19 is no longer a threat.* This wording implies that stay-at-home orders are no longer in effect and commuting and leisure travel patterns can return to normal. The respondent can then indicate whether they will return to their pre-COVID-19 habits or retain the changes they made to their behavior during the pandemic, which is inherently the goal of the question. However, providing such a vague frame of the hypothetical, post-COVID-19 scenario presents some disadvantages. This statement creates a bubble of uncertainty, as the time frame in which this will be true is unknown. No one knows when COVID-19 will no longer be a threat—it could be in a few months, or in a few years. And there is also the vagueness here because COVID-19 is likely to always be a threat, much like the common flu. Therefore, variability will exist in terms of each respondent's interpretation of this scenario. Additionally, respondents may not have an accurate idea of how they will be travelling when COVID-19 is no longer a threat, given the continuing increases in unemployment levels and the potentially enduring shift to teleworking. Although this phrasing is a good way to set the stage in general, some disadvantages are associated with the inherent variability of interpretation.

Another hypothetical scenario found in Survey 1 is this: *How likely are you to [conduct activity] during the first few months after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)?* This statement provides even greater room for respondent interpretation than the first scenario describes.

What does “after the COVID-19 outbreak” entail? When there are no more cases? When they have developed and distributed a vaccine? Are the conditions we are living in now “after”? Will society ever return to normal? The scenario framing lacks those specifics, which would clarify the scenario; this creates ambiguity across respondents’ answers, adding uncertainty when modeling. The timeline for this scenario is completely unknown and could occur anywhere between a few months ago to a few years from now. The respondents cannot truly provide their accurate travel behavior and therefore the results are not highly applicable for travel demand models.

Next is a hypothetical scenario from Survey 2: *The recent COVID-19 pandemic has heavily impacted the way people work, organize their household activities, socialize and travel; Please think of your life in a few months from now, in October 2020*. It is important to note that this survey was deployed through May 2020 and the COVID-19 conditions in October were unknown. It is now clear that though some restrictions have been lifted or loosened by October 2020, the pandemic is still prevalent in everyday life in many ways. This hypothetical scenario has a precise timeline, in which people can mentally insert themselves and visualize their lives. Given that people typically have plans for events in their near futures—family trips, weekend activities, holidays, etc.—respondents are more likely to feel more certainty about their situation and their travel activity and methods over the time frame of a few short months in the immediate future. This allows for less uncertainty in responding to the SP question.

A fourth hypothetical scenario, taken from Survey 7, reads: *After conditions return to normal*. This scenario framing has no associated timeline. Again, the respondent would not have a definite sense of when this scenario will take place, given the uncertainty about when normal conditions will resume. However, it does set a particular scenario and guides the respondent to answer accordingly while reflecting back to their life before the pandemic. However, the issue of whether the respondent believes their behavior will ever return to normal instills a bit of uncertainty in the accuracy of modeling of the responses.

In Survey 4, the respondent is presented with three different scenarios, in which a description of the status of COVID-19 is clearly conveyed.

- *Scenario 1: COVID-19 is no longer considered a threat due to mass vaccination, and everything goes back to the normal status.*
- *Scenario 2: The world's health care system fails to find a vaccine for COVID-19 which means we cannot go back to the normal status. We adapt to a new normal where our interactions are based on social distancing.*

- *Scenario 3: COVID-19's second wave or another pandemic hits our community, and we should go back to the strict lockdown phase once again.*

In each of these scenarios, the word "we" is used to make the respondent feel included and part of the question. There is also a description of the threat status of the virus—not a threat, still a threat, or a new threat has emerged—followed by society's reaction to that threat status. Thus, the respondent can respond to the hypothetical scenarios within a particular context. They do not necessarily need to agree with their community's reaction to the threat, but it is important to know the larger social context in order for the respondent to more accurately predict their behaviors within specific scenarios.

Another method to improve realism in SP scenarios is to include pictures. Images clarify the scenario being proposed, providing visual cues to help set the scene for the respondent. Such supporting graphics might include a visualization of a new technology, a diagram of a roadway scenario, or an interactive map, as was used in Survey 4. Here, the respondents were asked to choose one of four different options to relocate their household residential location, given an array of attributes. Each respondent was provided an interactive map of the Toronto region, as well as the description of conditions in the provided scenario. The map enables the respondent to explore the reality and possibility of their decision based on a spatial visualization of their options.

An additional approach to framing a hypothetical scenario for maximum clarity is providing real-world statistics for the respondent's consideration. In this case, the scenario would provide actual statistics of COVID-19 cases in the respondent's region, as Survey 5 did. Here, alongside clear descriptions of each of the presented alternatives, the respondent was presented with the fact that Ontario was at the time averaging 173 new cases of COVID-19 daily for the past 14 days, along with a list of the public safety measures the city was taking to limit the spread. This question's scenario depicts the pandemic as a continuing threat. This strategy may be used obtain a more accurate response, reiterating that the pandemic has not been stopped and—according to the listed attributes—there may or may not be an available vaccine in the scenario. This framing, alongside the available attributes, creates a more definite and universally understood scenario and time frame for each individual respondent and across all respondents.

Finally, some surveys, such as both of the surveys in Switzerland (Surveys 8 and 9), get even more specific and enumerate the specific contagion levels and infection risk of the pandemic in the respondent's area and address the health concerns to different populations before even displaying the SP choice experiment to the respondent. This way, every respondent answers the set of SP questions

under the same assumptions about the effect of the pandemic. However, this detailed description can be lengthy, which puts a burden on the respondent when they have a significant amount of reading to perform before they answer a question. Some respondents may even breeze over the description and go straight to the question, bypassing the attempt to set the specific scene, which impacts the accuracy of their response for that particular context. When developing an SP question, survey creators must find a balance between providing sufficient details to bring to life the hypothetical situation while keeping text readably concise.

### 3.3.4. Experimental design of the SP survey

To best harness the range of information SP questions can gather, the experimental design of a set of questions is extremely important. The SP component must be designed in such a way that information on a wide range of possibilities within the scenario of interest can be obtained using a minimal number of questions. This is a critical issue, since respondent burden must always be carefully evaluated and balanced against additional information that can be elicited through SP questions. Since it may not be possible to obtain SP information on all the possible instances of a hypothetical scenario, mathematical tools for experimental survey design are employed to select an optimal subset of instances that would be most useful for predicting travel behavior. These various experimental survey design methods are used to manage trade-offs to maximize the success of a study. It is important to note that experiential design is not necessary for contingent-behavior-type questions, but it is imperative for the various other SP format types previously discussed. Table 3.2 provides a brief overview of four statistical experimental design types typically used in SP surveys.

**Table 3.2 Statistical experimental designs**

| Type of Experiment | Characteristics |
|---|---|
| ***Full Factorial Design*** | Each level of each attribute is combined with every other level of every other attribute. For example, a design with two, three-level attributes and two, two-level attributes could have 36 scenarios or subsets ($3^2 * 2^2 = 36$). This design captures all the main effects and interaction effects of attributes within the dataset (TRB, 2019). |
| ***Fractional Factorial Design*** | When not all interaction effects are statistically significant, they can be ignored. Therefore, this type of experiment allows for the reduction of an extensively large volume of scenarios created by the full factorial design, while ignoring some interactions of attributes. |
| ***Orthogonal Design*** | All attributes are statistically independent of one another. Only main effects can be estimated as there is no interaction among attributes. |
| ***Efficient/Optimal Design*** | This method optimizes the amount of information obtained from a design, accomplished through multiple methods (such as D-efficient design). |

An optimal subset of SP questions is selected for each individual to respond to; however, in the majority of surveys, multiple subsets of SP questions are selected to vary across individuals in the complete respondent pool. In other words, individuals taking the same survey may be presented with different optimal subsets of questions or experiments, i.e., attributes with changed values. Optimization of an SP set can be performed multiple times, resulting in numerous optimal subsets, each containing a different combination of questions or experiments. Each statistical experimental design type included in Table 3.2 can be automated through various experimental design software and programs. Alternatives, attributes, respective attribute levels, and desired number of questions or scenarios for each SP subset are input into the experiment design software by the survey designer. The program will consider all possible combinations of attribute levels for each alternative and run the preferred experimental design algorithm, outputting an optimal subset for the designer to include in their survey. The array of selected questions highly depends on which experimental design type is chosen; orthogonal design is most commonly used, while D-efficient is a close second. Each experimental design type is basically a premeditated method to randomize the selection of attribute levels or values to be included in a set of SP questions.

Most of the reviewed COVID-19 surveys use a D-efficient experimental design to optimize an SP question set for their choice experiments. A few of the experimental designs of the nine surveys were not available, but the ones that are can be found in the column *Type of experimental design.* The mathematics behind the procedure to generate D-efficient designs are extremely technical and will not be the focus of this chapter. As previously addressed, many programs, such as SPSS, will perform the algorithm for the survey designer after certain variables are input into the software.

The experimental design should be conducted such that the SP data can be optimally combined with RP data to extract the most information possible for modeling structures. When determining the attribute levels for varying alternatives, it is important to ensure realism in the choice situation. This is done by making sure the attribute values are realistic to the respondent, so they are able to imagine the choice task with some existing memory and reference. For example, if most respondents report commuting times around 30 minutes, an attribute level for travel time will not vary between one to two hours. This would create an unrealistic scenario for the respondent and increase uncertainty in the accuracy of their response. It would also limit the modeling possibilities of linking current commute patterns (RP data) with future hypothetical commute patterns (SP data), because the RP and SP data impose such different travel times that they would almost be incomparable.

### 3.3.5. Linkage between the RP and SP components

Once the experimental design is configured and the set of SP questions is determined, the survey designer must decide which (if not all) respondents will see and answer the set of SP questions (also known as the SP component) as they proceed through the survey. To some respondents, the SP component will not be applicable. For example, a respondent who lives just a couple of blocks from work (as revealed by RP questions answered earlier in the survey) should not be presented with a hypothetical situation where he/she has to choose between rail and transit to go to work after the pandemic. Similarly, it may be difficult for a person currently not ordering groceries online to make a choice regarding the decision to continue doing so in a post COVID-19 context, even if they think they may start shopping online. The SP component should be anchored to the RP component so that the hypothetical situation developed in the SP component is relatable to the specific survey respondent. This, once again, helps provide some realism to respondents, so that they can better place themselves in the hypothetical context by making them position and evaluate the SP options through the lens of their current behaviors and preferences. Therefore, it is

important to use the earlier RP questions in the survey to determine which respondents need to be presented a specific SP question.

The actual SP scenario developed for an individual is relatively simple in online survey administration, where the respondent's answer to an earlier RP question in the survey can help determine the attributes characterizing the SP experiment. Most online tools allow for multiple RP questions to be linked to a single SP component, making it easy to construct good SP scenarios. If this RP-SP linkage in constructing SP scenarios is forgone, it would increase the uncertainty level in the SP data collected and reduce the validity of behavioral projections. Some SP questions may note require this linkage between RP and SP questions, as the topic is universally applicable to all respondents chosen to participate in the survey. For example, if a survey is being presented only to a group of individuals who have previously reported that they are employed in a given region, an SP component presenting alternative routes to work given varying travel times and toll costs will be applicable to all respondents taking that survey. The linkage between RP and SP components identified in the reviewed surveys is provided in the column *Logic to reveal this question*.

### 3.3.6. Survey administration

A survey designer should implement an SP design that recognizes the administration method used. Thus, the design considerations for a survey conducted through a multimedia device (such as a tablet) would differ from one that is conducted by phone. All of the COVID-19 surveys reviewed and most travel surveys administered by TxDOT are conducted online. The COVID-19 surveys reviewed were all administered on the online platform, Qualtrics. This, and other similar online platforms, are designed to provide survey layouts that easily transfer to any type of mobile device or computer. The platforms also save participants' responses in an easily accessible database, which can be downloaded into various formats to be used in additional programs for travel demand modeling and other forms of analysis. Most programs let the survey designer assign values to the question choices before the survey is deployed. For example, if the SP question asks for a yes-or-no answer, it would be beneficial to code *yes* as 1 and *no* as 0, so this step does not have to be taken once the dataset has been assembled. Coding schemes can also be developed in advance for rating-scale responses (such as for a four-level Likert scale ranging from completely disagree, somewhat disagree, somewhat agree, and completely agree). Further, it is advisable to eliminate any free-response answers to the SP questions; otherwise, significant manual post-coding will be required to make sense of and categorize the responses for use in modeling.

The implementation of an SP experimental design within an online platform allows for varying attribute levels to be easily coded. However, more often than not, logic structures will have to be utilized so respondents are presented only a given number of randomly chosen questions from a full set of combinations of attributes. In a platform such as Qualtrics, each version of the SP question, with varying attribute levels constructed through the experimental design process, should be input into a survey block. If the experimental design resulted in 30 possible scenarios, all with varying attribute levels across alternatives, each of these 30 questions should be uploaded onto the platform. Next, if only two of these 30 scenarios are to be presented to each respondent, an appropriate combination of logic and randomness needs to be used to identify the two scenarios. In the online platform, the attribute values and responses are automatically recorded in digitized form, making the online platform a very convenient survey administration approach for SP surveys.

All nine surveys reviewed as part of the COVID SP surveys were administered using Qualtrics, as noted in the column *SP administration*.

If the survey is administered over the phone, it will be up to the survey administrator to determine and keep track of which SP questions from the complete set are asked. Specific attribute levels must be noted when the responses are coded into an aggregate dataset in order to perform proper modeling.

## 3.4. Conclusion

To make informed transportation infrastructure planning decisions in response to the COVID-19 outbreak, planners and engineers have to be able to forecast these changing behaviors. Planning authorities can best comprehend the attitudes and preferences of the public by gauging responses to SP-styled surveys that pose hypothetical scenarios covering different time frames during and after the pandemic. However, the conditions of COVID-19 continue to vary over time and among regions, and the public's response also varies widely across respondents, as many people have differing views about its lasting impacts on their lifestyles and behaviors. This variability imparts significant uncertainty to any hypothetical simulation provided in a survey addressing COVID-19 effects. It is essential to develop the SP questions with this potential for uncertainty in mind and address specific characteristics when designing and preparing such a survey. The appropriate implementation of these technical components will help respondents better understand the survey they are responding to, which will be the focus of Chapter 4 and the remaining chapters of the project in the context of predicting COVID-19 impacts on commuting patterns.

# Chapter 4. Recommendations of methods for SP data integration within current TxDOT survey program[2]

## 4.1. Introduction

The coronavirus, or COVID-19, was declared a threat in the United States in March 2020. One major challenge related to COVID-19 has been the mitigation of the risk of contagion spread. In this regard, some cities took action at the municipal level, placing restrictions on gatherings in public and common spaces; precautions at the individual level have also now become routine over the last six months. A few common individual-level measures have been to self-quarantine, create social or physical distance between self and other people, and practice adequate hygiene by more frequently washing hands and wearing masks in public (Bruinen de Bruin *et al*., 2020).

The immediate impact of COVID-19 has been a shutdown of institutions and spaces where people typically gather. This included most workplace settings, schools, universities, restaurants, and other event venues (Wu and McGoogan, 2020). Participation in regular out-of-home work and study activities saw the most change, with almost all employees working from home (referred to as teleworking). While some employees miss the structure of traveling to the workplace and the informal socialization at the workplace, many report that they are happier and more productive when they can shift or split their work hours and are allowed to perform their jobs from anywhere they wish. Additionally, employers are seeing direct positive impacts as well, including increased efficiency, reduced real-estate costs of the physical office, reduced employee absence, and more time-effective methods for recruiting qualified staff (López-Igual and Rodríguez-Modroño, 2020).

In this backdrop of the pandemic that has gripped the world for a little more than a year, the year 2021 has brought with it immense promise in opening up the U.S., especially as vaccine distribution and "shots in the arm" have proceeded at a steady rate. Some employers have begun to call their employees back to the office a few times a week or even full time, though many businesses are unsure about a reopening timeline. Many office-based employees are being given the option to

[2] This chapter was written during the peak of COVID (September 2020 to the end of March 2021). Major changes, including the mass distribution of vaccines, occurred between the writing of this chapter and completion of the report in fall 2022.

choose whether they want to continue working from home, shift to a hybrid workplace schedule, or go back to working in the office full time.

An important question related to work (and other non-work) activity participations is whether the dramatic changes observed (and still being observed) during the ongoing COVID period will remain after the pandemic has substantially subsided. While it may be expected that many of the pandemic-caused travel behavior changes are transient, and some return to pre-COVID travel behavior is to be expected after the pandemic "calms" down, the nature and length of the new activity-travel experiences during the pandemic may carry over (at least to some extent) as we move into the post-COVID period. In particular, as working from home has been a transition many have made, some may choose to continue teleworking after the pandemic is over. This shift, and many others, are of considerable interest to transportation planning agencies as they plan for the future. That being said, extrapolating current COVID-era data and revealed preference (RP) activity travel patterns to plan for the future would not be appropriate. What is needed is an approach to ascertain individual intentions regarding activity-travel patterns in a post-COVID future, through the use of a stated preference (SP) experimental design.

As part of the ongoing RP-SP project, TxDOT embarked on an effort to consider the inclusion of SP questions within their usual RP-based survey procedures. Given the current circumstances, it was decided to develop guidelines for SP survey data collection in the context of examining COVID-19 effects on current and future activity travel patterns. This current chapter will discuss the design of an SP survey that has been developed to specifically address how Texas residents may shift in their commuting behaviors and workplace locations in future COVID-19 scenarios as vaccines become widely available and the country begins to open up once again. The survey design will be focused on gauging perspectives on commuting, given the pandemic experience of working from home, and how these commuting-related and broader lifestyle perspectives may be impacted by commute distance. The results from the implementation of such a survey may be used to forecast shifts in peak-traffic hours (rush hour), congestion levels, general telecommuting trends, and travel/congestion formation around centralized/dense workplace locations.

## 4.2. SP survey format/type

The survey design utilized the SP elicitation mechanism of a *Choice Experiment.* As a reminder, in this format, respondents are presented a set of SP questions and are instructed to choose from, or rank, a set of two or more alternatives with varying attributes levels across the SP question set. In the specific context of this

SP experiment, respondents were asked to choose from three different workplace alternatives with seven total varying attribute levels. This SP format, the choice experiment, presents a complex hypothetical scenario, as characterized by specific parameters and conditions, and provides data to analyze behavioral responses through the use of quantitative statistical models. Though a choice experiment with multiple questions, alternatives, and attribute levels may seem a bit cumbersome to a respondent, the data gathered from such a set of SP questions is extremely rich and valuable for projecting a wide range of future travel behaviors and demands. Such a choice experiment SP format offers an effective method to collect responses on potential behavior in a future unknown situation, taking into consideration the evolution of lifestyles and attitudes around workplace choice based on the COVID-era experience.

## 4.3. SP questions employed

As previously discussed, the topic of the SP experiment revolves around the impacts on teleworking and overall workplace choice, even as an increasing percentage of the population get vaccinated across Texas and the whole country. A link to the pilot of the survey can be found here: https://utexas.qualtrics.com/jfe/form/SV_6Stz13LnZlYjNZQ[3]. Before the respondent is presented the scenarios, they are briefed with an overview of the SP exercise. This overview indicates that the survey presents two hypothetical workplace scenarios and provides the context for some of the attributes that respondents are about to be presented with, as shown in Figure 4.1.

[3] The SP experiment and survey designed during the earlier stages of the project differs slightly from the final workplace location (WPL) survey referenced in the later chapters of this project. The survey and SP experiment discussed in Chapters 4 and 5 are merely an example of a COVID-related workplace location contexed SP experiment and important associated RP questions. The finalized survey and experiment can be found in Chapters 6 through 11 and in Appendices D, E, F, and G.

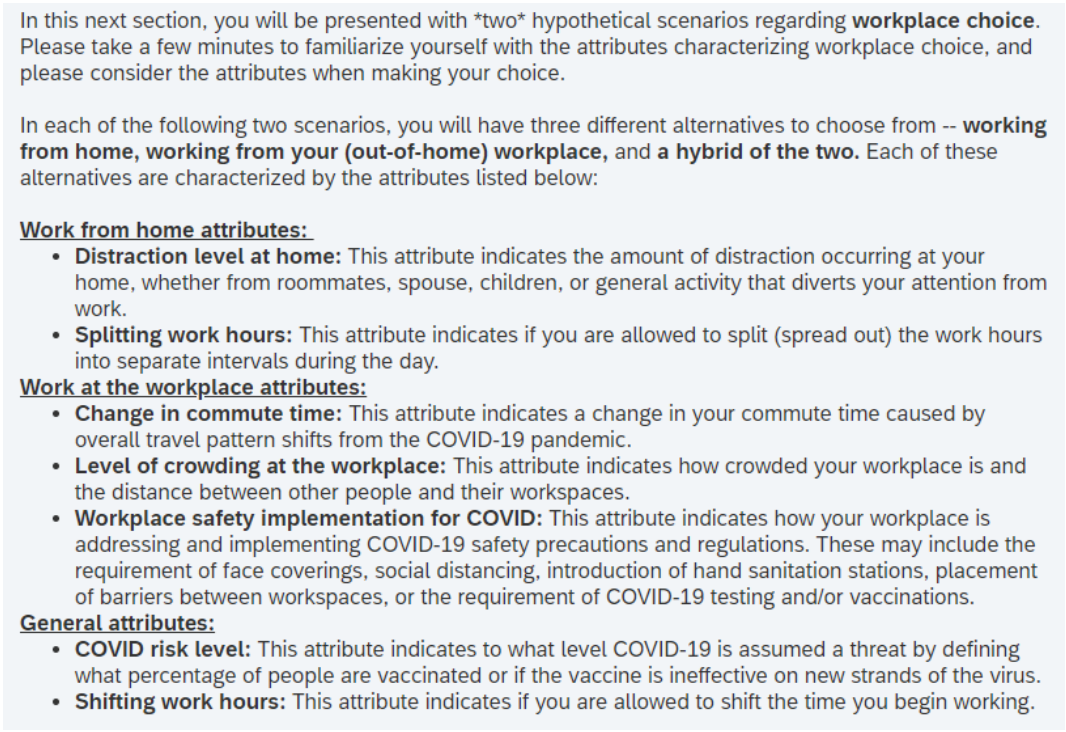



*Figure 4.1 Intro to the SP experiment*

Once respondents have read and understand each of the attributes, they are immediately presented with two different hypothetical scenarios—randomly selected from a total list of 32 scenarios that was developed through an orthogonal design procedure. The respondent is instructed to carefully review the options for a future workplace decision. The respondent can either choose to work from home, work from the out-of-home work office (referred to as work from the workplace), or work from a combination of both during any given week (a hybrid workplace choice option). Once they have considered all attributes for all three workplaces, along with the COVID-19 risk level during that hypothetical future time period, they must make a choice between the three workplace options. An example of a question the respondent could potentially be asked is presented in Figure 4.2.

In this scenario, you have three different options for where to work. Please carefully review your options.

| COVID Risk Level | Vaccine levels are unknown | | |
|---|---|---|---|
| ***Attributes*** | ***Work from Home*** | ***Hybrid Workplace (2-3 Days Teleworking)*** | ***Work from the Workplace*** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 30 minutes shorter than before | 30 minutes shorter than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementation for COVID** | - | No regulations | No regulations |

Please choose your preferred workplace location option based on the information presented in the table.

- ○ Work from home
- ○ Hybrid workplace (2-3 days teleworking a week)
- ○ Work from the workplace

*Figure 4.2 Example of SP question*

Each attribute, and its respective levels, are chosen and designed to effectively frame and differentiate between the hypothetical scenarios for the respondent. It is vital that the survey designer clearly and uniformly conveys the idea behind the hypothetical scenarios. The specific words and descriptions used to frame each question are critical. Wording used in the SP questions must be carefully crafted to ensure that the respondent comprehends the question presented in the context of the specific scenario envisioned by the researcher. In this designed SP experiment, each of the attributes are applied in the various experiments at different levels and for different reasons. Below is a description of why and how each attribute was implemented in the SP experiment.

- Covid risk level
  - Attribute levels
    - Vaccine levels are unknown
    - 40% of people have been vaccinated
    - 90% of people have been vaccinated
    - There is a new strand of virus and current vaccines do not work. Risk for the new strand is HIGH.
  - Intent behind this attribute: This attribute frames a specific COVID-19 situation for the respondent. Most individuals have a good understanding of how each of these attribute levels might impact their lives and can adequately imagine how they may act in the proposed hypothetical situation. Respondents can then indicate whether they will

return to their pre-COVID-19 out-of-home workplace, remain in the work location used during the pandemic, or adopt a hybrid approach—which is inherently the goal of the question.

- Distraction level at home
  - Attribute levels
    - High distraction
    - Low distraction
    - No distractions
  - Intent behind this question: Most respondents have had to work from home at some point during the COVID-19 pandemic and are well aware of the distractions in their home office. Whether these distractions come from their roommates, their partner's at-home workspace, rambunctious children, or other sources, the respondent has most likely made some adjustments to decrease distraction levels. This attribute allows for variation in the distraction amount and lets respondents decide if they would continue working from home given potentially high levels of distraction.
- Change in commute time
  - Attribute levels
    - Same commute time as before
    - 10 minutes longer than before
    - 30 minutes longer than before
    - 10 minutes shorter than before
    - 30 minutes shorter than before
  - Intent behind this question: Many individuals have eliminated any commute while working from home. With fewer cars on the road, congestion has significantly decreased, and individuals who are commuting to an in-person office are seeing much shorter commute times. There is much uncertainty as to whether these improved commute times will remain in a post-COVID-19 world, so this attribute's levels have a wide variability. Indeed, given the population growth trends in Texas, it is also possible that commute times may increase in the future, so that possibility has also been included as two options in these hypothetical scenarios.
- Splitting work hour (this attribute only shifts for the *Work from Home* option but remains "not allowed" for both the *Hybrid Workplace* and *Workplace* options)

- Attribute levels
    - Allowed
    - Not allowed
- Intent behind this question: Working from home gives many employees the option to split (spread out) their work hours (e.g., working from 8:00 a.m. to 12:00 p.m. and then from 4:00 p.m. to 8:00 p.m.). Some employers have allowed their employees to adjust their work schedule based on domestic responsibilities, as long as work is completed in a timely manner. This attribute allows for this option, but only for the work-from-home choice, as splitting hours is not usually an option when working in an office setting.

- Shifting work hour
    - Attribute levels
        - Not allowed to shift start time
        - Allowed to begin work earlier
        - Allowed to begin work later
    - Intent behind this question: Similar to splitting work hours, many employers are becoming more flexible with their employees' schedules, again as long as the work is still completed on time. This attribute indicates whether a start-time adjustment (either earlier or later) is allowed, and is applicable to all three work arrangements.

- Level of crowding at the out-of-home workplace
    - Attribute levels
        - No crowding, more than 6 feet between workspaces
        - Normal crowding, 6 feet distance is achievable between workspaces
        - High crowding, 6 feet distance is not achievable between workspaces
    - Intent behind this question: This attribute frames the in-person (out-of-home) workplace choice for the respondent. To create the safest workplace environment, many employers are implementing capacity limits or establishing schedules such that only specific groups of individuals are allowed to come into the office. However, some workplaces are not promising this type of precaution, and have normal or high crowding levels that do not allow for the suggested 6-foot distance from others. Concern about proximity to others is a predominant factor for many respondents when they are deciding

whether they are going to return to their in-person workplace. While this concern is likely to fade with time, it still may represent a deterrent factor to many for at least some period of time.

- Workplace safety implementation for COVID
  - Attribute levels
    - No regulations
    - Only one of these safety measures implemented
    - Two or more of these safety measures implemented
  - Intent behind this question: Similar to the last attribute, this attribute indicates which, if any, safety measures the employer has implemented in the workplace. The safety measures may include social distancing, required masks, hand sanitation stations, barriers, required testing, or required vaccination.

As previously mentioned, each respondent in the first pilot is shown two SP scenarios, from a possible array of 32, with optimized combinations of attribute levels. However, this number can be increased if desired. As detailed in Section 5, only two experiments were presented per respondent to prevent respondent fatigue in our pilot.

## 4.4. RP questions employed

Several RP questions are asked before and after the SP portion of the experiment to qualify respondents for participation. These questions were curated with a specific analysis intention in mind. Below is a list of the included questions and a brief explanation of how each will contribute to subsequent analysis. Additionally, a list of questions that could be included in later iterations of the survey is included for consideration.

### 4.4.1. Questions asked prior to the SP experiment

- What was your employment status before the COVID-19 pandemic?
  - Employed
  - Unemployed

  Intent behind this question: This question is used in tandem with the next question to filter out the respondents who were unemployed both before and during the pandemic, as the SP questions would not be applicable to them.

- What is your employment status now?
  - Employed

- Unemployed

  Intent behind this question: This question is used in tandem with the previous question to filter out the respondents who were unemployed both before and during the pandemic, as the SP questions would not be applicable to them.

- Did you work entirely from home before the COVID-19 pandemic?
  - Yes
  - No

  Intent behind this question: This question is used in tandem with the previous two question to filter out the respondents who teleworked full-time before the pandemic, as the SP questions would not be applicable to them.

- During the COVID-19 pandemic, have you been able to work from home?
  - Yes
  - No

  Intent behind this question: This question gauges whether teleworking has been an option for the respondent.

- How often do you typically telework during the week now? (*telework*, as used here, refers to working from home during the entire day, without going into an out-of-home office during that day to pursue the same work)
  - Never
  - Once a week
  - Twice a week
  - Three times a week
  - Four times a week
  - Five or more times a week

  Intent behind this question: As a follow-up to the previous question, this question specifically determines how often the respondent has been teleworking each week.

- How often do you typically commute (travel into an out-of-home office) during the week now?
  - Never
  - Once a week
  - Twice a week
  - Three times a week
  - Four times a week
  - Five or more times a week

Intent behind this question: This question specifically determines how often the respondent has been commuting to the physical out-of-home workplace each week.

- How often did you typically telework *before* the pandemic?
  - Never
  - Once a week
  - Twice a week
  - Three times a week
  - Four times a week
  - Five or more times a week

  Intent behind this question: This question will aid in understanding how the respondent may change their teleworking activity in future workplace choice scenarios, based on their choices prior to the pandemic. Additionally, this response may serve to indicate whether the respondent's employer would allow them to keep teleworking once the effects of the pandemic have eased or shifted.

- Before the COVID-19 pandemic, how far was your commute to work? (in miles)

  Intent behind this question: This question can be used to determine why a person may choose a specific workplace scenario. For instance, if a respondent's commute is very short, they may favor going into the office. If the respondent's commute is relatively long, the respondent may enjoy not having to drive to work, preferring to keep working from home in the future. Additionally, this response could be used to help gauge how congestion may change if a respondent decides to eliminate, or reduce, weekly commuting to the workplace in the future.

- Before the COVID-19 pandemic, how long was your commute to work? (in minutes)

  Intent behind this question: The purpose of this question is identical to the previous question, but provides the information in a unit of time rather than distance.

- Referring to your employment before COVID-19, where was your place of work located? Enter an address, cross street, or zip code. *If you do not wish to answer, please leave this question blank.*

  Intent behind this question: If many respondents stop driving to a specific, dense corporate or business district, the congestion in that area will significantly decline. This question aims to determine the location of areas that could potentially see decreases in travel. These areas may also soon see similar or even more travel and congestion than before the pandemic.

- Before the COVID-19 pandemic, how did you travel to work?
    - By car
    - By public transportation
    - By bicycle
    - By ride-sharing
    - By walking
    - Other

    Intent behind this question: Mode choice may have a huge impact on which workplace a respondent may choose, especially for safety and health reasons. The use of public transportation has significantly declined during the pandemic, as being in an enclosed space with multiple strangers can be perceived as a health hazard. Responses to this question can also be used to help determine which modes' usages may be impacted if respondents choose to reduce or eliminate traveling to work each week.

- Did you have to pay for parking at work before the COVID-19 pandemic?
    - Yes
    - No

    Intent behind this question: Having to pay for parking may become a disincentive to drive to work, which may increase the likelihood that a respondent chooses to work from home more often in the future.

- Have you changed jobs since the COVID-19 pandemic began?
    - Yes
    - No

    Intent behind this question: For those who have changed jobs during the pandemic, commute times are going to be unknown during normal circumstances, as well as other differences in answers to previous questions in the survey which may have been in regard to the previous job. Additionally, it is difficult to know how the in-person workplace rules and culture of a company when an employee has recently joined during the pandemic. The respondent may not be making entirely realistic decisions in the SP experiment. Changing jobs is important to note when performing analysis and measuring uncertainties.

- Does your employer currently have COVID-19 safety implementations in place, or plans to implement them in the near future? (please respond even if you are self-employed, in which case you would also be your own employer)
    - Yes
    - No

    Intent behind this question: For some, there is an option to work in the workplace. Answers to this question will be used to determine if current

or future safety implementations play a role in whether the respondent is more likely to work in their office, rather than at home.

- Which ones?
    - Social distancing
    - Mandatory face coverings
    - Hand sanitation stations
    - Barriers
    - Mandatory COVID testing
    - Mandatory vaccination

    Intent behind this question: This question will be used to determine how (and which) safety implementations, specifically, will have an effect on how likely someone is to re-enter the workplace, rather than work from home.

- How many vehicles does your household own?

    - Intent behind this question: Vehicle availability determines possible mode choices to and from the workplace. In a scenario where vehicle availability in the household is low, one must rely on alternative mode choices and may be more likely to work from home, given that some other modes (i.e., public transportation, shared ride services) prevent adequate social distancing.

- Has your vehicle availability changed during the COVID-19 pandemic? (i.e., have you bought or sold any vehicles, changing the total number of vehicles in your household)
    - Yes
    - No

    Intent behind this question: This question will determine whether the respondent's vehicle availability has changed, given the changes in activity-travel patterns that have arisen during the COVID-19 pandemic.

- How has the total number of vehicles in your household changed?
    - Increased by ___ vehicle(s)
    - Decreased by ___ vehicle(s)

    Intent behind this question: This question will determine how the respondent's vehicle availability has changed, given the changes in activity-travel patterns that have arisen during the COVID-19 pandemic.

- Have you moved residences since the COVID-19 pandemic began?
    - Yes
    - No

Intent behind this question: Since teleworking has become the normal during the COVID-19 pandemic, it is no longer necessary for people to live near their place of work. This question will determine if the respondent has changed their place of residence, which would also alter their activity-travel patterns.

- How many people (including you) live at your current residence?

  Intent behind this question: Household dynamic may have an effect on the teleworking environment of the respondent. This question will establish a sense of the household dynamic that provides this environment.

- Who do you currently live with?
  - Significant other
  - Family
  - Roommates
  - Both family and roommates
  - Other

  Intent behind this question: As a follow-up to the previous question if they report to not live alone, answers to this question will help establish a sense of the household dynamic.

### 4.4.2. Questions asked after the SP experiment

- Would you consider switching your mode choice when commuting to work under any of these hypothetical scenarios?
  - Yes
  - No

  Intent behind this question: This question can be used in tandem with the previous mode choice RP question to see if the pandemic has changed the way a respondent will get to their workplace, if they decide to continue commuting at all.

- If so, to which mode(s)? *Feel free to select more than one mode.*
  - Public transportation
  - Bicycle
  - Walk
  - Ride-sharing
  - Drive myself
  - Carpool with others

  Intent behind this question: This question will be used directly with the previous question to analyze COVID-19's impact on mode choice.

### 4.4.3. Additional questions that could be included

Many other questions may be included in future iterations of the survey. Though some may already appear in currently deployed TxDOT surveys, many of these questions are specific to COVID-19 and thus may not be included in existing surveys. These questions are categorized into a few specific topics:

- COVID-19-specific questions:
    - To what extent do/did you feel personal wellbeing is/was at risk during the pandemic?
    - Do you perceive COVID-19 as an immediate threat to your loved ones or you personally?
    - Would you consider yourself immunocompromised?
    - Is someone you live with or frequently visit immunocompromised?

    Intent behind these questions: These questions will help gauge the respondent's attitude and perspective on the COVID-19 pandemic. There are many alternative and contradicting views about COVID-19 in the population, and these questions may be helpful in predicting a respondent's preference regarding workplace location.

- Commute/employment-related questions
    - Were you happy with your commute to your usual out-of-home work location before the pandemic?
    - Do you think your commute time/distance is too long? Too short? (referring to the situation before the pandemic)
    - Has your commute time changed during the COVID-19 pandemic (applicable only if respondent has traveled to work during the pandemic)?
    - Has your workplace closed its in-person office during the COVID-19 pandemic?
    - Did your employer allow working from home for one or more days before the COVID-19 pandemic (without the need to commute to work on those days)? If yes, how many days per week?
    - Did your employer allow flexible work hours before the COVID-19 pandemic? If yes, provide a set of categories to capture the level of flexibility, such as "arrival at work up to 30 minutes after usual start time", "up to an hour later than usual start time", "Leave work up to 30 minutes earlier than usual work end time", "Leave work 3-60 minutes earlier than usual work end time"….

    Intent behind these questions: These questions will provide additional insight into why a respondent may wish to reduce or eliminate working at the out-of-home workplace, as these questions help identify any individual- or employer-based predispositions related to the commute and work arrangement preferences. The attributes in the SP experiment

do not adequately reveal potential non-COVID-related incentives to work at home, yet these motivations are almost equally as important for analysis purposes and modeling future road network and travel behavior scenarios.

- Household-related questions
  - Do you have children?
  - How distracting has your environment been while teleworking during the COVID-19 pandemic?
  - Have you lived at your normal residence during the COVID-19 pandemic?

  Intent behind these questions: These questions gather more information on a respondent's household environment. If a respondent's children, spouse, or roommates are very distracting, a respondent may wish to go back to working from the out-of-home workplace to regain a sense of focus and control.

- General sociodemographic questions
  - Age
  - Income
  - Employment type
  - Residence in Texas

  Intent behind these questions: Answers to these questions can help accommodate for heterogeneity in preferences among respondents.

## 4.5. Survey content

As previously discussed, the survey content focuses on COVID-19 in the context of *teleworking*. The future of the "work-from-home" trend that has accompanied COVID-19 is already becoming uncertain. As detailed in Chapter 3, it remains to be seen whether a significant cohort of workers will return to their offices post-COVID. Equally unknown is what new traffic patterns may emerge. To fill this knowledge gap, this survey focuses on potential commuting behaviors in a post-COVID world.

### 4.5.1. Methods used to convey the characteristics of the hypothetical scenario

This SP experiment revolves around potential scenarios involving the COVID-19 pandemic. It is important to frame SP questions so that the survey designer clearly and uniformly conveys the idea behind the hypothetical scenarios. Two attributes are included to set the stage for the respondent: COVID-19 risk level and

COVID-19 safety precautions at the workplace. Additionally, each respondent is provided an overview of the scenarios presented.

### 4.5.2. Experimental design of the SP survey

The experimental design of the SP experiment is an orthogonal design. To reiterate, in an orthogonal design, the objective is to develop levels of an attribute that are statistically independent of the levels of other attributes, so that the individual main effects of each attribute can be accurately and precisely estimated. Such an orthogonal design may be generated using a variety of software packages, including R and the statistical software SPSS. In the survey developed here, the orthogonal design resulted in an optimal subset of 32 individual experiments based on seven attributes with varying level sizes. A list of these experiments and the corresponding attribute values is provided in Appendix B. The experimental design is conducted such that the RP and SP data, in combination, provide important information to predict future workplace location choices. When determining the attribute levels for the three different workplace location alternatives, it is important to ensure realism in the attribute values, so respondents are able to visualize and internalize the choice task with existing memory and reference.

Another factor of experimental design is deciding how many scenarios to present each respondent with. In the first pilot, each respondent was shown two SP questions, with a different combination of the preselected attributes. The number of questions presented can increase, depending on the goal of the analysis. For example, if the focus is to analyze how vaccine levels, safety precautions, or social distancing affect a person's opinion of working from home versus going to work, the survey may be designed to ask more than two questions. A significant issue with asking more questions is respondent fatigue. As the number of questions increases, respondents may become less interested in reading and differentiating between the attributes. This would lead to increased uncertainty in results. If the survey is designed to ask only a few SP questions, across many respondents, analysis will still be successful if respondents are grouped with other sociodemographic factors throughout the modeling process. To limit fatigue, SP experiments should range between two to four questions. Otherwise, there is a risk that the respondent will become distracted, bored, or otherwise uninterested in absorbing the information presented and providing an informed response.

### 4.5.3. Linkage between the RP and SP components

Once the experimental design is configured and the set of SP questions is determined, the survey designer must decide the subset of respondents who will

be presented with the SP questions (also known as the SP component). To some respondents, the SP component will not be applicable. In this experiment, respondents are first asked if they were unemployed or employed before the COVID-19 pandemic and during the COVID-19 pandemic. If the respondent answers "unemployed" to both of these questions, the survey ends, and they are not presented the SP questions or any of the other accompanying RP questions. Other such linkages could be implemented if the SP experiment is included in a larger survey that may ask for more information from the respondents. For example, if the respondent reports to work at a food industry job, they may not have ever been given the option to work remotely and can therefore be automatically excluded from the SP experiment.

The actual SP scenario developed for an individual is relatively simple to do in Qualtrics, where the respondent's answer to an earlier RP question in the survey can help determine the attributes characterizing the SP experiment. Most online tools allow for multiple RP questions to be linked to a single SP component, making it easy to construct good SP scenarios. If this RP-SP linkage in constructing SP scenarios is forgone, it would increase the uncertainty level in the SP data collected and reduce the validity of behavioral projections.

## 4.6. Survey administration

The survey was administered through an online platform: Qualtrics. The implementation of an SP experimental design within Qualtrics allows for varying attribute levels to be easily coded. Further, a logic structure may be utilized so that respondents are presented only a specified number of randomly chosen questions from a full set of combinations of attributes. In the SP experiment used in the current effort, a total of 32 different SP scenarios were coded into the Qualtrics platform, but the distribution was randomized so that each respondent saw only two versions of the scenarios, with varying attribute levels. In the online platform, the attribute values and responses are automatically recorded in digitized form, making the online platform a convenient survey administration approach for SP surveys.

The online survey platforms are designed to provide survey layouts that easily transfer to any type of mobile device or computer. The platforms also save participants' responses in an easily accessible database, which can be downloaded in various formats to be used in additional programs for travel demand modeling and other forms of analysis. Most programs let the survey designer assign values to the question responses before the survey is deployed. For example, if the SP question asks for a yes-or-no answer, such as if the respondent is or has been

allowed to telework or work from home, it is beneficial to code *yes* as 1 and *no* as 0, so this step does not have to be taken once the dataset has been assembled.

## 4.7. Survey deployment

The SP survey was deployed for an initial close friends-and-family pilot by the survey designers[4] (since this pilot was a simple functional test of understandability and reasonability of the designed survey rather than an instrument to collect data, and was administered only to immediate friends and family of the survey designers, a formal University of Texas at Austin IRB review was not undertaken). This first pilot resulted in 31 responses, although one respondent replied "unemployed" for both of the two pre- and during the pandemic work RP questions and did not proceed to the SP experiment, due to the use of logic statements. This individual's responses were removed from the analysis. Preliminary statistics from this pilot survey are presented in the next section.

A second pilot of the survey is to be scheduled with TxDOT to distribute among their staff, friends, and family, and/or a focus group of their choice[5]. Together, both pilots will be used as a case study to analyze the limitations and results of this SP experiment, as well as the accompanying RP questions, included in the complete guidebook prepared in a later step. This will allow the components, analysis approach, and other factors of the designed SP experiment to be discussed.

### 4.7.1. Preliminary descriptive statistics

After running an initial pilot of the survey, responses from 30 individuals were collected, leading to a total of 60 choice occasions across the 30 individuals (because each individual was presented with two SP choice questions). Tables 1 through 8 represent descriptive statistics from the SP questions posed within the survey. These descriptive statistics constitute responses associated with workplace choice, and workplace choice by COVID-19 risk levels, distraction levels at home, changes in commute time from home, splitting work hours, shifting work hours, level of crowding at the workplace, and workplace safety implementations for COVID. The responses from the pilot survey to the RP questions listed in Section 4 are not presented here, because, again, the emphasis here is on the understandability of the SP component of the survey. Note also that because only two SP questions were asked of each respondent in the SP component, and this

[4] This pilot was conducted in Spring 2021.
[5] This pilot was also conducted in Spring 2021.

exercise was a pilot with only 30 individuals, the number of respondents presented with each scenario (that is, combination of attributes and attribute levels) is not evenly distributed across attributes or attribute levels. For example, while 17 individuals had a scenario that included the attribute level of "vaccine levels unknown" as part of one of the two SP questions, only 15 individuals had a scenario that included the attribute level of "40% vaccinated of people are vaccinated." So, we focus on the percentage distributions across the three workplace choices for each attribute and attribute level, rather than the actual absolute number of responses. Additionally, it must be emphasized that this exercise is intended simply to provide a sense of functionality of the survey instrument, rather than providing any substantial insights on behavior, given the very limited sample size. As such, we present the descriptive statistics to examine overall trends and check if the responses seem plausible given the attribute levels, rather than as any definitive source of information for planning or other purposes.

**Table 4.1 Overall workplace choice statistics**

| Workplace Choice | Frequency chosen | Percent chosen |
|---|---|---|
| ***Work from home*** | 18 | 30% |
| ***Hybrid workplace (2-3 days teleworking a week)*** | 19 | 32% |
| ***Work from the (out-of-home) workplace*** | 23 | 38% |

**Table 4.2 Workplace choice statistics by COVID-19 risk level (percentages)**

| COVID-19 Risk Level | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *Vaccine levels are unknown* | 29.4 | 41.2 | 29.4 |
| *40% of people have been vaccinated* | 33.3 | 33.3 | 33.3 |
| *90% of people have been vaccinated* | 40.0 | 0.0 | 60.0 |
| *There is a new strand of the virus and current vaccines do not work. Risk for the new strand is HIGH.* | 30.0 | 53.8 | 30.8 |

**Table 4.3 Workplace choice statistics by distraction level at home (percentages)**

| Distraction Level | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *High distraction* | 27.6 | 24.1 | 48.3 |
| *Low distraction* | 41.7 | 33.3 | 25.0 |
| *No distractions* | 26.3 | 42.1 | 31.6 |

**Table 4.4 Workplace choice statistics by change in commute time (percentages)**

| Change in Commute Time | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *Same commute time as before* | 35.7 | 28.6 | 35.7 |
| *10 minutes longer than before* | 26.1 | 34.8 | 39.1 |
| *30 minutes longer than before* | 38.5 | 30.8 | 30.8 |
| *10 minutes shorter than before* | 50.0 | 0.0 | 50.0 |
| *30 minutes shorter than before* | 12.5 | 37.5 | 50.0 |

**Table 4.5 Workplace choice statistics by splitting work hour (applicable only for work from home) (percentages)**

| Splitting Work Hour | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *Allowed* | 30.8 | 34.6 | 34.6 |
| *Not allowed* | 29.4 | 29.4 | 41.2 |

**Table 4.6 Workplace choice statistics by shifting work hour (for all workplace choices) (percentages)**

| Shifting Work Hour | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *Not allowed to shift start time* | 42.3 | 34.6 | 23.1 |
| *Allowed to begin work earlier* | 18.8 | 25.0 | 56.2 |
| *Allowed to begin work later* | 22.2 | 33.3 | 44.4 |

**Table 4.7 Workplace choice statistics by level of crowding at the workplace (percentages)**

| Level of Crowding at the Workplace | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *No crowding, more than 6 feet between workspaces* | 17.2 | 31.0 | 51.7 |
| *Normal crowding, 6 feet distance is achievable between workspaces* | 53.3 | 20.0 | 26.7 |
| *High crowding, 6 feet distance is not achievable between workspaces* | 31.2 | 43.8 | 25.0 |

**Table 4.8 Workplace choice statistics by workplace safety implementations for COVID (percentages)**

| Workplace Safety Implementations for COVID | Work from home (Percent) | Hybrid workplace (2-3 days teleworking a week) (Percent) | Work from the workplace (Percent) |
|---|---|---|---|
| *No regulations* | 31.2 | 37.5 | 31.2 |
| *Only one of these safety implementations* | 28.6 | 35.7 | 35.7 |
| *Two or more of these safety implementations* | 28.6 | 14.3 | 57.1 |

Table 4.1 represents an approximately even split in the percentage of respondents that chose working from home, a hybrid workplace, and working from the workplace. The highest single percentage is those who chose to return to the workplace, resuming a daily commute on pre-COVID transportation networks. However, 62% of respondents chose to work from home or chose a hybrid schedule, which allows for 2 to 3 days of teleworking per week. In Table 4.2, as the percentage of people who are vaccinated increased, the percentage of respondents who chose to return to the workplace increased—from 33.3% to

60.0%. This result reflects the respondents' concerns about safety. Respondents are more likely to return to a place of gathering, such as a traditional office space, if the risk of being exposed to COVID-19 by unvaccinated coworkers is less prevalent. Table 4.3 describes workplace choice due to distraction levels at home. The results indicate that the percentage of respondents who chose to return to the workplace is highest when distraction levels at home are high. In contrast, in a situation where levels of distraction at home are low, the percentage of respondents who chose to work from home was highest. In Table 4.4, it may be observed that upon a commute time 30 minutes longer than its previous length, the percentage of respondents who chose to work from home was highest. In contrast, a commute time 30 minutes shorter than before leads to one-half of respondents choosing to return to the workplace. Commute time affects workplace choice. In Table 4.5, upon being allowed to split work hours across the day, there is very little different in workplace preference, as there is an even 30% splits across all three alternatives. However, when not allowed to split work hours, there is a 10% higher preference towards only working from the in-person workplace. In Table 4.6, upon being allowed to start work later, the majority of respondents chose to work in the workplace. However, when respondents were not given the option to shift start times, the majority chose to work from home. Start time has a strong connection with commute time, as workers may prefer to adjust their travel window to avoid heavy congestion. Table 4.7 suggests that social distancing measures in the workplace, or providing 6 feet between workspaces, would prove effective in inducing respondents to return to the workplace. Almost 52% of respondents chose to return to work if there is more than six feet between workspaces. Table 4.8 shows that as safety implementations increase in the workplace, the percentage of respondents choosing to return to work steadily increases. Again, if given an indication that employers are making efforts to create a safe work environment for their employees, respondents are more likely to choose to work from that workplace.

### 4.7.2. Limitations of the survey design and preliminary results

Every experiment comes with limitations and uncertainties, especially when the nature of the experiment revolves around hypothetical scenarios. The first pilot deployed revealed a few issues with the survey, which were easily fixed once pointed out. These included logic issues in the presentation of certain questions to specific respondents and some clarification issues with the attribute descriptions in the SP experiment overview. Once those were addressed, the first SP survey pilot deployment went smoothly. The results were exported from Qualtrics and examined in both Excel and R for any odd and strange responses and trends. None

were found after the first pilot, though this does not mean a second pilot among TxDOT employees, friends, and family or another focus group will not reveal issues that need attention. Therefore, it is very important to be prepared to address other limitations and uncertainties as the deployment and the data collection process continues and advances. A "Dos and Don'ts" recommendation list is presented in the final guidebook, in order to ensure feasibility and sustainability of SP efforts.

## 4.8. Conclusion

To make informed transportation infrastructure planning decisions, planners and engineers have to be able to forecast changing activity-travel behaviors. This can be achieved through SP experiments that pose hypothetical future scenarios. The importance of understanding and forecasting post-COVID activity-travel patterns led to a decision in the current TxDOT project to develop guidelines for SP survey data collection procedures and protocols in the context of examining potential COVID-19 work arrangement experiences on post-COVID workplace choice. The survey was designed with an emphasis on survey flow, appropriate wording for tightness and clarity, effective scenario framing, and an efficient experimental design. The survey also entailed the presentation of RP questions before and after the SP experiment to provide additional contextual and sociodemographic information on respondents. A preliminary deployment has yielded descriptive statistics. The appropriate implementation of the technical components discussed in this chapter should help TxDOT include SP questions and experiments within the context of their current RP-based travel surveys.

# Chapter 5. Proposing a modeling framework for RP-SP integration[6]

## 5.1. Introduction

Traditional regional travel surveys primarily present revealed preference (RP) questions that record the socio-demographic characteristics of individuals as well as their general travel behavior. In the context of workplace location choice, travel forecast models abstract these travel behaviors into a few attributes. These attributes include the number of commuting trips made in a week; the individual's value of time; and the baseline preference or employers' consent for individuals to telework, work from the office, or engage in a hybrid of both. The abstracted travel characteristics identified for an individual through RP questions are usually sufficient to predict the decision-making process of the individual in a "business-as-usual" setting. However, technological advancements (and life-changing experiences such as those caused by the COVID pandemic) are creating unprecedented possibilities for work and travel, and creating scenarios that were unimaginable before the COVID pandemic. These scenarios are also becoming increasingly complex and not always easy for the average traveler to visualize. One of the only ways to limit the uncertainty for survey respondents (in terms of both visualizing the hypothetical scenario and maintaining consistency of this visualization across collected responses), while still being able to forecast into a highly variable future, is through incorporating stated preference (SP) questions into traditional travel demand surveys. The integration and joint modeling of RP and SP responses provides more accurate and complete data for travel demand models, enabling improved forecasts for a travel future that is continually evolving.

One specific novel setting is whether the dramatic changes to travel behavior observed during the ongoing COVID period will persist after the pandemic has substantially subsided. The current expectation is that many of the travel behavior changes caused by the pandemic are transient. However, some of the new activity-travel behaviors may continue into the post-COVID period. The shift to teleworking has proven popular with many workers, who may choose to continue teleworking after the pandemic is over if employers give them the option. This shift, and many others, are of considerable interest to transportation planning agencies as they map out the future. That being said, extrapolating current COVID-era data and RP activity travel patterns to plan for this future would not

[6] This chapter was written in May and June of 2021. Major changes occurred between the writing of this chapter and completion of the report in fall 2022.

be appropriate. An approach is needed to ascertain individual intentions regarding activity-travel patterns in a post-COVID future—an approach involving the use of an SP experimental design.

As part of the ongoing RP-SP project, an SP survey, combined with initial and necessary RP questions, was designed and piloted. The workplace choice location survey specifically addressed how Texas residents may shift in their commuting behaviors and workplace locations in future COVID-19 scenarios as vaccines become widely available and the country opens up again. The survey focused on gauging attitudes toward commuting, given the pandemic experience of working from home, and how these commuting-related and broader lifestyle perspectives may be impacted by commute distance. Respondents' behaviors and perspectives were collected through both RP and SP approaches. This chapter will discuss the benefits and intricacies of jointly modeling the responses collected from both approaches, to convey potential analysis results and policy implications. To that end, Section 5.2 will describe the process of organizing an RP-SP survey dataset to enable analysis. Section 5.3 presents a blueprint for the structure of models and associated RP-SP estimation approach using a mixed multinomial logit formulation. Section 5.4 discusses the generalized benefits of jointly modeling RP and SP data. Throughout each of these steps, the decision-making process of the joint RP-SP estimation approach will be demonstrated through a case study of the workplace choice location survey.

## 5.2. Organization of an RP-SP survey's dataset

Before the structure of the joint RP-SP model is discussed, it is important to review the setup of the dataset used in the model. Typically, an RP-SP survey consists of an array of sociodemographic or household questions: a set of RP questions to reveal current travel behavior, and an SP experiment to gather responses associated with a hypothetical choice scenario. Therefore, the resulting dataset will contain a significant amount of information, which demands a thorough organization.

Due to the nature of an SP experiment[7], each respondent is typically shown two to four different SP questions of varying attribute levels (a single SP question will be

[7]Though an SP experiment can be designed through many different elicitation mechanisms, a Choice Experiment format is used in most surveys (other formats are discussed in Chapter 3). As a reminder, in this format, respondents are presented an array of SP questions and instructed to choose from, or rank, a set of two or more alternatives with varying attribute levels across the SP question set. The full SP experiment consists of an optimal set of SP questions, selected through one of four statistical experimental design and optimization strategies (an overview of these optimization strategies can also be found in Chapter 3), though any individual respondent will see only two to four of the questions, to limit fatigue.

referred to as a *choice occasion* for the remainder of this discussion). In the workplace location choice survey, for example, each respondent was presented only two of 32 possible SP scenarios, alongside an array of RP and sociodemographic questions. In an effort to keep analysis efforts as simple and straightforward as possible, the dataset will be organized so an individual's response to each choice occasion (along with the occasion's respective attribute level values) becomes its own row in the dataset. Each row will also contain that individual's sociodemographic and household characteristic data as well as the current travel behaviors extracted from the RP questions (or RP choice occasions)[8]. Thus, some repetition occurs within the dataset structure, as the same demographic and RP information will appear on both rows holding an individual's responses to the two SP choice occasions. A visualization of an organized database is provided in Figure 1 (though it excludes most individual and household sociodemographic data for simplicity). Notice that each respondent has been put in the dataset twice, with their RP data replicated exactly, though their SP choice occasion, and its respective attribute levels, are different. This demonstrates that each respondent was asked two different SP questions, and the dataset now consists of double the respondents. This duplication has no effect on later estimations, and provides an easy and straightforward method of organization during the modeling process.

[8]This is effectively treating each SP choice occasion as repeated choice events from the same individual.

| | RP Questions | | | | | SP Questions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Respondent ID | Work Status Before COVID | Work Status Now | Current Safety Precautions at Workplace | Frequency of Telecommuting each week before COVID | Household Size | SP Workplace Location Choice | COVID Risk Level | Distraction Level at Home | Increase in Commute | Splitting Work Hours | Shifting Work Hours | Crowding at the Workplace | Safety Precautions at Workplace |
| R_1 | Unemployed | Employed | Social distancing, Required masks, Hand sanitation stations, Barriers | 3 | 2 | Hybrid workplace (2-3 days teleworking a week) | 1 | 3 | 5 | 2 | 2 | 2 | 1 |
| R_1 | Unemployed | Employed | Social distancing, Required masks, Hand sanitation stations, Barriers | 3 | 2 | Work from home | 3 | 3 | 1 | 2 | 3 | 3 | 3 |
| R_2 | Unemployed | Employed | Social distancing, Required masks, Hand sanitation stations | 2 | 5 or more | Work from the workplace | 2 | 1 | 2 | 1 | 3 | 1 | 2 |
| R_2 | Unemployed | Employed | Social distancing, Required masks, Hand sanitation stations | 2 | 5 or more | Work from the workplace | 3 | 1 | 3 | 1 | 1 | 3 | 1 |
| R_3 | Employed | Employed | Required masks, Hand sanitation stations, Required testing | 3 | 4 | Work from home | 1 | 1 | 4 | 2 | 2 | 3 | 2 |
| R_3 | Employed | Employed | Required masks, Hand sanitation stations, Required testing | 3 | 4 | Work from home | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

*Figure 5.1 Example of an organized dataset for use in modeling an SP experiment*

This organization can also be described in mathematical terms. Assume X number of respondents to a survey, with each respondent answering two SP choice occasions. Let there be Y currently observed RP choices, and an array of sociodemographic/household questions. This just described data may be housed within a dataset that has X rows, each containing two SP choice occasion columns, Y RP choice indicator columns, and multiple columns for the sociodemographic/household information types. But, for joint RP-SP estimation, it is convenient to translate this dataset structure (with X rows) to a new dataset structure with 2*X rows, each row holding one SP choice occasion, Y RP choice columns (with the RP data in each of the two rows for the same individual having identical entries), and the array of sociodemographic/household columns (again, with this information being identical in the two rows from the same individual). Blueprint for the structure of joint RP-SP models

Most of the analytical tools that may be used for forecasting travel behavior based on RP survey data can also be used with SP survey data. These analytical tools include frequency tabulations, linear regressions, discrete choice models, and ordinal variable models. However, some analytical tools are generally better suited for use with SP components. Examples of these analytical models are ranking models and best-worst preference models, which can be used only if the preference elicitation method allows. The hypothetical bias in the SP data can be effectively controlled by joint modeling the SP and RP components. Some effective methods for controlling the bias in this manner are demonstrated in Bhat and Castelar (2002). When designing a survey, certain RP questions are asked before and after the SP portion of the experiment, serving as anchors to ensure that the SP responses (made in the context of hypothetical scenarios) are reasonably consistent with the actual RP-based travel behaviors manifested by individuals (Loomis, 2011). These RP questions are curated with that specific analysis intention in mind; their use alongside the SP data ensures “grounding” of the SP data with the RP component.

Although each of the RP grounding questions may provide valuable data in their own right, the combination of the RP anchoring the SP components results in a more robust analysis of travel behavior and allows projection into a future environment quite different from today’s reality. In the workplace location choice survey, the topic of the SP experiment is the pandemic’s impacts on teleworking and overall workplace choice. Here, the objective of the SP questions is to obtain data to gauge perspectives on commuting, given the pandemic experience of working from home, and how these commuting-related and broader lifestyle perspectives may be impacted by commute distance. Specific RP questions were also incorporated before and after the SP experiment to collect information on

both pre-COVID and current travel behaviors. These questions included actual teleworking and commuting habits, both current and pre-pandemic, as well as other vehicle availability and job status queries. The objective of these RP questions is simple: to provide data for the continued development and refinement of travel demand models. Recognizing the actual travel habits and preferences of respondents is vital. Therefore, the RP data is finally estimated as a dependent outcome that is jointly modeled alongside the SP experiment's dependent outcomes, while also informing the SP experiment's dependent outcomes as an endogenous explanatory variable.

Consequently, the joint modeling of RP and SP dimensions can forecast shifts in peak-traffic hours (rush hour), congestion levels, general telecommuting trends, and travel/congestion formation around centralized/dense workplace locations. (However, to reiterate, using the current COVID-era data and RP activity travel patterns to plan for future travel patterns would not be appropriate.)

Applications of joint RP-SP models have become increasingly popular in transportation research. One of the most common modeling structures is a *mixed multinomial logit formulation.* A mixed multinomial logit model provides a straightforward method to consider both the RP and SP responses for a single individual simultaneously. This formulation relies on two formulation components: *mixed* and *multinomial.*

> **Mixed:** The presence of multiple observations of stated choice responses and actual revealed behavior for each sampled individual suggests that the potential for correlated responses across observations is a violation of the 'independence of observations' assumption in classical model estimation. The *mixed* formulation relaxes the independence assumption and accounts for the correlation in decision-making across multiple choice instances of the sane individual. A *mixed* logit model is a logit model for which all parameters or variables are assumed to vary from one individual to another, therefore accounting for the heterogeneity of the population.
>
> **Multinomial:** In any single SP or RP question, an individual can be presented any number of options to choose between/from. To account for any scenario that does not offer only two options, or a binary choice, a *multinomial* formulation is used when the decision in question is nominal (or categorical, meaning that it falls into one of a set of categories) and for which there are more than two categories. For example, in our workplace location choice, the respondent is presented three options to choose from: work from home, work at the office (referred to as "work from the workplace"), or work from a combination of both locations during any

given week (a hybrid workplace choice option). Including these three options creates a multinomial regression setup.

Essentially, a mixed multinomial logit model takes the structure of a multinomial logit model for each individual, conditional on the coefficient value (taste sensitivity to variables) for that specific individual. This coefficient value may be affected by unobserved individual-specific factors (for example, some people, because of their sociable and extroverted nature (which would be an unobserved variable in most studies) may intrinsically prefer to go their workplace rather than work from home. The effect of such unobserved individual factors (in terms of shifting taste sensitivity) is assumed to be captured in a realization from a specific mixing distribution (typically a normal distribution). Finally, the analyst simply integrates over the mixing distribution (with the multinomial logit kernel as the conditional basis) to get the desired probability in the mixed multinomial logit model.

Numerous statistical software programs can estimate mixed multinomial logit models; many of these, such as R, are free or open-sourced. Other programs, such as SPSS, Stata, and Gauss, can also be used to estimate a mixed multinomial logit model, though they require a yearly subscription to access.

An example of a mixed multinomial logit model can be outlined using RP and SP data from the workplace location choice survey. This example is designed to answer the following research question: How does an individual's commuting patterns before the pandemic influence future commuting patterns? The analytic framework is presented in Figure 5.1. As seen under "Main Outcomes," in the SP dimension, three dependent outcomes form the hypothetical scenario: telework, work from the office, or a hybrid of both. The RP dimension will consist of three identical dependent outcomes, though now set in a pre-COVID scenario: telework, work from the office, or opt for a hybrid of both[9]. The SP dimension will come straight from the SP experiment, while the RP dimension will be extracted from the following RP question asking respondents how often they typically telecommuted *before* the pandemic:

- How often did you typically telework *before* the pandemic?
  - Never
  - Once a week
  - Twice a week
  - Three times a week

[9] Refer to Chapter 4 for additional information on the format and contents of this SP experiment.

- Four times a week
- Five or more times a week

To adapt this question for modeling needs, if a respondent answered "Never," then their dominant work mode is assumed to be "work from the office"; if they answered, "Five or more times a week," then their dominant work mode is assumed to be "telework." Lastly, if the respondent chooses any of the remaining options, then their dominant work mode is assumed to be "participate in the hybrid of both."

As seen in the top box of Figure 5.2 under "Exogenous Variables," the model will contain an array of individual-level characteristics, such as individual and household demographics. Typical examples include respondents' age, income, education level, employment status, ethnicity, household structure, presence of children in the household, residential location, and vehicle availability. Notice that not all of this data was included in the initial workplace location choice survey, as this survey was originally intended for inclusion within a typical TxDOT regional travel survey, which already collects this information. If an actual estimation of this joint RP-SP formulation occurred, then sociodemographic data would be necessary to estimate both the RP and SP dimensions and obtain accurate and applicable results. The sociodemographic data will be used to demonstrate how different groups of individuals vary across workplace location, highlighting which socio-demographic groups are shifting their commute patterns and therefore impacting congestion levels.

In the middle box of Figure 5.2, under "Exogenous Variables," are commute and workplace characteristics. This variable type will account for real commute times/distances, attitudes towards commute characteristics, ability to telework during/before the pandemic, teleworking and commuting patterns during the pandemic, real workplace safety implementations set by employers, and mode choice for work commutes, as well as many other factors. These variables will assist in determining how commute standards, workplace environments, and employment regulations influence workplace location choice. Additionally, they will determine how location choice may shift in the future, as the choice of a flexible workplace location may be at the discretion of the employee. The degree to which these flexible choices impact travel behavior, and therefore roadway environments and congestion conditions, is an essential question to answer.

The bottom-left box in Figure 5.2, under "Exogenous Variables," accounts for the workplace, home, and job attributes (which will be the attributes and their respective levels included in the SP experiment). Though they may not all be used if this were an actual model, these variables would include COVID risk level,

distraction level at home, change in commute time, splitting/shifting work hours, level of crowding at the out-of-home workplace, and workplace safety implementation for COVID. These exogenous variables will be estimated only for the SP dimension. They will be used to gather information concerning how the residual effects of COVID continue to impact commuting/travel behavior and the actual workplace environment/rules (such as shifting or splitting hours). If the impact is large enough, commuting behavior will inevitably be impacted, and therefore overall congestion on the roads.

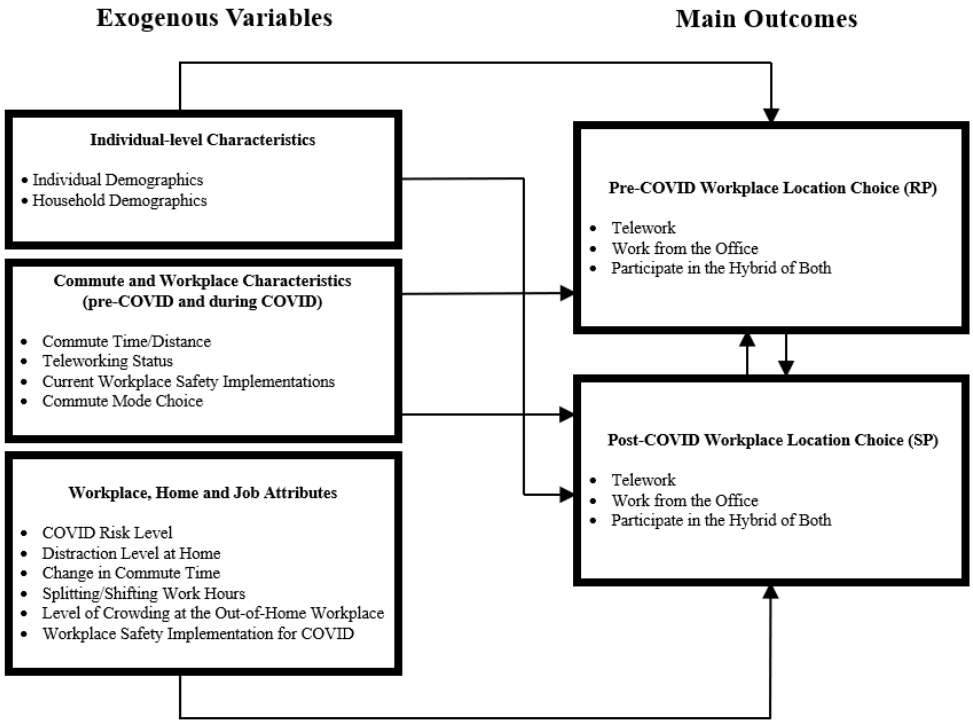



*Figure 5.2 Analytic framework*

## 5.3. Interpretation of jointly modeled RP-SP results

Interpreting the results from a jointly modeled RP-SP formulation is identical to any other regression analysis of a similar model. This case uses a mixed multinomial logit model. Compared to modeling the RP and SP data individually, there is no difference in terms of the interpretation of the results. The only difference is the benefits provided by the joint modeling, as discussed in the next section. These benefits impact the estimate/coefficient value by influencing correlation and error effects.

As mentioned previously, the joint RP-SP multinomial logit model could not actually be estimated at this point because the workplace location choice survey was not fully deployed during the initial phases of the project. However, Figure

5.3 was created to provide an example of the hypothetical analysis results. This example employs two sets of results: the set on the left in Figure 5.3 is based on an RP question in the survey, revealing respondents' actual behavior, while the set on the right is from the hypothetical scenario set forth in the SP experiment. All variables mentioned above have been included in the table. However, their actual significance in the model cannot be predicted without running the actual model. As with any logit model, there must always be a dependent outcome that is treated as the base for each dimension. In this example, "work from the workplace" was chosen as the base for both RP and SP dimensions. Most variables will not be estimated on these outcomes. Only commute-related variables will be estimated on these base outcomes in this specific model.

Notice in Figure 5.3 that each variable has a "coefficient" value and a "t-stat" value. The numeric value of the coefficient is not important to interpret, but rather the sign (whether it is positive or negative). If the sign reads positive, it is interpreted that, relative to the base outcome and the base for that variable, respondents in that variable category are more likely to choose that specific workplace choice. If the sign is negative, respondents are *less* likely to choose that specific workplace choice. Certain exogenous variables should be kept in the model only if their t-stat value is above either 1.5 or 2, depending on the analyst's choice of significance level. If the value of the t-stat (regardless of sign) is lower than the designated significance level for a certain outcome variable, then that variable is omitted from that specific outcome, replaced in the table with a long dash (—). This then implies that the variable has no significant impact on that outcome, relative to the base outcome for the same dimension. As stated earlier, the process used to arrive at the Figure 5.3 interpretation of results was identical to that used by a logit model employing only RP data (whether mixed, not mixed, multinomial, or binary).

| Exogenous Variables (base category) | Pre-COVID Workplace Location Choice (RP) | | | | | | Post-COVID Workplace Location Choice (SP) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Work from Office (Base) | | Telework | | Hybrid of Both | | Work from Office (Base) | | Telework | | Hybrid of Both | |
| | Coeff. | t-stat | Coeff. | t-stat | Coeff. | t-stat | Coeff. | t-stat | Coeff. | t-stat | Coeff. | t-stat |
| ***Individual-level Characteristics*** | | | | | | | | | | | | |
| Gender | -- | | | | | | -- | | | | | |
| Age | -- | | | | | | -- | | | | | |
| Education Level | -- | | | | | | -- | | | | | |
| Employment Status | -- | | | | | | -- | | | | | |
| ***Household Characteristics*** | | | | | | | | | | | | |
| Income Level | -- | | | | | | -- | | | | | |
| Presence of Children | -- | | | | | | -- | | | | | |
| Household Structure | -- | | | | | | -- | | | | | |
| Vehicle Availability | -- | | | | | | -- | | | | | |
| Residential Location | -- | | | | | | -- | | | | | |
| ***Commute and Workplace Characteristics (pre-COVID and during COVID)*** | | | | | | | | | | | | |
| Commute Time | | | | | | | | | | | | |
| Commute Distance | | | | | | | | | | | | |
| Teleworking Status | -- | | | | | | -- | | | | | |
| ***Workplace, Home and Job Attributes*** | | | | | | | | | | | | |
| COVID Risk Level | NA | | NA | | NA | | -- | | | | | |
| Distraction Level at Home | NA | | NA | | NA | | -- | | | | | |
| Change in Commute Time | NA | | NA | | NA | | | | | | | |
| Splitting/Shifting Work Hours | NA | | NA | | NA | | | | | | | |
| Level of Crowding at the Out-of-Home Workplace | NA | | NA | | NA | | | | | | | |
| Workplace Safety Implementation for COVID | NA | | NA | | NA | | | | | | | |
| ***Pre-COVID Workplace Location Choices (RP)*** | | | | | | | | | | | | |
| Telework | NA | | NA | | NA | | -- | | | | | |
| Hybrid of Both | NA | | NA | | NA | | -- | | | | | |

*Figure 5.3 Example of joint RP-SP table*

## 5.4. Benefits of jointly modeling RP and SP data

Jointly modeling RP and SP data, as opposed to modeling these dimensions independently, imparts many benefits. As previously discussed, forecasts that solely use SP data tend to be biased, as those responses are based on a completely hypothetical scenario. Therefore, by jointly modeling the RP and SP dimensions, the SP data is "grounded" by an RP component, eliminating the concern about bias and delivering more realistic information about preferences in an actual choice environment, while providing easily interpretable results and, later, applicable policy implications. On the other hand, as already alluded to, many technology and mobility services not currently available are already looming large on the horizon. Therefore, travel impacts resulting from new travel environments cannot be modeled using only RP travel choices. In addition, because of their controlled nature, SP surveys do offer several benefits, including more precise estimation of behavioral parameters of interest and the reduction of multicollinearity[10] among service attributes that is pervasive in RP data. Reducing the multicollinearity through the joint formulation allows for an increased extraction of sensitivity in the dependent outcome of both dimensions, as the heterogeneous correlations are accounted for and more apparent results are extracted.

Several other technical considerations support use of the joint modeling formulation of the RP and SP data over the independent models. Because the workplace location choice survey has undergone only one round of family-and-friends piloting, an actual comparison of the results from an RP-only model, an SP-only model, and a joint RP-SP model cannot be presented at this time. However, the research team is confident in the benefits of a higher degree of sensitivity between dependent outcomes, as well as the consumer preference identified through the attributes of the SP experiment, due to the model's recognition of heteroscedastic patterns and reduction of multicollinearity.

## 5.5. Conclusion

In summary, the joint RP-SP estimation can be valuable to MPOs and TxDOT to model future travel demand. These joint models provide additional policy insight and technical benefits over modeling the two types of data separately. Both RP and SP data have a common travel-based preference structure, allowing for easy

[10] Multicollinearity occurs when the regression model includes multiple factors/variables that are correlated not just to the dependent outcome variable, but also to one another. That is to say, it arises when using factors that are a bit redundant.

joint formulation through the same well-known analytical tools already used for analyzing RP-only surveys. As with the traditional methods used by MPOs and TxDOT today for forecasting travel behavior, the joint modeling procedure encompasses database organization, design of a modeling framework, estimation of the actual model, and interpretation of results. This procedure has been demonstrated using the workplace location choice survey designed earlier in this project. Joint RP-SP estimation will support future iterations of the same RP-SP survey analysis, as well as future surveys aimed to address other novel settings that might have a significant impact on future roadway environments and overall travel behaviors.

# Chapter 6. Review of the deployment strategy for the Workplace Location Choice (WPL) survey[11]

## 6.1. Introduction

The administration strategy to "land" a survey into the hands of the general public is as important as the survey instrument design itself. Thus, even as efforts to design the instrument are underway, there must be a simultaneous effort to brainstorm how to deploy the survey. Several issues need to be considered during the formulation of such a deployment strategy:

- Define the geographic region of interest
- Set a desired sample size
- Determine the survey deployment method
- Ensure an adequate sample
- Determine the survey length

The following sections will review the specifics related to each consideration above when deploying the Workplace Location Choice (WPL) survey.

## 6.2. Define the geographic region of interest

The first issue in survey design is defining the geographic region of interest. For the WPL survey, this decision is straightforward: the sample includes the entire state of Texas. The goal is to reach out to respondents across Texas through different channels (see later section) to obtain the best representation of their past, present and future commuting behaviors. Settling on a region for administration of the survey is essential before deciding on deployment methods/channels because some deployment channels are region specific and may or may not be relevant depending on the area/region of study.

## 6.3. Set a desired sample size

The general consensus in the survey data collection literature is that a sample size of about 1,100 to 1,200 respondents is a "sweet spot" for joint revealed preference and stated preference (RPSP) analysis, though most survey designers prefer to

[11] This chapter was written in the Fall of 2021. Major changes occurred between the writing of this chapter and completion of the report in Fall 2022.

achieve the slightly higher number of about 1,400 to 1,500 respondents. For the WPL survey, the goal sample size is between 1,100 and 1,300 respondents to reach a middle ground between the two ranges. The number for the sample size at the end will be based on ensuring an adequately representative sample and on the pace at which responses are received, as survey data collection cannot proceed indefinitely. The timeline for deployment of this survey is near the end of January 2022 (when individual travel patterns begin to return to normal after the holiday season). Survey deployment and data collection will occur over approximately two months, until the end of March 2022.

## 6.4. Determine the survey deployment method

The next vital task is developing a strategy to elicit responses in the most cost-effective manner. Deployment should not be limited to one strategy; multiple strategies can be used for collecting responses. For the WPL survey, several deployment channels have been identified. These include:

- Austin Chamber of Commerce
    - This business network and association facilitates connections through
        - Businesses in Austin: Austin Chamber of commerce has agreed to deliver the survey to the human resource departments of companies located in and around the Austin region, which will then distribute the survey to their employees via email or through other channels specific to the company.
        - Other Texas Chambers of Commerce: Austin Chamber of Commerce will ask other Texas Chambers to do the same thing as discussed in the bullet above, but with to businesses under their jurisdiction.
- Administering Facebook ads
    - This channel involves paying a set fee to Facebook, or other social media accounts, to issue a small advertisement with information about the study and the survey link to its users in Texas.
- Reaching out to media sources, such as:
    - Online or televised local news sources, specifically in smaller towns across the state of Texas, in order to reach as many geographic and sociodemographic populations possible. The media sources may promote the survey on their websites or on televised news segments and send listeners/readers the link.

    - Local or regional radio stations across the state for feature in public service announcements, which may involve playing a short, recorded statement about the survey and where to find it.
- School districts
    - This distribution channel will involve gathering responses from larger household sizes (specifically households with children) and enable us to specifically target lower income groups in predetermined school districts.

Survey deployment methods are not limited to those listed above. Part of deploying surveys and ensuring an adequate sample involves flexible survey distribution efforts to target groups that are not represented in the initial set of responses. Possible continually adaptive strategies are discussed in the following section.

Incentives are frequently used to help encourage survey completion. UT Austin may decide to provide such incentives. If pursued, incentives will be provided solely from UT Austin's end. TxDOT will not be associated with the survey, so that no policy is violated regarding the use of public funds for "prize" money or gifts.

## 6.5. Ensure an adequate sample

Deployment methods are designed to help ensure an adequate sample. While a complete representation of the region under study is not needed for most modeling purposes, it is important to set demographic size targets in a sample. Setting a goal for an adequate sample involves identifying the target audience for the stated preference (SP) experiment (or the entire survey), and working toward capturing an adequate range of individuals in the sample being collected. Groups that may need encouragement include older populations, employed populations, and minority groups. For the WPL survey, *employed individuals* will be initially targeted. In order to ensure employed individuals receive the survey, we have contacted several Chambers of Commerce across Texas that have access to hundreds of businesses across the state. Additionally, the WPL sample must consist of an acceptable *range of ages, income groups, and geographic distribution across the state*, as well as a sufficient range of *employment industries*. A sample size of 50 individuals within each specified range for each relevant demographic variable will be a target.

Another important sample consideration includes responses from individuals *who work, have worked, or still telework from a third workplace location*. These sample requirements will be ensured through the predetermined deployment

strategies. For example, distribution through schools will ensure that responses are collected from both larger household sizes and potentially lower income groups as well. Daily monitoring of collected data will be necessary to develop responsive strategies in the event that certain sociodemographic groups are over- or not represented. Such strategies include: maintaining a list of media sources, parent teacher associations (PTAs), or other email accessible groups on hand; sending a follow-up email to groups across Texas that have been less responsive; and, contacting Chambers of Commerce again to resend the survey to businesses in their jurisdiction. The goal will be that a second round of contact will collect additional responses from the groups who are underrepresented.

### 6.5.1. Decisions on weighting the sample

While estimated behavioral relationships among variables would not be affected by a non-representative sample (based on demographics), application of estimated models to examine effects of a specific policy would be. To evaluate impacts of interventions or policies or even projections into the future, the sample may have to be weighted by key demographics in the post-data collection and post-estimation phase to be "representative" of Texas residents[12].

## 6.6. The survey length

While strategizing how a survey will be deployed is important to collect an adequate sample of a certain size, an additional factor that has a significant impact on the number of responses is the survey length (to avoid respondent fatigue). Though survey length decisions typically arise within the design of the actual survey, setting a target at the outset is important because it can help drive the survey instrument design. An ideal survey length is between 20 and 120 questions, which will require between 5 and 25 minutes to complete. The WPL survey will consist of 80 to 100 questions and is intended to take 15 to 20 minutes to complete.

## 6.7. Conclusion

The most important factors considered in survey design and deployment are: (1) defining the geographic location of interest, (2) setting a desired sample size, (3) determining deployment methods, (4) achieving an adequate sample by way of representation of the target population, and (5) establishing the survey length. As discussed earlier, it is vital that these factors are comprehensively considered, especially prior to survey deployment. Failure to consider these factors may result

[12] Ultimately, the sample was not weighted.

in a survey that has too few respondents, or does not capture the diversity of socio-demographic groups, or does not provide helpful information on the topic at hand. The WPL survey is designed with each of these factors in mind.

The WPL survey will employ the methods and recommendations described in this chapter to survey employees in Texas regarding their workplace location choices. Through professional contacts at the Austin Chamber of Commerce, Facebook ads and media, and school district contacts, the performing agency will collect a sample that does not over- or under-represent specific sociodemographic groups. A moderate length of 80 to 100 questions will be considered, so that survey participants do not experience response fatigue. Finally, the survey team will ensure an adequate number of responses through diligent review and assessment of responses throughout the timeline of deployment.

# Chapter 7. Design the final WPL survey instrument and deployment of a pilot survey[13]

## 7.1. Introduction

As people begin to recover from the height of the COVID-19 pandemic, adjust their lives and, for many, re-enter a changed public sphere, many employees will integrate new habits and work preferences acquired during the pandemic and many employers will adopt new post-COVID rules. Employees' decisions about workplace locations and teleworking options are critical information collected in the Workplace Location Choice (WPL) survey and will be topics ultimately analyzed in both travel demand models and other forecasting models. This document discusses the final survey instrument and the deployment of a pilot survey, as well as all of the following aspects of the survey design:

- Finalization of the WPL stated preference (SP) experiment and the attributes and their respective levels
- Addition of the revealed preference (RP) questions to the existing survey
- Survey design process
- Initiation of a friends-and-family pilot of the survey

The following sections will review the specifics of each aspect of deploying the WPL survey, including summaries of the finalized survey and the pilot survey.

## 7.2. Final survey instrument

The WPL survey design is based on the SP experiment design detailed in earlier phases of the project. Focusing on teleworking and workplace location, the final survey instrument collects sociodemographic, employment, commute, and online behavior information to maximize researchers' ability to connect these survey results to other past, current, and future data and analyses, such as the traditional TxDOT Household Travel Surveys deployed across the state.

[13] This chapter was written in the late Fall of 2021, while the pilot survey was deployed across the months of October and November during the same year.

When the WPL survey will be deployed in early 2022, the pandemic's immediate effects were slightly dampened (with no shelter-in-place orders or entirely closed offices as were common during the beginning of the crisis), and most individuals who are given the choice will have already made their decisions about whether they will continue to telework, return to the office, or a combination of the two. Therefore, the hypothetical nature of the prior SP experiment will become more realized (even if the pandemic may stay with us a little longer). Because of this, new questions have been added to the survey to collect information about an even more detailed hypothetical workplace scenario to better represent the preferences of individuals regarding their workplace (including any dissonance between what employers currently allow and workers' desired arrangements, such as the preferred combination of the number of days traveling to the outside-of-home workplace and days teleworking). These questions utilize the SP strategy to best harness and exemplify the benefits of using an SP experiment, gathering data about a futuristic scenario that RP responses would not be able to gather.

The final survey is split into eight sections, labeled A through H:

- Section A: Residential Preferences and Household Vehicles
- Section B: Employment Information
- Section C: Telecommuting Habits
- Section D: Commute Information
- Section E: Workplace Location Preferences (The SP Experiment)
- Section F: Perception of the Threat of COVID-19
- Section G: Online Behavior
- Section H: Background Information

The following sections summarize each component.

### 7.2.1. Residential preferences and household vehicles

Right off the bat, it is advantageous to begin a survey by asking respondents for information that they are very confident in. The WPL survey begins with a set of questions about respondents' place of residence at both macro (where is your home located) and micro (does your home have a private office) levels. Spatial-temporal patterns have important effects on the shifts of trip-types and future traffic demand, and vice versa. Where one lives or the size/crowdedness of the home may impact trip type/frequency or work-from-

home habits. The COVID-19 pandemic has forced many employers to offer their employees the opportunity to work from anywhere. With continued telecommuting, individuals may choose to change their place of residence or downsize the number of motorized vehicles in the household. Residential preferences and household vehicle ownership are important to the employees' decisions regarding teleworking and make up one of the demographic sections of the WPL survey.

### 7.2.2. Employment information

The impacts of the pandemic are widespread but were especially severe in terms of employment status, triggering one of the worst job crises since the Great Depression (OECD.org, 2022). This portion of the survey inquires about respondents' employment status at three points in time:

- Pre-COVID
- During the worst of the COVID-19 pandemic (March 2020 – June 2021)
- Early 2022 (coined as "now" in later sections)

These three time periods will be coupled with the telecommuting and commuting habits collected in latter parts of the survey to track how employment and travel behavior changed throughout the pandemic. Additionally, these time divisions will provide valuable comparisons for predicting how commuting and teleworking habits will change into the future, especially when observing projections amongst different industries.

### 7.2.3. Telecommuting habits

As people adjust their lives in reaction to the "new normal," some employers will adopt new post-COVID rules and some employees will integrate the new habits and work preferences acquired during the pandemic into their weekly routine. Deciding upon teleworking options will remain important. Similar to the employment information, an individual's telecommuting habits will be collected for the same three time periods: before the pandemic, during its height, and now.

As intelligent communication technology and the internet have become more widespread during the past few decades, teleworking has become more popular for employees. Whether from home or from a third workplace (a coffee shop, cafe, hotel, or co-working space, also referred to as *hoteling*), every day or just a few days a month, this travel behavior trend is impacting roadway congestion and other aspects of our society. The COVID-19 pandemic has made teleworking even more common, and now that many employees and employers have

experienced the pros and cons that come with not having to commute regularly to their in-person workplace or office, the decision regarding what is to come is of substantial interest to researchers, MPOs, and DOTs across the state and country. Determining what the respondent has been and is currently doing (using RP questions) is necessary to ground the responses to the WPL SP experiment in a later section of the survey.

### 7.2.4. Commute information

From individuals' new telecommuting habits comes the potential for new commute patterns as well. Those who telecommute will no longer commute to work, altering congestion levels. Therefore, questions on telecommuting and physically commuting are coupled to determine respondents' patterns during the three time periods

An important question included in this section queries how many days during a month the respondent works. A typical five-day work week averages out to 22 work days per month. Their responses were integrated as the guide for the temporal allocation in the WPL SP experiment in the next section of the survey.

### 7.2.5. Workplace location preferences (SP)

The COVID-19 pandemic forced many employers to shift their employees' work environment into a virtual space, allowing employees to telework, at first from home in the height of the crisis and then from other third workplaces, as COVID rates began to decline and vaccines became available. Today, many employers are beginning to rethink their policies for the future, and employees are beginning to consider the pros and cons of all workplace location choices to develop their ideal, and permitted, new normal. Deciding upon workplace locations will remain important for both parties. Because of this, an SP experiment (formatted as a choice experiment) is included within the survey to collect information about an even-more-detailed hypothetical workplace location choice scenario, representing the preferences of individuals regarding their workplace. This scenario will reveal any dissonance between what employers currently allow and employees' desired arrangements, such as the preferred combination of number of days to travel to the outside-of-home workplace and days to telework.

Within this hypothetical scenario, we present to the respondents three different workplace locations: 1) home, 2) a third workplace, and 3) their in-person workplace. Instead of the respondent picking their single most preferred workplace location, they are tasked with allocating the number of days they reported to work across an entire month (which was collected in the previous

section) amongst the three options to create their ideal month of work. The hypothetical scenario is regulated and randomized using an array of attributes that provide context for each location option. These attributes and their respective levels have been finalized to include:

- COVID-19 risk level
  - There is a new strand of the virus and current vaccines are ineffective. Risk for the new strand is HIGH.
  - Both the vaccine's effectiveness against all current strands and the % of people vaccinated are unknown. Risk is unknown.
  - 60% of people are vaccinated and the vaccine is effective for all current strands. Risk is low.
  - 80% of people are vaccinated and the vaccine is effective for all current strands. Risk is extremely low.
- Shifting work hours
  - Not allowed
  - Allowed
- Splitting work hours
  - Not allowed
  - Allowed
- Distraction level (at home)
  - High distraction
  - Low distraction
  - No distractions
- Change in commute time[14]
  - 75% longer than before
  - 50% longer than before
  - Same commute length as before
  - 50% shorter than before
  - 75% shorter than before
- Level of crowding at the outside-of-home workplace
  - No crowding at the outside-of-home workplace; you have your own designated, quiet, closed-off room (No distractions)

[14] Note that these percentages are applied to respondents' reported CURRENT commute time. If they only work from home now, the coded base commute time is 26.4 minutes (average for Texas).

    - Some crowding at the outside-of-home workplace, but you have a small area to yourself or with chosen coworkers (Extremely low distraction)
    - The outside-of-home workplace is crowded and you are in close proximity to quiet coworkers (Low distraction)
    - The outside-of-home workplace is crowded and you are in close proximity to loud coworkers (High distraction)
- Workplace safety implementation for COVID
    - No safety regulations
    - Only one safety measure is implemented
    - Two or more safety measures are implemented
- Crowding and distraction level at the third workplace
    - No crowding at the third workplace; you have your own designated, quiet, closed-off room (No distraction)
    - Some crowding at the third workplace, but you have a small area to yourself or with chosen coworkers (Extremely low distraction)
    - The third workplace is crowded and you are in close proximity to quiet strangers (Low distraction)
    - The third workplace is crowded and you are in close proximity to loud strangers (High distraction)
- Commute length to third workplace
    - Shorter than your outside-of-home workplace commute
    - Same length as your outside-of-home commute to the workplace

Each respondent will be presented two SP questions based on hypothetical scenarios, which have been randomly selected from a group of 40 total scenarios. These 40 scenarios, each of which consists of a different set of attribute levels, have been generated through an orthogonal design experimental design process, in order to optimize the information gathered through the most efficient and succinct set of attribute combinations. More details about the experimental design process will be elaborated upon in a later section of this document. Additionally, a more in-depth description of the intention behind the decision to use the SP format, and the choice of attributes and their respective levels, can be found in Chapter 4 for this project. The only change between the finalized experiment and the example experiment (presented in Chapter 4) is the inclusion of the third workplace option and related attribute levels. However, these new attribute levels are analogous to those of the outside-of-home workplace alternative.

### 7.2.6. Perception of the threat of COVID-19

An individual's perspective of the COVID-19 threat influences their comfort level regarding returning to the office, their commuting patterns, and their online or in-person shopping habits. Respondents' perceptions will be assessed and the relationship to their choices, specifically regarding workplace location, analyzed.

### 7.2.7. Online behavior

In addition to those on workplace location choice, important new RP questions have been added to obtain a comprehensive picture of changes in travel patterns in a post-COVID world. For example, due to increased online shopping, it is quite possible that (1) non-home-based trips (trips whose destination are not home - especially shopping trips undertaken during a commute to or from work) will decrease even if individuals return to the workplace, and (2) home-based trips for leisure and other purposes will increase (because of the time freed up by teleworking for at least a few days a week). Adding questions related to in-person versus online shopping, as well as questions about other virtual activities, in the project will enable a richer understanding of future travel patterns based on the following analyses:

- Before COVID-19 versus during COVID-19: The survey will facilitate comparisons of individuals' past and current shopping habits and predict future habits.
- Online and in-person purchasing "activities" over the past week: The investigation will distinguish between virtual purchases delivered directly to a residence/drop-off location and virtual purchases picked up through a curbside pick-up service. Here an "activity" describes both performing a task home (such as teleworking or online shopping) from and taking an in-person trip (such as to work or to a shopping center). Analysis of virtual and in-person interactions for different types of activity purposes (for example, work and shopping) are critical to obtain a comprehensive picture of travel patterns in a post-COVID world.

Additionally, several potential SP experiments about online behavior were designed for the survey; however, the piloting process exposed that the survey was too lengthy with the SP questions. Due to the induced respondent fatigue, the SP experiment about future online behavior was omitted. The RP online behavior questions will remain, as they reveal significant information about households' shifting travel behavior before and after the pandemic, as well as their current habits of online shopping and other virtual activities.

### 7.2.8. Background information

In addition to the questions on individuals' workplace and online/virtual activity participation choices, sociodemographic questions shall be used to analyze relationships between the responses and to connect the survey results with TxDOT's other survey data and analyses, such as the traditional Household Travel Survey. With any survey, it is important to gather information from all the respondents on their general individual and household sociodemographic, including, but not limited to, age, gender, and income. This information is a vital input in travel demand models as well as other models in order to characterize and group society.

## 7.3. Survey design process

The entire survey has been finalized, which required several iterative steps. The final survey was originally constructed around the initial WPL SP experiment that was used as an example for earlier stages in this project. That experiment already had some RP questions associated with it; however, it was important to add other necessary RP questions in order to both ground the survey and allow the results to translate to other survey instruments and their respective results. The following subsections will review a few important elements related to survey design.

### 7.3.1. Survey design platform

The survey was designed and deployment administered through the Qualtrics platform. This online program allows for easy design implementation, response collection, and data management throughout the entire lifetime of the survey. Qualtrics also offers post-processing and analysis features; however, most of the post-processing will not be done through their program.

### 7.3.2. Choice of questions and question type

Through the discussion between and amongst the receiving agency (RA) and performing agency (PA), the final set of RP questions and the SP experiment's attributes were finalized. The question topics can be found in the previous section, and the specific questions are listed in Appendix C of this document. The organization and format of the questions were designed to gather the greatest amount of information in the most efficient way possible. Different question formats were used, including multiple choice, matrix selection, fill-in-the-blank, and scaled ranking/rating. The variety of question formats was used to mix up the survey flow and reduce respondent fatigue and boredom, as well as to gather specific type of information. For example, a matrix format was used when asking

about pre-COVID, the pre-vaccine timeframe of COVID, and current commuting patterns. Identical queries were asked for all time periods (such as “when did you leave” and “what mode of transportation did you take”), so a matrix format allowed the questions to be quickly answered and each option could be easily compared across all time periods.

### 7.3.3. Flow of questions and sections

The flow of the survey was a very critical element of its design, as the question topics may have different psychological impacts on each respondent depending on the order in which they are presented. The addition of the RP questions and their associated sections in the survey were carefully crafted and organized to create a natural flow for the respondents, as well as to eliminate respondent fatigue. In particular, we organized the sections so that relatively easy-to-answer questions, such as household and individual demographics, were positioned at the beginning and end of the survey.

The SP experiment was placed near the end of the survey, for two reasons. First, the answers to some previous RP questions (such as the number of days worked per month, or typical commute time) contribute to the algorithm’s random selection for certain attributes or level values in the specific question. Second, this allows us, in earlier survey sections, to define and familiarize the respondent with certain terminology, such as third workplace. This should contribute to a consistent interpretation of the hypothetical scenarios across the entire sample of respondents.

### 7.3.4. Length of survey

While a survey designer may wish to ask an endless number of questions, it is important to keep the survey at a manageable length for the respondents. The final survey comprises around 85 questions that will take approximately 15 minutes to answer. A key part of the friends-and-family pilot asked respondents to report how long the survey took them, and where in the survey they began to “lose it”. As respondent fatigue was considered when designing the survey in the first place, few questions had to be cut or reorganized due to length issues. Also, as previously mentioned, the proposed SP experiment on online shopping and virtual behavior was removed. While a set of RP questions on the topic remains in the survey, the addition of an SP question would lengthen it by 3 minutes or more. As alternatives and attributes had to be defined, the presentation of two hypothetical scenarios to each respondent significantly increased fatigue. The decision to remove this section causes little-to-no impact on the overall quality of the survey and its potential applications.

### 7.3.5. Experimental design for the WPL SP experiment

As listed in section 7.2.5, the WPL SP experiment's hypothetical scenarios consist of nine attributes and a total of 29 different attribute levels. Because of this, it would be overwhelming, and unnecessary for analysis purposes, to include every possible combination in the total set of hypothetical scenarios for the SP experiment. An orthogonal experimental design process was employed to determine levels of an attribute that are statistically independent of the levels of other attributes, so that the individual main effects of each attribute can be accurately and precisely estimated. While a similar design process was used to optimize the selected subset of experiments for the sample survey in Chapter 4, it will be reiterated here.

The orthogonal design for this survey was generated using the software package R. In the survey developed here, the orthogonal design resulted in an optimal subset of 40 individual experiments (from a complete set of 23,040 possible attribute level combinations). A list of these experiments and the corresponding attribute values is provided in Appendix D. When determining the attribute levels for the three different workplace locations, it is important to ensure realism in the hypothetical scenarios, so respondents are able to visualize and internalize the choice with existing memory and reference.

Another factor of experimental design is deciding how many scenarios to present each respondent with. For this SP experiment, each respondent is shown two SP questions, with different combinations of the preselected attributes, from the subset of 40. Even with only two answers from each respondent, an adequate amount of information and consumer choice/behaviors can be extracted and analyzed from the sample.

## 7.4. Friends-and-family pilot survey

The designed survey instrument, involving an SP experiment and associated RP questions, was deployed as a friends-and-family pilot survey to identify and fix any issues with the questions, experiment, or logic of the survey. The goal of the pilot survey was to ensure that each question makes sense to respondents and is presented in a streamlined fashion.

A sample of friends, family members, and coworkers offered feedback and highlighted potential response issues before deployment of the survey in the real world. As sample subjects, respondents were asked to pay special attention to logic issues, spelling and grammar mistakes, confusing wording and descriptions, repetitive questions/sections/statements that led to fatigue and boredom, and the

amount of time required to complete the survey. As a result of this feedback, several iterative pilot survey rounds were deployed, each correcting for issues experienced or comments made by pilot respondents at the end of the survey, directly via email, or within internal meetings with the TxDOT team.

## 7.5. Conclusion

Chapter 7 discusses the final WPL survey instrument and the deployment of a pilot survey, as well as all aspects of the survey design. Focusing on teleworking and workplace location, the final survey instrument (seen in a simplified outline form in Appendix E and in full form in Appendix F) allows researchers to analyze the data's internal relationships and to connect the survey results to other data and analyses. Split into eight sections, the survey inquires about different aspects of adjusting to and recovering from the height of the COVID-19 pandemic. To prepare for deployment, a sample of friends, family members, and coworkers completed a pilot survey to ensure each question and section was clear, logical, and streamlined. As a result of sample respondents' feedback, several iterative pilot survey rounds were deployed, each correcting for issues experienced or comments made by pilot respondents.

To the best of the RA and PA's ability and knowledge, the survey is finalized and prepared for deployment; however, there still remains the chance that slight alterations may need to be made in response to concerns during the official survey deployment. While concerns are expected to be minimal, it is important that the survey designer be ready to adjust for whatever critiques or issues arise during deployment.

# Chapter 8. WPL survey deployment

## 8.1. Introduction

The deployment of a survey requires meticulous thought and preparation. Survey designers (a) spend endless hours crafting the specific wording, flow, and logic; (b) continuously pilot and revise the questionnaire to clarify and streamline the instrument; (c) carefully develop a robust deployment plan; and (d) remain engaged with the survey even after it has been distributed to respondents. In all of these tasks, survey designers need to be nimble and quick to respond. Luckily, the deployment of the Workplace Location Choice (WPL) survey proceeded relatively smoothly, thanks to multiple rounds of piloting and revisions before the final survey deployment.

This document discusses the procedures used for the final WPL survey deployment, as well as the protocols adopted to monitor the three following metrics during the course of the survey:

- the number of responses
- the completeness of responses
- the representation of the sample vis-à-vis Texas's population of workers

## 8.2. Broad review of the deployment process

The WPL survey was deployed in the first few months of 2022. The PA and RA initially deployed the survey through their networks in the state of Texas, promoting it through personal social media sites and contacts with specific professional organizations. The first week of deployment was relatively slow with regard to the number of responses; however, survey returns picked up in the subsequent weeks. The response rate increased even more rapidly when the PA gained access to a database with 55,000 Texas residents' email addresses (more details on this database and the number of responses it generated will be discussed in the following section). Access to the email database was a significant turning point, making it unnecessary to target schools or media sources as planned in the original strategy for survey deployment.

Before taking the survey, respondents were provided with the contact information of two members of the PA (including the cell phone number of the research supervisor) so they could promptly inform them of questions or concerns when taking the survey. A handful of individuals reached out, and their comments were quickly addressed by the PA. However, none of these questions warranted

adjustments to the wording, flow, or logic of the survey, confirming the value of the multiple rounds of iterative piloting of the WPL survey. After only four weeks of deployment, the target sample size of close to 1,200 complete, relevant responses was achieved (a total of 2,000 complete responses was collected; however, roughly 800 respondents were neither employed nor a student, and so did not constitute the target population of specific interest for the WPL analysis). The end-result was an adequate sample size to analyze the new habits and work preferences of individuals, even as many employers are beginning to adopt (or contemplating adopting) new post-COVID work arrangements.

## 8.3. The distribution process

As discussed earlier, the first stage of distribution focused on the PA's and RA's professional and personal networks. The survey team disseminated the instrument via e-mail to several chambers of commerce across the state of Texas, alongside other businesses, professional organizations, and media outlets. Special thanks to Matthew Geske of the Austin Chamber of Commerce for publicizing the survey in Austin and beyond. In this first stage of distribution, the PA and RA provided information on the context for, and motivation behind, the survey so that the first set of recipients could then use appropriate messaging when distributing it more widely within their own networks. The survey was disseminated by these initial recipients through Twitter accounts, weekly newsletters, email chains, and other online platforms.

The initial stage of distribution efforts led to around 30 responses a day for roughly two weeks. While this pace may have been sufficient if access to networks continued to exponentially multiply, or if the time frame for deployment was not limited, the PA felt the need to move toward the planned second stage of deployment, which entailed publicizing the survey through the purchase of Facebook and Instagram ads. But even as preparations were under way for the launch of this second phase, the need for it was obviated by a new and opportune deployment avenue that presented itself.

Specifically, about two weeks into survey deployment, the PA was provided access to a database of roughly 55,000 Texan residents' email addresses (thanks to CTR Deputy Director Michael Murphy). For three consecutive weeks, an email was sent out each Monday to this listserv. Response rates skyrocketed. Each Monday brought at least 350 new respondents, followed by 60 responses a day for the remainder of the work week.

In just four weeks, the target sample size was achieved, with adequate numbers of complete responses in each of multiple categories of demographic groupings. The

remainder of the three-month time frame allocated for deployment resulted in several hundred additional responses, though the response rate started to drop off as the research team turned its attention from survey deployment to data review and cleaning. Overall, the distribution process proved efficient, effective, and successful.

## 8.4. Monitoring the responses

Throughout the entire deployment process, the PA meticulously and continually monitored the incoming responses, including checking on their completeness and discarding responses if there were too many item non-responses. At the same time, across all responses, a continual cumulative check for adequate representation of the range of demographics and employment sectors of the Texas population was undertaken. The next three sections discuss the PA's monitoring procedures.

### 8.4.1. Number of responses

For the WPL survey, the target sample size was 1,100–1,300 employed (or student) respondents. The survey distribution led to 2,000 complete responses, with a little under 1,200 coming from respondents who were employed or a student (the target population). Through its targeting channels and procedures, the PA also achieved its objective of not overrepresenting individuals who were strictly students (as opposed to being non-student employees or employed individuals who were also students). Specifically, of the close to 1,200 target-group respondents, roughly 1% were strictly students, who did no paid work.

Throughout the survey deployment, the sample size was carefully monitored. This monitoring was, of course, not simply a count of received responses but also entailed an examination of the completeness of the responses, as detailed in the next section. While the PA had pre-planned for multiple "push" phases if needed (that is, if the rate of incoming daily responses did not seem adequate), only two phases were ultimately employed to reach the target sample size. In total, over 2,500 individuals "took" the survey, though about 20% of responses were removed because of a substantial number of item non-responses. Another 32% were not part of the target population (workers and/or students). Each of the remaining respondents provided thorough and complete responses.

### 8.4.2. Completeness of responses

Throughout data collection, the PA closely examined the returns' completeness. This completeness check was undertaken in a streamlined and multi-layered

manner. The first check was based on the time it took a respondent to complete the survey. Before going into the field, the PA estimated it would take about 20 minutes to complete the survey. As the first responses came in, the average time to complete was roughly 15 minutes. So, the PA flagged responses that were completed in under five minutes. Such responses were then manually assessed for reasonableness; a majority were discarded because of missing item responses. A second check layer was to investigate the response to the Stated Preference (SP) workplace choice experiment. If the respondent did not answer both of the scenarios, or if their distribution of workdays across all three location choices did not equal their response to the number of days they usually work in a month, the corresponding overall responses were flagged and their removal from the sample is pending until the official analysis process begins. A third check layer for completeness involved an examination of whether the respondent answered the employment and demographic questions. For the purpose of much of our analysis, accommodating heterogeneity across individuals in WPL preferences is critical, and so responses to the employment/demographic questions are imperative.

Responses that passed all the three layers of checks above were labeled as "complete" responses, while the remainder were categorized as "incomplete" responses. Of the 1,450 responses from the target population (workers/students), the number of complete responses was 1,218. The remainder of the responses, categorized as "incomplete," underwent careful manual checks to determine if some may be salvaged for our analysis. Ultimately, all of these incomplete responses could not be salvaged, because the respondent opened the survey, responded to the first few questions, and very quickly exited the survey (these responses were submitted within five minutes of opening).

### 8.4.3. Representation of a range of demographics in the sample

In addition to sample size and completeness of the responses, the representation of a range of demographic groups in the sample is also important. During the planning process for survey deployment, the PA and RA established desired minimum numbers of respondents by *age, household income, employment sector,* and *geographic distribution across the state.* Specifically, based on pre-determined categorizations for each demographic variable (for example, the age categories established were 18–29 years old, 30–44 years old, 45–64 years old, and 65 years and older), *the PA ensured there were a minimum of 50–100 responses in each demographic variable category*. More details on the sample's demographics will be provided in the next project chapter.

Overall, it is the PA's assessment that the survey deployment gathered a good representation of demographic groupings, and that the resulting sample will provide valuable insights for both the RA and PA on current and future commute and employment behavior.

## 8.5. Conclusions

As the time frame allocated for survey deployment draws to a close, a complete and sizable sample of responses for WPL analysis has been achieved. During survey deployment, the PA monitored the number of responses, the completeness of the responses, and the sample's representation of the Texas working/student population. This monitoring, even as responses were being received, has provided the PA with a good immediate sense of *who* makes up the sample, as well as of overall trends in commute and teleworking patterns for different population groups in Texas. These trends will be further analyzed and discussed in subsequent Chapters.

Overall, the deployment of the survey went relatively smoothly; over 2,000 complete responses were collected within a month, and even more over the full three months. In the next few weeks and months, the data analysis will reveal how COVID has impacted workplace choice and commute patterns across the entire state of Texas, and how the pandemic may influence our future work-related rhythms and patterns.

# Chapter 9. Assembly and formatting of WPL survey responses

## 9.1. Introduction

With the conclusion of the Workplace Location Choice (WPL) survey deployment process, the research team shifted attention to organizing the data so that it can be effectively used for analysis purposes. Typically, an RP-SP (revealed preference–stated preference) dataset consists of four main elements: 1) an array of sociodemographic or household information, 2) a set of RP responses that reveal current travel behavior, 3) responses to SP questions about respondents' preferred future, and 4) responses to a hypothetical choice scenario (the SP experiment). This chapter will discuss how an RP-SP dataset can be compiled and organized for analysis. It will provide a step-by-step description of the different data protocols and procedures to be applied to prepare the data.

## 9.2. Protocol for organizing the dataset

The key steps involved in compiling and organizing the data include the following:

1) Download the data (see Section 9.3.1).
2) Clean the dataset by removing incomplete and incorrect responses (see Section 9.3.2).
3) Organize the RP data following the relevant approach based on the type of response data (see Section 9.3.3), including:
    a. Binary
    b. Numerical grouping
    c. Verbal grouping
    d. Likert scale
4) Organize the SP experiment data (see Section 9.3.4) by:
    a. Identifying the two scenarios presented to a respondent
    b. Identifying the answers reported by a respondent
    c. Duplicating all RP data for a respondent so there is a unique row for their responses to each scenario in the dataset
    d. Appending the dataset with the attribute levels associated with the specific scenario

5) Develop a condensed dataset with only relevant, organized data and the ResponseID (see Section 9.2.5).

## 9.3. In-depth dataset organization procedure

### 9.3.1. Download the data

To begin the creation and organization of an RP-SP dataset, the responses from the survey instrument must be downloaded from Qualtrics in a format that can be easily imported into a database software, such as R (which was chosen for this work). Such formats include, but are not limited to, .csv and .sav. The downloaded data will resemble the example in Figure 9.1.

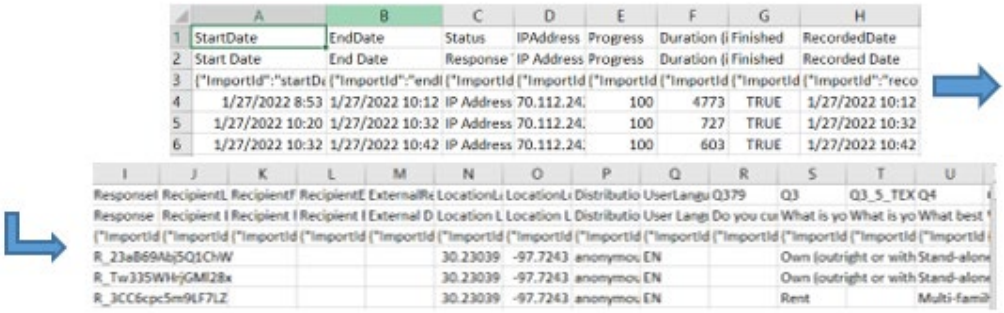



*Figure 9.1 Dataset format when downloaded from Qualtrics*

The first 17 columns of the dataset (A through Q) in Figure 9.1 (which have been split into two parts for ease of viewing) are managerial data automatically generated by the survey platform (Qualtrics). Responses to actual survey questions begin in column R (Q379). The only column of significance from A through Q is column I, "ResponseID." Column I will act as a unique label for each survey respondent. The ResponseID must remain a column in all future iterations of the dataset, as it will act as a useful "key" for mapping different data versions[15].

The next step is to create a new file (the PA used Microsoft Excel) that acts as a "header guide" for the survey. Notice in Figure 9.1 that the first three rows of the downloaded dataset are headers. Copy and paste the first and second rows, transposing the text so that it is in a vertical list form instead of horizontal, into the header guide file (Figure 9.2 demonstrates the header guide developed for this

[15] This may occur when a dataset has been winnowed down to only a few important variables so that it is more manageable (as done in Section 9.2.5). If the analyst wants to add some of the excluded data back in, they can use the ResponseID as a key to reconnect a data column from a more comprehensive version of the database.

data based on Figure 9.1). This makes an easy-to-reference list that spells out the meaning of each header. For example, the column label “Q379” means nothing to an analyst, but rather than having to reference the survey instrument to see what this means, they can simply search for that column label in the header file. This ability to quickly reference the meaning of a header will be very helpful throughout the modeling and analysis process. It is important to only have one header guide file to ensure consistency.

| | A | B |
|---|---|---|
| 1 | StartDate | Start Date |
| 2 | EndDate | End Date |
| 3 | Status | Response Type |
| 4 | IPAddress | IP Address |
| 5 | Progress | Progress |
| 6 | Duration (in seconds) | Duration (in seconds) |
| 7 | Finished | Finished |
| 8 | RecordedDate | Recorded Date |
| 9 | ResponseId | Response ID |
| 10 | RecipientLastName | Recipient Last Name |
| 11 | RecipientFirstName | Recipient First Name |
| 12 | RecipientEmail | Recipient Email |
| 13 | ExternalReference | External Data Reference |
| 14 | LocationLatitude | Location Latitude |
| 15 | LocationLongitude | Location Longitude |
| 16 | DistributionChannel | Distribution Channel |
| 17 | UserLanguage | User Language |
| 18 | Q379 | Do you currently reside in Texas? |
| 19 | Q3 | What is your current housing arrangement? - Selected Choice |
| 20 | Q3_5_TEXT | What is your current housing arrangement? - Other: - Text |

*Figure 9.2 Header guide file*

Next, the analyst needs to go back to the original data file and delete the second and third rows. Following the deletion of these two rows, only one row of headers remains before the rows of responses begin in the original datafile. This is important, as there can only be one header or label for each column in a dataset. R, like most software, will only read the first row in every dataset as labels, and every row that follows is analyzed as part of the response section, so having another header row will interfere with analysis. Now that the dataset consists of a single row of headers/column labels followed by rows of responses, data organization can begin.

### 9.3.2. Eliminating incomplete or invalid responses

The first step after compiling the initial dataset is to remove incomplete or non-targeted respondents from the dataset. While responses falling into either of those two categories were closely monitored during survey deployment, as discussed in TM 10, they remain in the original dataset and must be removed before a final sample of respondents is generated. Responses from respondents who met any of

the following conditions were removed: 1) do not live in Texas, 2) are neither a worker nor a student, or 3) did not correctly complete both questions from the SP workplace choice experiment. Explanations of how to remove respondents using R for each of these three reasons (specific to the WPL survey) follow.

1. Do not live in Texas:
    - The response to the question "do you currently reside in Texas?" was recorded in column Q379. If the respondent answered, "No," then the survey terminated for them with a note of thanks for their time. As this was a study of Texans, these "no" respondents need to be removed. The R code to remove non-Texans from the dataset is:

```
my_data = subset(my_data, (Q379 == "Yes"))
```

2. Neither a worker nor a student:
    - The target audience of the survey is individuals who work or are students. Therefore non-traditional workers and non-students must be removed from the dataset with the following R code:

```
my_data = subset(my_data, (Q20 == "A student
      (part-time or full-time)") | (Q20 == "Both
      employed and a student") | (Q20 ==
      "Employed (part-time or full-time)"))
```

3. Did not correctly complete both questions from the SP workplace choice experiment:
    - As this project's main objective is to analyze the results of the SP experiment (which will be an assessment of workers and students' workplace location choices in a hypothetical scenario), the final dataset discussed in this report will only include those individuals who correctly and completely answered the SP experiment questions. There are two steps to removing the respondents who did not do so: 1) convert the SP experiment responses to be numeric, and 2) check to see if the respondent completely and correctly answered both of the SP scenarios presented.
        - The R code for the first step is a bit cumbersome and requires all responses in the SP experiment columns to be in numeric form—there can be no "NA"s or blank cells; all responses must be a number, or 0 if the question was not shown to a respondent. To accomplish this, the analyst should repeat the lines of code below, replacing "XX" with

the appropriate number for each of the 40 SP experiment questions, beginning with 62 and ending with 101.

```
my_data$QXX_1 = as.numeric(my_data$QXX_1)
my_data$QXX_2 = as.numeric(my_data$QXX_2)
my_data$QXX_3 = as.numeric(my_data$QXX_3)
my_data[is.na(my_data)] <- 0
```

- The second step is a check for whether respondents fully and correctly completed the SP experiments. Note that the SP experiment responses are located in columns 181 through 300. The first line of the code sums the cells in each row involved with the SP experiments and then divides that sum by 2 times the number of days the respondent reported working in a typical month. This should result in either (1) a value of 1 if the respondent answered both SP questions correctly (i.e., they distributed their time across the three workplace location choices so that the number of days equaled their reported total number of days worked in a typical month), or (2) 0 if they did not answer the SP experiment, or (3) a different number than 1 if they did not correctly answer the questions (though this third situation was not possible in our particular survey because of the restricting logic encoded in the survey platform, where the respondent could not proceed to the next question in the survey if their allocation of time in one SP experiment did not add up to their reported days worked in a month). The second line of code subsets the dataset to only include responses from individuals who correctly answered the SP experiment.

```
my_data$SPcorrect =
      rowSums(my_data[181:300]) / (2*
      as.numeric(my_data$Q45))
my_data = subset(my_data, (SPcorrect ==
      "1"))
```

It is important to note that all surveys are different, and in future RP-SP surveys, there will be different target audiences and different formats for the SP experiment. Therefore, different approaches for eliminating unwanted or incomplete responses will need to be devised and implemented. The above approaches are specific to the WPL survey, though other surveys will use similar logic and R codes.

Now that incomplete responses and ineligible respondents have been filtered out of the dataset, further organization can proceed.

### 9.3.3. Organize the RP data

The original dataset as downloaded from the site used for distribution is adequate for descriptive analysis, though not in a format that is suitable for modeling. Gender responses, for example, are already categorized and organized straightforwardly in the downloaded dataset. By running a simple frequency table, the analyst will be able to determine the number of individuals in their sample who are male, female, non-binary, or other.

For use in a regression or other analyses, as well as for general ease of use, the RP data will need to be organized and grouped in an alternative way, depending on the nature of the question. Typically, there are four different types of variables resulting from an RP survey:

1) Binary variables (example: Do you have a driver's license? (Q16)). A respondent answers *yes* or *no* to a question, and their response is converted into a single binary column, displaying 1 for yes or 0 for no. The following code performs this conversion:

```
my_data$license = as.numeric((my_data[["Q16"]] ==
"Yes"))
```

2) Verbal categories (example: What type of region is your residence located in: urban, suburban, or rural? (Q11)). For this type of question, a new binary column must be created for each possible response. The following code will convert, for example, the answer *urban* into a 1 (yes) in the urban column and a 0 (no) in the suburban and rural columns.

```
my_data$rural = as.numeric((my_data[['Q11']] ==
"Rural"))
my_data$suburban = as.numeric((my_data[['Q11']] ==
"Suburban"))
my_data$urban = as.numeric((my_data[['Q11']] ==
"Urban"))
```

3) Numerical categories (example: what year were you born in? (Q116)). These numerical responses may either be a) continuous (such as birth year, when respondents can input any reasonable year) or b) already grouped to a certain extent (such as for current commute time, where respondents are asked to select the most appropriate 5-minute increment (Q41.1_3)). It is not uncommon for the analyst to have to regroup elementary categories

into broader categories if there are too few responses in any elementary category to provide the ability to distinguish the characteristics of that category from those of others; combining responses into, for example, 15-year age groupings or 20-minute commute increments may improve and simplify the modeling and interpretation. The analyst can test successively broader groupings during the analysis process. Example code for each of these situations is below.

a) **Continuous numbers:** the following code calculates age from birth year (see row 2) and then assigns the respondent to one of eight age groups (see row 3):

```
my_data$age1 =
as.numeric(as.character(my_data$Q116))
my_data$age2 = 2021 - my_data$age1)
my_data$age3 = cut(my_data$age1,
                       breaks=c(Inf, 1942, 1957,
                       1972, 1982, 1992, 1997, 2003,
                       -Inf),
                       labels=c("80+", "65-79", "50-
                       64", "40-49", "30-39", "25-
                       29", "18-24", "under 18"))
```

b) **Already grouped numbers:** The survey asked respondents to indicate their commute time to their in-person workplace in the closest 5-minute increment up to 75 minutes, meaning there were 16 possible selections. However, upon review of the number of responses in each commuter time category, it became clear that the analysis could not support such a disaggregate categorization. So, in addition to testing a continuous value of commute time (by ascribing mid-point values for each category, and 3 minutes to the 0-5 minutes category and 90 minutes for the 75 minutes or longer category), the research team also tested a broader categorization of commute time into seven categories (doing so allows a potentially non-linear effect of commute time on the decision variable of interest). The following code groups commute times into seven different increments.[16]

```
my_data$comm0 = as.numeric((my_data$Q41.1_3 == 0))
my_data$comm10 = as.numeric((my_data$Q41.1_3 <= 10)
& (my_data$Q41.1_3 != 0))
```

[16] "==" means "equal to"; "<=" means "equal to or less than"; ">=" means "equal to or greater than"; and "!=" means "does not include."

```
my_data$comm25 = as.numeric((my_data$Q41.1_3 > 10)
& (my_data$Q41.1_3 <= 25))
my_data$comm45 = as.numeric((my_data$Q41.1_3 > 25)
& (my_data$Q41.1_3 <= 45))
my_data$comm60 = as.numeric((my_data$Q41.1_3 > 45)
& (my_data$Q41.1_3 <= 60))
my_data$comm75 = as.numeric((my_data$Q41.1_3 > 60)
& (my_data$Q41.1_3 <= 75))
```

4) Likert scale groupings (example: How satisfied are you with your current commute to your in-person workplace: extremely dissatisfied, somewhat dissatisfied, neither satisfied nor dissatisfied, somewhat satisfied, or extremely satisfied? (Q49)). The analyst will assign an ascending value to each of the Likert measures, with the most negative response (which may be in the form of "dissatisfied" or "strongly disagree") assigned a value of 1, the next most negative ("somewhat dissatisfied" or " somewhat disagree") assigned a value of 2, and so on. There may be three, five, or even more categories of the Likert scale, with the highest value equaling the number of possible responses. A neutral option ("neither satisfied nor dissatisfied" or "neither agree nor disagree") is typically included, which will fall in the middle of the answers and should then receive the middle, or median, value (regarding commute time, "neither satisfied nor dissatisfied" will be assigned a value of 3).

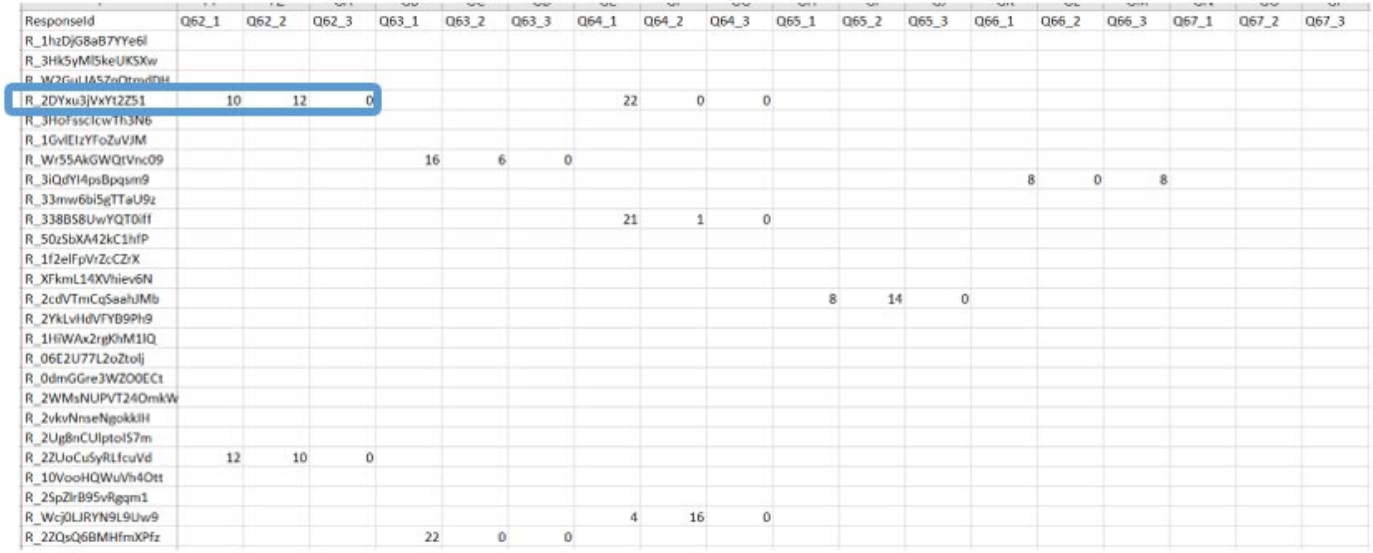
```
my_data$comSat = car::recode(my_data$Q49,
                  "'Extremely dissatisfied' = 1;
                   'Somewhat dissatisfied'  = 2;
                   'Neither satisfied nor
                  dissatisfied'  = 3;
                   'Somewhat satisfied'  = 4;
                   'Extremely satisfied' = 5")
my_data$comSat = as.numeric(my_data$comSat)
```

Though the RP data may need additional adjustment before further analysis can occur, these are the four most common variable types in analysis.

### 9.3.4. Organize the SP data

The SP experiment data requires a considerably greater amount of organization compared to the RP data. The dataset downloaded from Qualtrics will contain minimal information concerning the specific attribute levels of the SP scenarios that were shown to each respondent. The only information the analyst will get from the dataset about the SP experiment will be which questions each respondent

was presented with and what they answered (Figure 9.3 demonstrates the presentation of responses in the downloaded dataset). The SP scenarios will be numbered, so the analyst will need to refer to a key indicating which scenario number aligns with which attribute level combinations. Only then will the analyst be able to append the attribute levels associated with each respondent's scenario into the dataset. Appendix G contains the key that was used for the WPL SP experiment.



| ResponseId | Q62_1 | Q62_2 | Q62_3 | Q63_1 | Q63_2 | Q63_3 | Q64_1 | Q64_2 | Q64_3 | Q65_1 | Q65_2 | Q65_3 | Q66_1 | Q66_2 | Q66_3 | Q67_1 | Q67_2 | Q67_3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R_1hzDjG8aB7YYe6l | | | | | | | | | | | | | | | | | | |
| R_3Hk5yMl5keUKSXw | | | | | | | | | | | | | | | | | | |
| R_W2GuUA57oQtmvfDH | | | | | | | | | | | | | | | | | | |
| R_2DYxu3jVxYt2Z51 | 10 | 12 | 0 | | | | 22 | 0 | 0 | | | | | | | | | |
| R_3HoFsscIcwTh3N6 | | | | | | | | | | | | | | | | | | |
| R_1GvlEIzYFoZuVJM | | | | | | | | | | | | | | | | | | |
| R_Wr55AkGWQtVnc09 | | | | 16 | 6 | 0 | | | | | | | | | | | | |
| R_3iQdYl4psBpqsm9 | | | | | | | | | | | | | 8 | 0 | 8 | | | |
| R_33mw6bi5gTTaU9z | | | | | | | | | | | | | | | | | | |
| R_338BS8UwYQT0lfI | | | | | | | 21 | 1 | 0 | | | | | | | | | |
| R_50zSbXA42kC1hfP | | | | | | | | | | | | | | | | | | |
| R_1f2elFpVrZcCZrX | | | | | | | | | | | | | | | | | | |
| R_XFkmL14XVhiev6N | | | | | | | | | | | | | | | | | | |
| R_2cdVTmCqSaahJMb | | | | | | | | | | 8 | 14 | 0 | | | | | | |
| R_2YkLvHdVTYB9Ph9 | | | | | | | | | | | | | | | | | | |
| R_1HiWAx2rgKhM1IQ | | | | | | | | | | | | | | | | | | |
| R_06E2U77L2oZtolj | | | | | | | | | | | | | | | | | | |
| R_0dmGGre3WZO0ECt | | | | | | | | | | | | | | | | | | |
| R_2WMsNUPVT24OmkW | | | | | | | | | | | | | | | | | | |
| R_2vkvNnseNgokkIH | | | | | | | | | | | | | | | | | | |
| R_2Ug8nCUlptoI57m | | | | | | | | | | | | | | | | | | |
| R_2ZUoCu5yRLfcuVd | 12 | 10 | 0 | | | | | | | | | | | | | | | |
| R_10VooHQWuVh4Ott | | | | | | | | | | | | | | | | | | |
| R_2SpZlrB95vRgqm1 | | | | | | | | | | | | | | | | | | |
| R_Wcj0LJRYN9L9Uw9 | | | | | | | 4 | 16 | 0 | | | | | | | | | |
| R_2ZQsQ6BMHfmXPfz | | | | 22 | 0 | 0 | | | | | | | | | | | | |

*Figure 9.3 Downloaded representation of SP experiment data, with a highlighted response example*

As Figure 9.3 also demonstrates, the downloaded dataset for any SP experiment that uses many different possible scenarios will be unwieldy. Each possible scenario that could have been shown (in the case of the WPL survey there were 40) will have its own column (or columns, since for the WPL survey, the respondent was effectively asked to answer three questions regarding workplace location options per scenario). In the case of the WPL survey dataset, there are 120 (40 scenarios × 3 workplace location options) columns that represent the SP experiment data, though for each respondent only 6 cells (2 scenarios × 3 workplace location options) per row contain data, and the other 114 cells are empty. Therefore, as the analyst reports which questions each respondent was shown, they will also have to delete the empty columns (as it is difficult to delete partial columns from a dataset without removing all rows) associated with the questions that the respondent was not shown. This can be done in one of two ways. The first is manually—the analyst can go through and create new columns to report which questions each specific respondent was shown (one new column per scenario presented; in this case, two). For example, in Figure 9.3, respondent R_2DYxu3jVxYt2Z51 (highlighted in the blue box) was presented with scenario 62 for their first SP question, so the analyst would type 62 into the first of the two new columns, which will ultimately allow them to link the attribute levels for that scenario. As the analyst continues with this manual approach, they will have to carefully review every respondent's data and manually fill in the two scenario numbers, while deleting the empty answer boxes for the questions that were not shown to a certain respondent in order to condense the dataset and only reveal responses and not blank cells in the dataset.

Alternately, and more efficiently, the analyst can develop a code that will implement this procedure for them. The PA has developed a simple code in R to perform this process automatically for future use. Guides to this code and the code itself can be found in Appendix H. A visualization of the set of SP data cleaning processes is found in Figure 9.4 below. Note that the example in the visualization is a simplification of the WPL SP experiment, using six scenarios rather than 40.

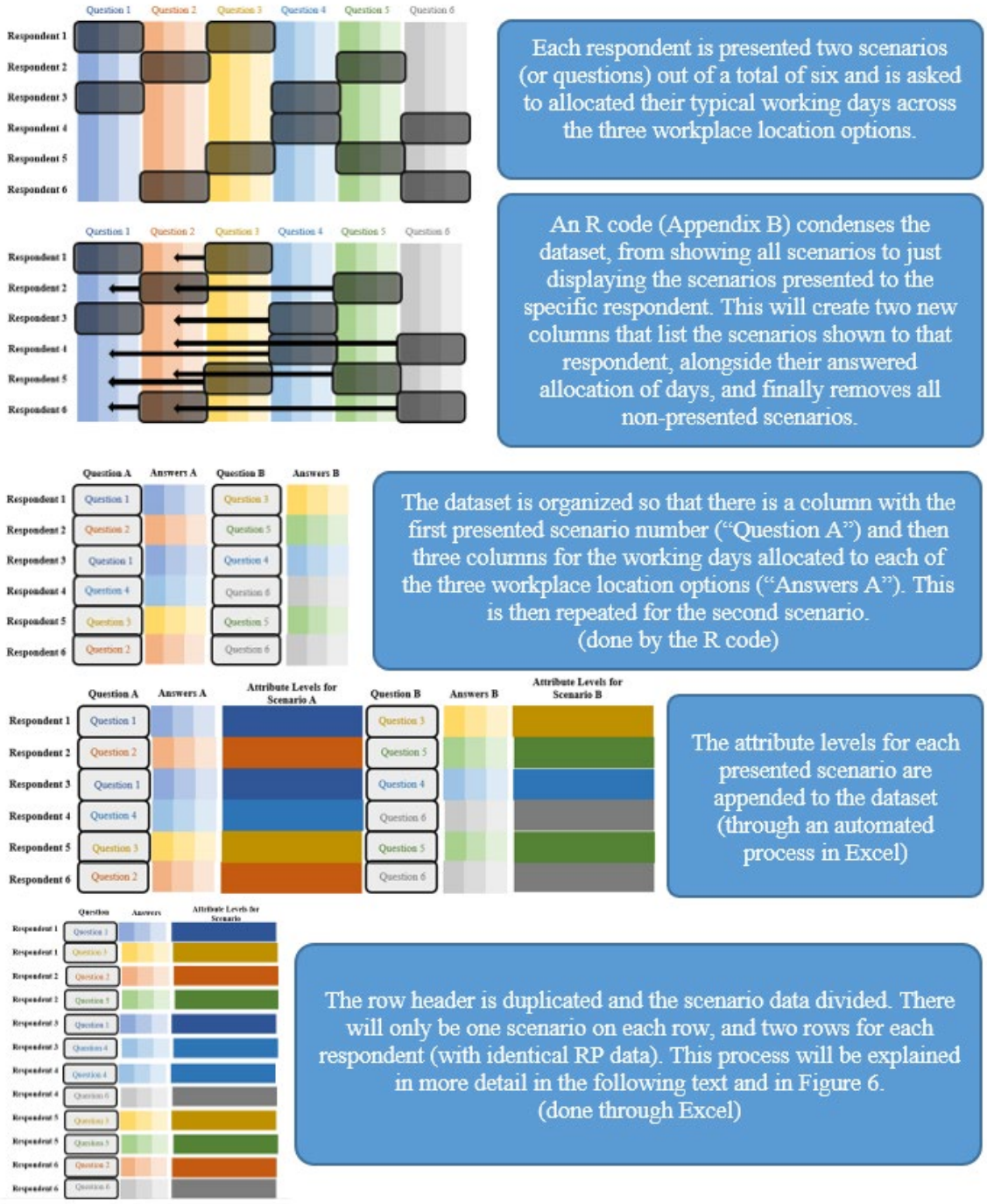



*Figure 9.4 Visualization of the organization of the SP data*

As previously mentioned, in any SP experiment, each respondent is typically shown questions regarding two to four different SP scenarios with varying levels of key attributes (a single SP scenario will be referred to as a *choice occasion* for the remainder of this discussion), alongside an array of RP and sociodemographic questions. To simplify analysis, the dataset should typically be organized so that an individual's response to each choice occasion (along with the occasion's

attribute levels) becomes its own row in the dataset; this is referred to as "the duplication process." Each respondent's sociodemographics, household characteristics data, and current travel behaviors extracted from the RP questions are duplicated so that they remain connected to their SP responses.[17] Thus, this process leads to repetition within the dataset structure. Figure 9.5 provides a visualization of the WPL survey database that has undergone this duplication process (though it only shows a few columns of the individual and household sociodemographic data for simplicity). Each respondent is represented twice in the dataset, with their RP data replicated exactly in both rows and their SP choice occasion, and its respective attribute levels, varying between rows. This reflects that each respondent was asked two different SP questions—had they been presented with four choice occasions, each respondent would be represented four times in the database following this process. This duplication has no effect on later estimations and provides an easy and straightforward method of organization during the modeling process. If not duplicated and disaggregated, then the analyst would have to run two separate analyses on both questions. This would be repetitive and unnecessary, and may even cause conflicting or inconsistent results when the two models are compared; the SP data can be easily condensed and duplicated with the process reviewed above, without causing any technical or correlation issues during the modeling process and essentially doubles the sample size the analyst can to gather results from.

[17] This is effectively treating each SP choice occasion as repeated choice events from the same individual.

| ResponseID | RP Questions | | | | SP Experiment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Work Status Before COVID | Work Status Now | Frequency of Telecommuting each week before COVID | Household Size | Scenario | WPL: WFH[12] | WPL: WFO[13] | WPL: WF3[14] | COVID Risk Level | Distraction Level at Home | Crowding at the Workplace | Safety Precautions at Workplace |
| R_1 | Unemployed | Employed | 3 | 2 | 1 | 10 | 4 | 8 | 1 | 3 | 2 | 1 |
| R_1 | Unemployed | Employed | 3 | 2 | 37 | 22 | 0 | 0 | 3 | 3 | 3 | 3 |
| R_2 | Unemployed | Employed | 2 | 5 or more | 4 | 4 | 18 | 0 | 2 | 1 | 1 | 2 |
| R_2 | Unemployed | Employed | 2 | 5 or more | 19 | 7 | 12 | 3 | 3 | 1 | 3 | 1 |
| R_3 | Employed | Employed | 3 | 4 | 23 | 15 | 0 | 7 | 1 | 1 | 3 | 2 |
| R_3 | Employed | Employed | 3 | 4 | 32 | 15 | 0 | 7 | 1 | 1 | 1 | 1 |

*Figure 9.5 Example of an organized dataset for use in modeling an SP experiment[18]*

[18] WFH: work from home; WFO: work from in-person workplace/office; WF3: work from a third workplace

Now, the actual manual duplication process needs to be performed in Excel. While automating this process should be possible through R as well, for this project the PA only developed a process through Excel. First, the dataset should be opened in Excel as a .csv file (Step 1 shows all the data while Step 2 demonstrates that the RP data will remain). Next, copy all of the rows of respondent answers (i.e., all except the top row of headers) and paste them below the last row of responses (Step 3). Highlighting either the original or duplicated share of responses before duplicating can create a useful visual indicator of the delineation. From the first set of responses only (shaded gray in Figure 6), delete the contents of all cells related to Scenario B (Step 4). Then, from the second set of responses (shaded yellow in Figure 6), delete the contents of all cells related to scenario A (Step 4). Cut the contents of the Scenario B–related columns in the second set of responses and copy them over into the now-empty Scenario A columns (Step 5). The finalized dataset contains each respondent's SP choice occasion data in a separate row, alongside their RP data, and the highlighting used to distinguish the sets of responses can now be removed (Step 6).

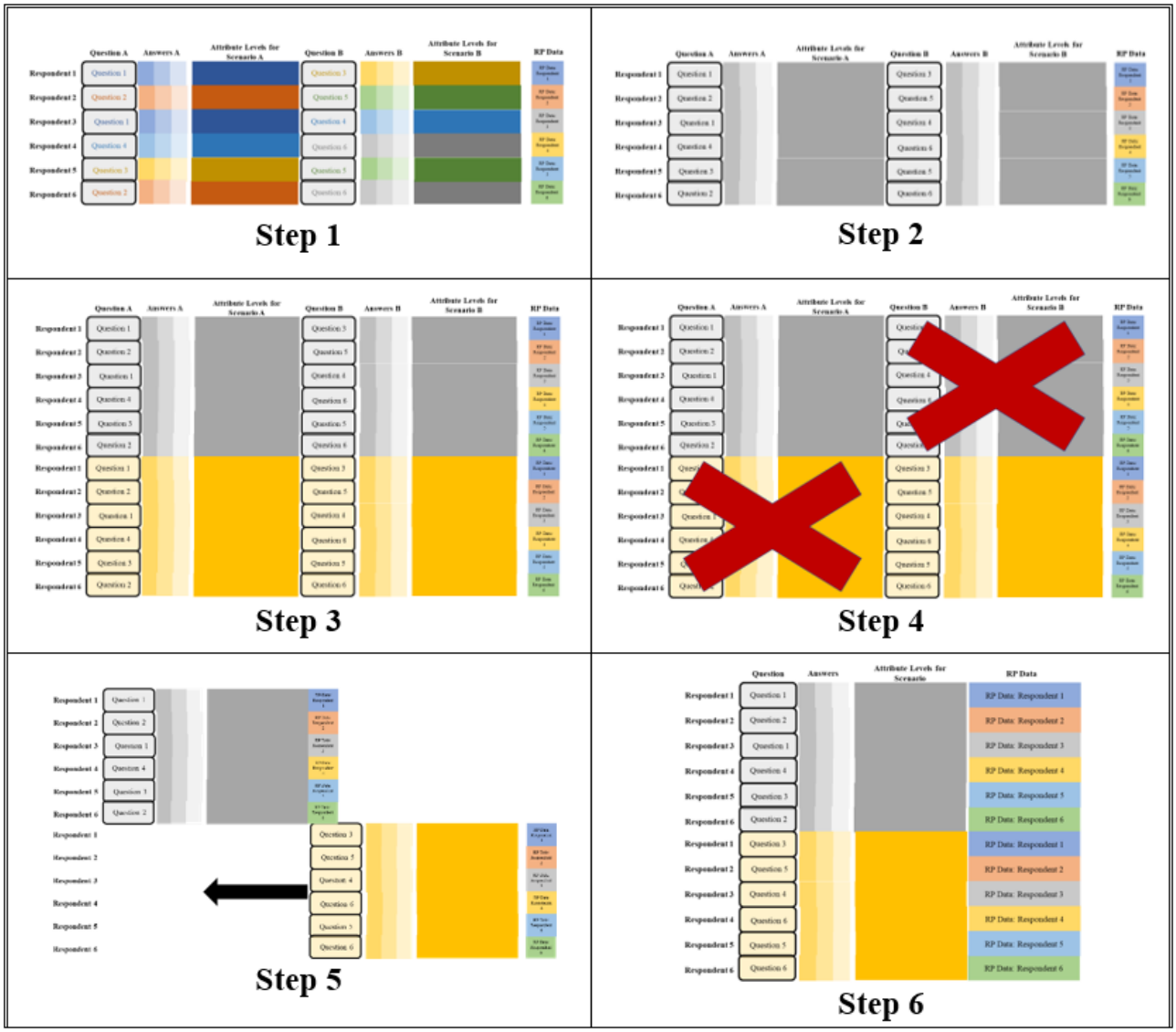



*Figure 9.6 Visualization of the duplication process*

This organization can also be described in mathematical terms. Assume X number of respondents to a survey, with each respondent answering two SP choice occasions. Let there be Y currently observed RP choices, and an array of sociodemographic/household questions. The resulting data may be housed within a dataset that has X rows, each containing two SP choice occasion columns, Y RP choice indicator columns, and multiple columns for the sociodemographic/ household information types. But, for joint RP-SP estimation, it is convenient to translate this dataset structure (with X rows) to a new dataset structure with 2*X rows, each row holding one SP choice occasion, Y RP choice columns (with the RP data in each of the two rows for the same individual having identical entries), and the array of sociodemographic/household columns (again, with this information being identical in the two rows from the same individual, as shown in Figure 9.5).

Notice that, in Figure 9.5 the attribute levels for each SP scenario exist as a column within the dataset. This was done through Excel, using the function VLOOKUP to link the master key of attribute levels that was used for the WPL SP experiment with the column showing the scenario number each respondent was presented with.

## 9.4. Split up the dataset

The dataset resulting from an RP/SP survey will contain a large number of columns, making it cumbersome to scroll through in Excel, R, or any other software. Therefore, the analyst may wish to create one or more smaller datasets with only the columns relevant to a particular analysis, while keeping the respondent key (ResponseID) in all versions of the dataset so that removed columns can be appended later, if needed. The organized dataset may need to be split up between columns that have already undergone organization and the original "base" column (in this case, ResponseID), so that the dataset does not keep growing in number of columns and become too unmanageable for the analyst to use, reference, save, and distribute. In this case, the analyst can create a new dataset with only the relevant columns, including ResponseID, using a version of the following code:

```
my_data2 = data.frame(ResponseId= my_data$ResponseId,
   Q1 = my_data$Q1, Q24 = my_data$Q24, miles =
   my_data$Q41.2_3_1, time = my_data$Q41.1_3,Q43 =
   my_data$Q43, Q46_3 = my_data$Q46_3, Q46_1 =
   my_data$Q46_1, Q49 = my_data$Q49, Q51 = my_data$Q51,
   Q26 = my_data$Q26)
```

Once the dataset has been organized to a size the analyst finds suitable for their modeling and analysis purposes, it is finally ready for the initial stages of analysis. Incomplete and unusable responses have been eliminated, the RP data have been filtered and organized, the data from the SP experiment have been disaggregated, and the attribute levels of each SP scenario have been integrated into the dataset.

## 9.5. Conclusion

For the WPL survey and those like it, following data collection and before data analysis, an analysis-suitable dataset needs to be assembled through a step-by-step organizational process. When loaded from the survey administration platform, the responses will not be organized as needed for analysis, especially for the SP experiment data and the choice occasions associated attribute levels. It is essential to clean the dataset to create clear column formatting with easy-to-impute SP experiment results and a straightforward approach to interpreting RP responses in later analysis procedures. This chapter has detailed the procedures undertaken as part of this task to organize the data into a usable format for analysis, in a manner that can be implemented for future replication.

The protocol begins with removing incomplete and unusable responses from the dataset to determine the final sample. Next, the response type for each RP data column is identified, and the data organized accordingly, including grouping if needed. Subsequently, the SP experiment responses need to be recoded within the database so that the details of the hypothetical scenarios (i.e., the attribute levels) presented to each respondent are extracted. A code for this, along with an associated procedure, was developed so that the process can be replicated for future SP experiments and their datasets.

Now that the data has been assembled and formatted, the organized database is ready for immediate analysis, which will be the focus of the subsequent chapter of the project.

# Chapter 10. Analysis of WPL survey results

## 10.1. Introduction

The 2022 Workplace Location Choice (WPL) survey was deployed in early 2022, resulting in a clean, usable sample of over 1,200 respondents. Deployment strategies were focused in Texas, primarily collecting responses from employed Texans. Non-employed Texans were limited to answering only the sociodemographic and online shopping portions of the survey; they were not the target population and are therefore underrepresented in the sample, when compared with the entire Texas population. Due to the focus and bias of the sample, analysis of the survey responses and modeling results will be limited to the employed population.

To recapitulate, the final sample consists of 1,218 Texans over the age of 18 who were employed or a student both before and after the COVID-19 pandemic. These 1,218 respondents will all be included in the first section of the analysis of results, the descriptive statistics part. The second section of analysis, the choice modeling portion, will consist of a slightly smaller sample of 1,136 respondents[19].

To explain this in more detail, the analysis of the survey results contains two separate approaches and uses different sets of data from the sample, as follows:

- Descriptive statistical analysis (found in the current Chapter 10) of:
  - Revealed preference (RP) data
    - Individual characteristics
    - Household characteristics
    - Job-related characteristics
    - Residential characteristics
    - Workplace characteristics
    - Past and current workplace trends
    - COVID perspectives
    - Online shopping habits
  - Stated preference (SP) data
    - WPL SP experiment responses
- Choice modeling analysis (the introduction is included in Chapter 10, but the entirety of the analysis is included as Chapter 11) of:

[19] 82 respondents were removed from the choice modeling process due to their incomplete responses to the stated preference (SP) experiment.

- SP experiment data as the dependent variables
- RP data as exogenous, explanatory variables

This chapter, as well as the subsequent chapter (which solely includes the published analysis paper developed from efforts of this project), will present and discuss the analysis process undertaken using the WPL survey data and provide comprehensive results regarding how telecommuting and online shopping behaviors are changing. They will qualitatively assess the information gained by adding an SP component to a traditional RP-only survey method and highlight the results that the joint RP-SP analysis makes possible.

## 10.2. Descriptive statistical analysis

Descriptive statistics are used to review who is in the sample and the distribution of responses of individuals, as well as to check the sample's representativeness of the region in question. Normally, we would begin by reviewing the makeup of the sample relative to the Texas population. However, the sample for the WPL survey was restricted to employed Texans, and there is no easily accessible data on the makeup of this demographic group. Because of this, the research team could only use the 2020 Texas Census to check the representativeness of the geographic distribution and job characteristics of the sample. A majority of key descriptive statistics can be found in Table 10.1, in the form of a frequency table.

The descriptive statistics will be reviewed in the following order:

1. Individual characteristics
2. Household characteristics
3. Job-related characteristics
4. Residential characteristics
5. Workplace characteristics
6. Past and current workplace trends
7. COVID perspectives
8. Online shopping habits

While the survey and associated dataset consists of a number of different variables, descriptives of only the most relevant of them (for our WPL analysis) will be presented. Please refer to the project's associated guidebook for tips on how to review any variables that have not been included here. Additionally, the header guide located in Appendix I may be as a useful precursor reference to the analysis presented here.

**Table 10.1 Descriptive statistics**

| Variable | Count | % |
|---|---|---|
| *Individual Demographics* | | |
| **Gender** | | |
| Female | 718 | 58.9 |
| Male | 492 | 40.4 |
| Non-binary | 8 | 0.7 |
| **Age** | | |
| 18 to 29 | 84 | 6.9 |
| 30 to 39 | 145 | 11.9 |
| 40 to 49 | 239 | 19.6 |
| 50 to 64 | 564 | 46.3 |
| 65 or older | 186 | 15.3 |
| *Household Characteristics* | | |
| **Household Annual Income** | | |
| Less than $25,000 | 20 | 1.6 |
| $25,000 to $49,999 | 74 | 6.1 |
| $50,000 to $74,999 | 154 | 12.6 |
| $75,000 to $99,999 | 163 | 13.4 |
| $100,000 to $149,999 | 333 | 27.3 |
| $150,000 to $249,999 | 327 | 26.8 |
| $250,000 or more | 147 | 12.2 |
| **Household Structure** | | |
| Lives with partner | 827 | 67.9 |
| **Presence of Children (including ages)**[20] | | |
| No kids | 907 | 74.5 |
| Child(ren) aged 0 to 4 | 60 | 4.9 |
| Child(ren) aged 5 to 12 | 172 | 14.1 |
| Child(ren) aged 13 to 17 | 161 | 13.2 |
| *Job-Related Characteristics* | | |
| **Employment Status** | | |
| Full-time, self-employed | 171 | 14.0 |
| Part-time, self-employed | 29 | 2.4 |
| Full-time, not self-employed | 971 | 79.7 |
| Part-time, not self-employed | 47 | 3.9 |
| **# of Days Worked per Month** | | |
| 1 to 5 days | 35 | 2.9 |
| 6 to 19 days | 82 | 6.7 |
| 20 to 24 days | 947 | 77.8 |
| 25 days or more | 154 | 12.6 |
| **Occupation/Industry Type** | | |
| Manufacturing/Construction/Farming/Warehousing | 114 | 9.4 |
| Healthcare | 66 | 5.4 |
| Sales/Food Services | 25 | 2.1 |
| Education/Social services | 443 | 36.4 |
| Public Services/Administration | 61 | 5.0 |
| Information/Finance | 113 | 9.3 |
| Professional | 182 | 14.9 |
| Trade | 10 | 0.8 |

[20] These numbers will not add up to 100%, as a household can have children in multiple age categories (for example, both a child aged 0 to 4 and a child aged 13 to 17).

| Variable | Count | % |
|---|---|---|
| Other | 204 | 16.7 |
| *Residential Characteristics* | | |
| **Community Region Type** | | |
| Rural | 239 | 19.6 |
| Suburban | 688 | 56.5 |
| Urban | 291 | 23.9 |
| **Household Ownership Status** | | |
| Rent | 225 | 18.5 |
| Own | 993 | 81.5 |
| **Private Study** | | |
| Yes | 913 | 75.0 |
| No | 305 | 25.0 |
| *Work Office Characteristics* | | |
| **Employment Density around office** | | |
| Medium to low | 950 | 78.0 |
| High | 268 | 22.0 |
| **Congestion Level of Commute** | | |
| Commute traffic is intolerable | 499 | 41.0 |
| *COVID-19 Threat* | | |
| **Immunocompromised Status** | | |
| Regularly sees an immunocompromised individual | 460 | 37.8 |
| Individual is immunocompromised | 199 | 16.3 |

### 10.2.1. Individual characteristics

The sample consists of 58.9% women, 40.4% men, and 0.7% non-binary individuals, as may be observed Table 10.1. The sample is spread across all age groups.

**Table 10.2 Gender and age crosstab**

| Age Group | Female | Male | Non-binary | Sample Total |
|---|---|---|---|---|
| **18 to 29** | 3.6% | 3.1% | 0.2% | 6.9% |
| **30 to 39** | 6.3% | 5.4% | 0.2% | 11.9% |
| **40 to 49** | 16.1% | 3.3% | 0.2% | 19.6% |
| **50 to 64** | 25.1% | 21.1% | 0.1% | 46.3% |
| **65 and older** | 7.8% | 7.5% | 0.0% | 15.3% |
| **Sample Total** | 58.9% | 40.4% | 0.7% | 100.0% |

Table 10.2 presents this data in another way, indicating the sample makeup by both gender and age. In these types of crosstabs, both a univariate and multivariate analysis can be performed. The univariate descriptive analyses were already obtained in Table 10.1 for gender and age. Next, a multivariate analysis can be performed (where a cross tab between two or more variables is explored), which may be helpful to pinpoint the largest gender-age group. As may be observed in Table 10.2, in the case of the WPL sample, the largest gender-age

group corresponds to women aged 50 to 64 (25.1% of the sample), followed by men of the same age group (21.1%).

### 10.2.2. Household characteristics

Table 10.1 shows a high share of respondents making over $100,000 a year. Of the employees in the sample, 67.9% live with a partner, while only 25.6% live with children. Overall, 4.9% of households have at least one young child (0 to 4 years), while 14.1% have an elementary-school-aged child (5 to 12 years) and 13.2% have a high-school-aged child (13 to 17).

### 10.2.3. Job-related characteristics

Table 10.1 also includes three important job-related characteristics. As mentioned above, we can use these job-related characteristics to compare the sample to the Texas population. We are unable to compare the individual-level demographic characteristics with Census Bureau data or the five-year American Community Survey, because these latter databases do not distinguish between employed and non-employed individuals. But we are able to compare the WPL survey sample's geographic attributes and job characteristics with those with those drawn from the 2020 Texas Census (Texas Demographic Center, 2022). Our sample overrepresents the self-employed population in Texas by over double (16.4% of the sample relative to 7% in the 2020 Texas Census). On the other hand, our sample underrepresents part-time employees (6.3% as compared with 11.4% of the Texas population). We can also compare the number of days worked per month. Less than 10% of the sample reports to work 19 days or fewer, while a little over 10% works 25 days or more a month. The large majority of the sample falls within the 20-to-24-workday grouping, where most full-time workers fall in Texas. This number, 77.8%, is almost identical to the full-time, not-self-employed portion of the sample, 79.7%, as seen in Table 10.1.

Next, the occupation or industry-type spread of the sample was reviewed. Surprisingly five of the nine categories are representative of Texas's industries, give or take a few percentage points for each type. The outliers corresponds to an overrepresentation of education and social services (36.4% in our sample compared to 21% in Texas), and underrepresentation of manufacturing, construction, and farming (9.4% in our sample and 19.5% in Texas), food services and retail sales (2.1% in our sample and 8.9% in Texas), and trade (0.8% in our sample and 6.9% in Texas).

### 10.2.4. Residential characteristics

Table 10.1 reveals that the sample consists of roughly the same proportion of urban and rural dwellers, at about 20% of each. The majority of the sample lives in a suburban area.

The same section in Table 10.1 also presents the sample's household ownership statistics. There is a 20-80 split between renting and owning a home. Similarly, there is a 25-75 split between households who don't and who do have a private study in their home, which may lead to an increased propensity to work from home, as will be explored later in the choice model.

### 10.2.5. Workplace characteristics

The section labeled "In-Person Workplace Characteristics" in Table 10.1 shows that 80% of Texan employees' in-person workplace or office is located in a medium-to-low-density region, which is to say a suburban or rural area. The other 20% works in a high-density region, such as a large office park or a metropolitan area[21].

Not shown in the table, but still important for comparison to statewide statistics, is the average commute time. The average one-way commute time in Texas is 26.4 minutes, while our sample's average commute time is 25.2 minutes. Similarly, as was briefly discussed in 10.2.3, the average number of days an employee works in a month is 22, and our sample reported working an average of 21.5 days. These statistics suggest that our sample reasonably represents characteristics of the employed population in Texas; the desired future WPL as expressed in our sample may be considered a good reflection of the future WPL desires of Texas's employed population as a whole.

A second workplace characteristic reviewed in Table 10.1 is employees' perception on the current congestion level on the commute to their in-person workplace. Overall, levels of congestion are still lighter than their pre-COVID levels, but about 40% of employees consider this congestion to be intolerable, disincentivizing them to regularly commute to and work from the office.

[21] The workplace density characterization is determined based on employment density, which represents the total number of jobs per unprotected acre for each zip code. Based on Ramsey and Bell (2014), zip codes with an employment density less than 2.2 jobs per unprotected acre of land are classified as "low" employment density, while those with employment densities higher than 5.2 jobs per unprotected acre are classified as "high"; all other zip codes are classified as "medium."

### 10.2.6. Past and current workplace habits

The focus of the WPL survey was to determine where employees will work in the future based on where they work today and worked in the past (both during and before COVID). Therefore, a detailed exploratory analysis of WPL trends and remote working habits is vital before beginning any type of choice modeling process.

First, exploring the split of who is allowed to telework is important. This statistic is not presented in a table, but before COVID, 9.3% of the sample was allowed by their company to work 100% remote (compared to 5.0% of the Texas population). Today, 19.4% of the sample works remotely every day, compared to 22.0% of the Texas population. Once again, these numbers align fairly well, growing our confidence that the sample is representative of the population of Texas.

**Table 10.3 Past and future workplace habits**

| Response | At some point over the past five years has your employer allowed you to work remote? | At some point over the past five years have you always worked from home? | Did you change your commute during COVID? | In the future, will your employer allow you to work remotely? |
|---|---|---|---|---|
| **I don't know** | -- | -- | -- | 25.8% |
| **No** | 18.0% | 88.2% | 32.5% | 31.6% |
| **Yes** | 82.0% | 11.8% | 67.5% | 42.6% |

Table 10.3 presents statistics on the WPL survey sample's past and future remote work options. This data can be summarized as follows:

- Almost 20% of employees report being full-time in-office workers
- Over 10% of employees report being full-time teleworkers
- Almost one-third of employees' commutes were not impacted by COVID
- Nearly one-third of employers will not allow remote work in the future

**Table 10.4 Remote work frequency**

| How often did/do/will you telework? | Before COVID | | During COVID | | "Now" Early 2022 | | In the future | |
|---|---|---|---|---|---|---|---|---|
| % Type | %(T)[22] | %(P)[23] | %(T) | %(P) | %(T) | %(P) | %(T) | %(P) |
| **Never telecommuted** | **59.4%** | -- | **8.6%** | -- | **34.1%** | -- | **36.6%** | -- |
| **A few times per month** | 16.4% | 40.5% | 8.4% | 9.2% | 13.6% | 20.6% | 14.2% | 22.3% |
| **Once per week** | 5.9% | 14.6% | 3.7% | 4.0% | 7.2% | 11.0% | 7.1% | 11.3% |
| **2–4 days per week** | 6.9% | 17.0% | 12.6% | 13.7% | 19.9% | 30.2% | 23.9% | 37.7% |
| **5 days a week (every day)** | 11.4% | 27.9% | 66.8% | 73.1% | 25.2% | 38.2% | 18.2% | 28.7% |

Table 10.4 shows the binary of how many respondents teleworked and how many did or do not (the first row labeled "never telecommuted"), as well as, for those who do telework, how often they have done so (in the sequential rows). Both of these dimensions are recorded for the four discrete time periods. While much more insight can be gathered from this table, some important trends to notice are:

- The non-teleworking population has dropped by nearly half from before COVID to early 2022
- Teleworking at least once a week has increased over 100% from before COVID to early 2022 (24.2% to 52.3%)
- There was roughly a 100% shift away from never teleworking (59.4% to 34.1%) and a 100% towards teleworking every day (11.4% to 25.2%) from before COVID to early 2022
- Relative to before COVID, rates of teleworking in early 2022 were higher, as may be observed in the decrease (between "Before COVID" and "Now" columns of Table 10.4) in percentages corresponding to the "Never Telecommuted" and "A few times per month", and an increase in percentages corresponding to other teleworking frequency categories
- The telework trends "now" and "in the future" columns are roughly identical. The main difference lies between the "2–4 days per week" and the "5 days a week (every day)" teleworking frequencies, with more

[22] %(T) – percent of the total sample
[23] %(P) – percent of those who telework

respondents predicting that in the future they will work partially, rather than fully, from home, relative to today's trends

**Table 10.5 Remote work location trends**

| Where have you teleworked from? | Before COVID | During COVID | "Now" (Early 2022) | In the future |
|---|---|---|---|---|
| From your home only | 85.4% | 95.8% | 89.8% | 86.3% |
| From a third workplace only | 4.3% | 1.2% | 3.9% | 4.2% |
| From both your home and a third workplace | 10.3% | 3.0% | 6.3% | 9.5% |

Next, Table 10.5 presents where these remote employees were working from during each time period. One important insight from Table 10.5 is that remote work from a third workplace has decreased slightly since before COVID, but employees intend to work from them more in the future, relative to now.

**Table 10.6 Telework frequency comparison prior to COVID and Early 2022**

| Telework Frequency before COVID | Telework Frequency Early 2022 | | | | |
|---|---|---|---|---|---|
| | Never telecommuted | A few times per month | Once per week | 2–4 days per week | 5 days a week (every day) |
| **Never telecommuted** | 52.7% | 12.7% | 6.5% | 16.5% | 11.5% |
| **A few times per month** | 7.5% | 32.3% | 10.6% | 24.2% | 25.5% |
| **Once per week** | 6.9% | 1.7% | 17.2% | 37.9% | 36.2% |
| **2–4 days per week** | 7.4% | 5.9% | 2.9% | 45.6% | 38.2% |
| **5 days a week (every day)** | 5.4% | 1.8% | 3.6% | 6.3% | 82.9% |

Table 10.6 shows a crosstab of pre-COVID teleworking frequencies with current teleworking frequencies. A few important insights from Table 10.6 are:

- Over four fifths of employees who worked 100% remote before COVID work 100% remote now as well (see the 82.9% value in the last cell of the table above).

- In general, the level of teleworking has increased from before COVID to Early 2022 (as can be observed from the higher percentages above the diagonal relative to below the diagonal in the crosstabulation above).
- About 5% of employees who never telecommute now were fully remote before COVID

#### 10.2.6.1. SP experiment data

Performing an initial descriptive exploratory analysis of the SP experimental data is necessary before the choice modeling of the experiment can begin. Before choice modeling, the analyst must also determine if they will model RP-SP data jointly or just model the SP data. Neither is inherently better, but depending on which direction is selected, the modeler may have to take an additional descriptive statistical analysis step. In short, because only SP choices will be modeled, then the descriptive statistical analysis must be performed to compare similar variables between the SP and RP data. This comparison is necessary to make sure that the SP data, which is reflective of an individual's response or behavior in a hypothetical and possibly hard-to-imagine scenario, is realistic. In the case of the WPL choice model, we chose to only model the SP data. The reasons why modeling SP data by itself still provides the same insightful and applicable results as jointly modeling RP and SP data will be explained more fully in the next chapter.

An RP question that is almost identical to the SP experiment was included in the survey. While the SP experiment asks respondents to allocate their typical number of working days per month across three WPLs, the RP question asks the respondent to record where they actually worked for the past month. The comparison between RP and SP WPL trends is presented in the next several tables.

**Table 10.7 Portion of choice occasions with positive participation**

| **WPL** | **Total number (%) of choice occasions with positive participation** | |
|---|---|---|
| **Data Type** | **RP data** (1,136 responses) | **SP data** (1,136*2 total) |
| **Home** | 671 (59.1) | 1635 (72.0) |
| **Work Office** | 897 (79.0) | 1561 (68.7) |
| **Third WPL** | 86 (7.6) | 330 (14.5) |

From Table 10.7, we can see that the splits between the RP and SP data are not identical, but that is not required to confirm minimal bias in the SP data. Instead,

we can confirm this minimal bias by assessing that the general trend across and between all alternatives is similar, and no alternative has a much higher representations (which would be the case if, for example, the third workplace response in the SP data suddenly shot up to over 50% participation, compared to 7.9% in the RP data).

Additionally, to make the comparison and ground the SP data, the analyst must consider the differences in the situational circumstances between the SP and RP data. In the instance of the WPL study, the RP WPL questions were not controlled for distraction level or COVID risk, while the point of the SP experiment is to control workplace environment and location characteristics in order to see how employees will react and change their WPL preferences. Therefore, the slight difference in the RP and SP data for positive participation for working from home is excusable, and the SP data can be deemed limited in bias and grounded through adequate comparison with RP data. Similar considerations, assumptions, and assessments should be evaluated whenever RP data is being directly compared to SP data.

Data comparisons that go into more depth on respondents' preferences for the ratio of working from the three workplace options are provided in Table 10.8.

**Table 10.8 Monthly WPL split[24]**

| For what portion of the month have (RP) and would (SP) you work from this location? | Work from home | | Work from in-person work office | | Work from a third workplace | |
|---|---|---|---|---|---|---|
| **Data type** | **RP** | **SP** | **RP** | **SP** | **RP** | **SP** |
| **Never** | 40.0% | 28.0% | 20.4% | 31.3% | 91.5% | 85.5% |
| **Less than 10%[25]** | 8.7% | 2.4% | 5.1% | 3.2% | 5.0% | 3.6% |
| **10–19%** | 5.2% | 5.5% | 2.9% | 5.8% | 1.1% | 2.7% |
| **20–29%** | 4.5% | 5.7% | 3.6% | 4.3% | 1.0% | 2.6% |
| **30–39%** | 2.8% | 3.0% | 2.8% | 4.7% | 0.6% | 1.4% |
| **40–49%** | 2.4% | 4.2% | 1.8% | 3.7% | 0.2% | 0.8% |
| **50–59%** | 2.3% | 7.1% | 3.0% | 5.8% | 0.3% | 1.4% |
| **60–69%** | 3.7% | 5.2% | 2.8% | 3.3% | 0.1% | 0.3% |
| **70–79%** | 3.0% | 3.4% | 3.8% | 4.4% | 0.0% | 0.1% |
| **80–89%** | 3.3% | 5.9% | 6.0% | 5.9% | 0.0% | 0.3% |
| **90–99%** | 4.4% | 3.2% | 6.9% | 2.4% | 0.1% | 0.0% |
| **100%** | 19.7% | 26.4% | 40.9% | 25.2% | 0.1% | 1.3% |

[25] But not zero.

The top results rows in Table 10.8 show that respondents' rates of teleworking (from home or a third workplace) less than 10% of the time or never were higher in the RP data than the SP data, while the SP responses revealed a higher propensity to work from the in-person workplace never or less than 10% of the month, compared to the RP responses. This may be because the SP scenarios clearly presented the option to work from a third workplace, while that option may be less available or top-of-mind to employees currently. Working from any WPL 10–90% of the time (Table 10.8's bottom10 rows) is roughly the same between both the RP and SP data, though there are some higher SP likelihoods to work from home the higher the portion of the month gets. Respondents selected to work from either remote WPL for the entire month at higher rates for the SP choice occasion as compared to the RP question; a 15% lower number of respondents preferred working from the in-person workplace full-time in the hypothetical scenario as compared to those who stated they currently work 100% in the office. The average number of days per month each WPL was selected by respondents can also be analyzed.

- RP WPL alternatives (days per month):
  - Work from home: 7.79
  - Work from workplace: 13.41
  - Work from third workplace: 0.26
- SP WPL alternatives (days per month):
  - Work from home: 10.38
  - Work from workplace: 10.04
  - Work from third workplace: 1.04

These averages once again demonstrate the higher preference to work from home in the controlled WPL SP experiment, relative to respondents' habits in current scenarios. This does not demonstrate a limitation or bias in the SP WPL alternatives but reflects the fact that it was a controlled experiment. Pre-COVID or current RP WPL choices would not represent future desired WPL states well because these earlier/current actual choices are likely to have been constrained by employer allowance/opportunity and other general safety restrictions because of the pandemic. This position is supported by Jain et al. (2022), who provide empirical evidence to suggest that COVID-related lockdowns were like forced 'experiments' related to WPL choice that are not necessarily indicators of long-term desires or actual behavior. Besides, as discussed earlier, motivations and

priorities are likely to have changed because of the pandemic. Thus, in this analysis, we do not use current RP-based WPL choices to explain future desired WPL states.

Now that we have established that the SP data is suitable for choice modeling, we can explore this data on its own. Table 10.9 presents an interesting assessment of SP WPL alternative variables used for choice modeling.

**Table 10.9 Descriptive statistics of WPL participation and frequency of WPL participation**

| WPL | Total number (%) of choice occasions with at least one particpation from WPL[26][27] | Mean number of days of partipcation given at least one participation from WPL[28] |
|---|---|---|
| **Home** | 1635 (72.0) | 14.5 |
| **Work Office** | 1561 (68.7) | 14.5 |
| **Third Workplace** | 330 (14.5) | 6.9 |

[26] Percentages in the column do not sum to 100% because respondents could select more than one WPL.
[27] "Positive participation" indicates at least one participation from that WPL.
[28] This indicates the mean number of days respondents reported they would spend working from the WPL, subject to at least one participation in that WPL.

Two observations may be made from the statistics in the first three columns of Table 10.9.

1. The home and work office alternatives are chosen at roughly equal rates, about 70%, while the third WPL is less common, at only 14.5%.

2. Among respondents who selected at least one occasion of participation from home (work office), the mean number of days of partipcation from home (work office) was 14.5 days per month. On the otherhand, among those who selected at least one occasion of participation from a third WPL, the mean number of days of participation from the third WPL was lower, at about 7 days per month. That is, not only were respondents less likely to select a third WPL even once, they were also less likely to frequent at third workplace to work.

### 10.2.7. COVID threat

Finally, COVID threat level is an important variable on which to review the descriptive data. About 40% of the Texas employees sampled live with or frequently see someone who is immunocompromised, while only about 15% of employees report being immunocompromised. This demonstrates that the COVID pandemic is still on the front of the minds of a large number of Texans and their concerns won't be going away anytime soon

### 10.2.8. Online shopping

An additional dimension of the survey, though not a main focus of the descriptive analysis of the choice model, is its questions on shifts in online participation before COVID, during the peak of COVID, and today. The survey asked an array of questions comparing in-person and virtual purchasing behaviors, for shopping or eating out. Table 10.10 shows these trends, for groceries, prepared meals (such as takeout), and non-grocery items. Again, these results only reflect employed individuals and their households.

**Table 10.10 Shifts in online shopping trends**

| Increased from before COVID to now?[29] | Shopped for groceries online | Ordered prepared meals online for home delivery | Shopped for non-grocery items online |
|---|---|---|---|
| **Significantly more** | 29.8% | 22.6% | 32.5% |
| **A little bit more** | 21.8% | 22.3% | 35.1% |
| **No change** | 43.4% | 45.6% | 29.2% |

[29] The exact question asked for each of these columns was "In the past month, have you ____ more or less frequently than you did before the COVID-19 pandemic?"

| Increased from before COVID to now?[29] | Shopped for groceries online | Ordered prepared meals online for home delivery | Shopped for non-grocery items online |
|---|---|---|---|
| **A little bit less** | 0.9% | 3.8% | 1.6% |
| **Significantly less** | 4.0% | 5.6% | 1.6% |

Across all three categories, 45% or more of the respondents purchase goods online more now than they did before COVID. The largest shift is towards purchasing non-grocery items online, which increased for about 70% of respondents. This clearly shows that online participation has significantly increased in Texas. However, whether this has decreased in-person shopping and eat-out (or restaurant) trips is still up for debate, as many past studies report that online shopping actually has a complementary impact on in-person trips and that the number of overall trips (an individual's personal trips and delivery drivers' trips to them) will increase, augmenting traffic on the roads.

There are several other online and in-person shopping data points that have been included in the dataset. To further explore the data and its trends, please refer to several studies by Haddad et al. (2022a, b); the dataset is also publicly available for analysis. The header guide table for the dataset (which can also be found in Appendix I) provides information on which questions pertain to online shopping shifts due to the COVID-19 pandemic.

## 10.3. Choice modeling analysis

Choice modeling aims to reflect the decision process of an individual or segment of the population via revealed or stated preferences made in a particular context or contexts. Typically, choice models use discrete, continuous, ranked, ordered, or other formats of choices or preferences in order to deduce the positions of matters on some relevant latent scale. In the case of the WPL SP choice model, we employ a multinomial model known as the multiple discrete-continuous extreme value (MDCEV) model (Bhat, 2008), which has both discrete and continuous components, to analyze individuals' monthly split of WPL choices using the following three alternatives (1) work from home, (2) work from in-person office, and (3) work from a third workplace. This study has been included in full as Chapter 11 of this report. More on the model techniques used for this study can be found in the paper Asmussen et al., 2022. An MDCEV model is a beneficial approach to use when estimating individuals' behavior, as it includes the ability to measure both a preference (the discrete variable) and the frequency of choosing that preference (the continuous variable) in order to provide a multi-dimensional analysis of the issue in question. This is especially helpful when projecting society's behavior in an unprecedented future or its reaction to an emerging

technology, as more information and more insight can be extracted from the SP data at hand.

Before reviewing the results, it is important to note that in this modeling exercise, only SP data is modeled and a traditional joint model of RP and SP data is not undertaken for reasons mentioned earlier. Also, previous studies have left no doubt as to the importance, validity, and truth of SP experiments and data (whether used in congruence with RP data or alone) - the stronger the self-reported intention (through response to an SP question) to perform a behavior (even if in an uncertain future environment), the more likely the behavior will actually be performed (see, for example, Morosan and DeFranco, 2016, Foroudi et al., 2018, Marikyan et al., 2019, Gunden et al., 2020, and Bernheim et al., 2022). There is substantial value in using SP data, both alone and jointly with RP data for choice modeling purposes.

When compared, RP behavioral measures sometimes underperform relative to SP measures in terms of reliability, retest stability and criterion validity (Arslan et al., 2020). In an environment where technology is rapidly advancing and policies are quickly changing, today's behavior (that is RP behavior) will not be a good reflection of future behaviors. This is where SP surveys are useful. However, we used RP data as exogenous variables in the choice model and as inputs in the SP experiment design (such as respondents' reported commute times) to instill realism in the hypothetical scenario and to ground the SP data.

RP data is still and will never be "outdated", as it is nearly impossible to gather individual and household information through only SP data. Household travel surveys and measures of current demographics, behaviors, preferences and attitudes will continue to be gathered and modeled using RP data. However, there is much analysis benefit attained when SP data is available for use alongside RP data. It is necessary to either jointly model with RP data, accurately ground the SP data with RP data, or use RP data as attribute inputs or logic requirements for SP experiments, proving that RP data will never be out-of-style or superfluous for choice modeling or travel demand modeling uses.

The remainder of the choice modeling analysis is included as Chapter 11 and will include the finalized version of the study (which is pending publication) resulting from this project's effort, titled "On Modeling Future Workplace Location Decisions: An Analysis of Texas Employees". The finalized study includes some identical text that is included above in the descriptive analysis in Section 10.2.

# Chapter 11. Choice Model Results: On Modeling Future Workplace Location Decisions: An Analysis of Texas Employees[30]

## 11.1. Abstract

In this paper, we examine work place location (WPL) preferences of workers in an unpredictable and evolving future by investigating how workers would prefer to allocate their monthly working days among the three WPL alternatives of working from home, from the work office, and from a variable third WPL. In our analysis, we employ the multiple discrete-continuous extreme value (MDCEV) model, using a 2022 stated preference survey of future work preferences of employees residing in the state of Texas. The results indicate that single young women with very young children, those with long commutes and "intolerable" traffic congestion to the work office, individuals with a private study in their homes, self-employed workers, and those in non-essential service occupations have the highest preference for working from home. On the other hand, older men, individuals from low income households, those residing in rural areas, and workers in essential service occupations have the highest preference for the work office. And, for the third WPL, young non-single women with very young children, individuals from low income households, part-time employees, and those in professional, managerial or finance occupations have the highest predisposition. These results should provide valuable insights to urban planners, homebuilders, employers, travel demand modelers, and a whole host of other businesses to achieve specific desired end states. From a data collection standpoint, our study underscores the need to collect detailed information about work patterns in future activity-travel surveys.

## 11.2. Introduction

Over the past two years, the COVID-19 pandemic has upended the routines and lifestyles of almost every person across the world, and workers have been no exception. In terms of work place locations (WPLs), three possibilities (and their combinations) have become quite popular: (a) the regular work place (the pre-COVID norm), (b) the home (the post-COVID era norm), and a (c) third workplace location such as coffee shops, designated co-working locations, hotels

[30] The unabridged version of this study is located at https://www.caee.utexas.edu/prof/bhat/ABSTRACTS/WPLSP.pdf, where more conclusions on work environment, and differences in preferences by rural/ suburban/ urban dwellers are discussed.

and restaurant (throughout this paper, we will use the label "Pre-COVID" to refer to the period *before the onset* of COVID in early 2020, and the term "Post-COVID" to refer to the period *after the onset* of COVID). In the current study, we employ a multiple discrete-continuous (MDC) model[31] to determine the allocation of the monthly number of work days of an individual across these three possible work location alternatives.

The study is motivated from the fact that the three WPL arrangements are not always perfect substitutes of each other, but may be better viewed as imperfect substitutes. Each location arrangement may satisfy specific functional, social, productivity, emotional, privacy, visibility, networking, financial and other personal/professional objectives to different extents. As a consequence, it is likely that, given full choice of where to work from, many individuals will choose, over a certain period of time and within the context of their chosen/current career, a combination of these WPLs to satisfy different personal and professional desires. Thus, unlike the plethora of studies before the pandemic that focused on whether an individual telecommuted from home at all or not over the course of a certain period of time (occasionally along with the frequency dimension of the number of days the individual works from home over the period of time), the emphasis moving forward needs to be on the mix of work locations sought after by individuals over a period of time, including not only home and the regular work location, but also possibly a third work location (this third work location may be a hotel day room near the home or even a constantly varying *digital nomadic* way of living/working on the move such as connecting from a ski resort or working from a beachfront). At the same time, rather than employing statistical devices to tie the single discrete choice of telecommuting from home with the frequency of telecommuting, as in almost all pre-COVID studies, post-COVID decisions may be better characterized as a true utility-maximizing multiple discrete "horizontal" choice situation in which individuals balance the many pros and cons of each work location to determine an ideal mix of work locations over a certain duration of time. In this context, the MDC extreme value[32] (MDCEV) model structure that we employ in this study is particularly appropriate.

[31] This modeling strategy allows analysts to model both the adoption of an alternative (the discrete choice) and the intensity of adoption (the continuous choice). In our empirical context, this corresponds to whether an individual chooses each of the three WPL alternatives at all or not, and the frequency of days of participation from each WPL if chosen at all.
[32] "Extreme value" refers to the error term distribution in the utility function.

## 11.3. Previous Literature

The global shift to remote and virtual environments during the "shutdown" period of the pandemic has accelerated the growth in literature dedicated to the study of telework. However, even pre-COVID, there was a healthy body of literature on the topic, though almost exclusively confined to working from home as the alternative to working from the regular work place. However, as discussed in the previous section, the WPL upheaval caused by the pandemic suggests a hybridization choice process at play in the post-COVID era. In this regard, while there have been very recent studies (within the past two years) that investigate the kinds of WPL arrangements that may be most effective in the future, they do so more from a descriptive analysis standpoint or through the lens of what employees and employers view as positives and negatives of different WPLs, rather than as a multiple discrete horizontal process of WPL preference formation. Further, most of the post-COVID preference/choice studies use revealed preference studies of pre-COVID teleworking choice or "at present" teleworking choice in the midst of the pandemic. Only three studies, to our knowledge have focused on WPL desires in the more distant future using stated preference (SP) data, and these will be the focus of our overview in the rest of this section.

Nayak and Pundit (2021) and Jain et al. (2022) study an employee's intention to telework based on a direct question regarding stated intent in a future when "travel and other restrictions would be withdrawn after the elimination or control of the pandemic" (Nayak and Pundit, 2021) or the virus is "gone" (Jain et al., 2022). Specifically, Nayak and Pundit elicit a binary response to whether the employee would be willing to telework in the future, while Jain et al. pose a question related to how much more likely (as collected on a seven-point Likert scale) would the respondent be to telework in the future compared to pre-COVID times. The results from these studies indicate that highly educated individuals, those from small-sized households, younger individuals, women with children, and married women are most likely to remain remote workers in the future. Commute time did not affect stated teleworking adoption. But these studies did not consider work environment attributes (such as noise and crowdedness).

The third study by Appel-Meulenbroak (AM) et al. (2022) is the closest in spirit to the current study. As in the current paper that asks individuals to provide their ideal preferred WPL choice, AM et al. (3) ask respondents to assume that working from home is allowed as a free choice each day. In their stated preference experiment, a respondent is asked to choose their preferred discrete WPL choice during a specified day from among three varying in-person workplace alternatives and one "work from home" alternative. The in-person work alternatives are characterized, among other attributes, by work environment attributes (noise,

openness, space size, crowdedness, concentration spaces, communication spaces, and positioning workplace in relation to walking route). The results underscore the importance of work environment characteristics that have received little attention in the literature.

Overall, while close in spirit to the current paper, our research is also quite different from that of AM et al. paper. While AM et al. consider a single day as the analysis frame, we investigate individual desires for working from different WPLs over a period of a month. Besides, the AM et al. study does not consider the frequency dimension of teleworking.

### 11.3.1. Current Paper in Context

In the current paper, we build on past literature in multiple ways. First, we examine WPL choices and corresponding frequencies from the perspective of a unified (across choice and frequency) utility-based horizontal choice optimal arousal theory[33]. That is, in the WPL context, an employee will choose the optimal combination of WPL frequencies across their days of work over a period of time (a month in this paper). Second, we consider three possible WPL locations; Home, an established in-person work office (which we will refer to henceforth simply as work office), and a third work place (such as a hotel or a coffee shop). In doing so, we examine the characteristics of "digital nomads". Third, we recognize that the desired WPL choice combination over a month will be impacted by a comprehensive combination of three distinct sets of attributes associated with work location and job characteristics: (1) the geographic attributes of the alternative WPL locations, (2) the environment attributes of each of the alternative WPL locations, and (3) job-related attributes. *Geographic WPL attributes* refer to such "external" characteristics of the location such as commute time to the non-home WPL locations, congestion levels during the commute, and the built environment characteristics around the location (captured, admittedly, in a simple but important way through a density classification scheme of locations). *Environment WPL attributes*, on the other hand, refer to such "internal" characteristics of the location such as distraction level, crowding level, and socialization opportunities and access. We also include, for the first time to our knowledge, two home-related attributes within the environmental WPL set of attributes, including the tenure type of the house (renting versus owning) and the presence of a study/office at home. *Job-related attributes* include number of work days per month, employment status (full time or part-time), employment structure

[33] Optimal arousal is a psychological construct representing the level of mental stimulation and personal satisfaction at which physical performance, learning, or feelings of wellbeing are maximized and balanced (Smith 1990).

(self-employed versus non-self-employed), occupation sector, and the ability to shift work hours over the course of the day. As discussed earlier, some of these job-related attributes proxy employer-provided opportunity effects by investigating how employees themselves filter the reality of the needs of their respective jobs when developing optimal WPL desires. Fourth, from a methodological standpoint, we explicitly accommodate covariances across the baseline utilities of the different WPL alternatives as well as consider panel effects (unobserved individual effects that permeate across the two stated preference choice occasions of the same individual; ignoring such effects can lead to an underestimation of standard errors and potentially incorrect inferences about the statistical significance of the parameter estimates). Finally, a majority of the published post-COVID telework studies are at non-US locations and/or focus on current telework (from home) choice. In this paper, we examine the desired WPL state of individuals into the future using survey data collected from the state of Texas in the US.

## 11.4. Methodology

### 11.4.1. The Survey

The primary data for the current study is drawn from a workplace location (WPL) choice survey deployed across Texas, US in February and March, 2022, coordinated through efforts with the Texas Department of Transportation (TxDOT). The survey administration approach included an array of communication and information recruitment strategies, including promotion via e-mail to several chambers of commerce across the state of Texas, alongside other businesses, professional organizations, and media outlets, as well as a database of roughly 55,000 Texas residents' email addresses. Survey access was restricted to individuals who were employed/students, who were residents of the state of Texas at the time of the survey. Of the 1,450 responses from the target population (workers/students), 304 individuals did not respond to commute and current workplace-related questions and/or did not adequately respond to the SP experiments that formed the main outcome variable in the analysis. The resulting sample of 1,146 respondents had 10 students who were not employed, who were then removed to retain a final sample of 1,136 employed individuals (and 1,136x2 = 2,272 choice occasions). All these individuals had a work office at the time of the survey (even if they never commuted to that location). The survey was deployed at a time when the Omicron variant was past its January 2022 peak in Texas, and restrictions and safety measures in-place for the pandemic were declining. The survey collected information on pre-COVID, during the worst of COVID, and current work patterns. In addition, socio-demographics (age, gender,

employment type, education level, household annual income, and number of children in a household) and the current work office/home location information were obtained.

For this analysis, the focus, as in Appel-Meulenbroak et al. (2022), is the response to the stated preference questions regarding desired WPL state at a future time, though when COVID still would be present in an endemic state and enough of a threat to warrant some level of consideration. Pre-COVID or current WPL choices would not represent this future desired state well because these earlier/current actual choices are likely to have been constrained by employer allowance/opportunity and other general safety restrictions because of the pandemic.[34] Besides, motivations and priorities are likely to have changed because of the pandemic. Thus, in this analysis, we do not use these current WPL choices to explain future desired WPL states, though we do use current work office geographic attributes and job characteristics (including sector of work, part time versus full time work status, urban/suburban/rural location of the work office, and perceived congestion levels to the work office) to explain future desired WPL state. The implicit assumption here, as supported by earlier studies (see, for example, Gebbels et al. (2019)), is that individuals will generally stay in their current occupations and work arrangements into the not-too-distant future, even if their desired future WPL state is quite different from pre-COVID or current WPL choice.

In the SP part of the survey, each respondent was presented two scenarios and asked to allocate their total number of working days per month across the three different WPL alternatives: (1) home, (2) work office, and (3) third WPL. For example, in response to a specific scenario of attributes, a full-time worker employed 22 days in a month may split things up as five days from the work office, 15 days from home, and two days from a third WPL. The attributes used in each scenario include commute times to the work office and third WPL, measures of distraction and crowding level for different work locations, flexibility of work hours (both the permission to shift working start time and to split up hours across

[34] This position is supported by Jain et al. (2022), who provide empirical evidence to suggest that COVID-related lockdowns were like forced 'experiments' related to WPL choice that are not necessarily indicators of long-term desires or actual behavior. Further, on the issue of our use of stated preference data (in our case, the stated preference of work location configuration in an environment where individuals have full freedom to choose), it is well established that behavioral preferences/intentions precede behavioral action. Extensive studies in the social-psychology, information sciences, and consumer behavior literature have also validated the strong and unambiguous relationship between self-reported preferences/intentions to pursue a certain behavior and the actual future action (even if in an uncertain future environment and, even if not perfect, particularly for studying causal relationships; see, for example, Marikyan et al. (2019) and Bernheim et al. (2022)).

the day), and COVID-19 risk intensities associated with each possible location. The attributes and their respective levels are presented in Table 11.1, along with a sample SP WPL question in Figure 11.1. The attribute levels (for the experiment) themselves were designed with the intention to keep the scenarios realistic, while engendering good variability in the attribute values across scenarios. In all, there were 23,040 possible combinations of the attribute levels. From these combinations, a fractional factorial design selected 40 different scenarios with the emphasis on isolating main effects and, to some limited extent, two-way and higher-order interaction effects. It is clearly infeasible to present 40 SP choice questions to each respondent, and hence we used the randomization feature in the survey design software Qualtrics to randomly assign two of the 40 SP questions to each respondent.

**Table 11.1 Experimental Design Attribute and Levels**

| Attribute | Attribute Levels |
|---|---|
| ***Work from Home*** | |
| **Distraction level** | • High distraction<br>• Low distraction<br>• No distractions |
| ***Work from the Work Office*** | |
| **Distraction/Crowding Level** | • No crowding at the out-of-home workplace; you have your own designated, quiet, closed-off room (No distractions)<br>• Some crowding at the out-of-home workplace, but you have a small area to yourself or with chosen coworkers (Low distraction)<br>• The out-of-home workplace is crowded and you are in close proximity to quiet coworkers (Low distraction)<br>• The out-of-home workplace is crowded and you are in close proximity to loud coworkers (High distraction) |
| **Commute Time** | • Same commute length as before<br>• 50% longer than before<br>• 75% longer than before<br>• 50% shorter than before<br>• 75% shorter than before |
| **Workplace Safety Implementation for COVID** | • No safety regulations<br>• Only one safety measure is implemented<br>• Two or more safety measures are implemented |
| ***Work from a Third WPL*** | |
| **Distraction/Crowding Level** | • No crowding at the third workplace; you have your own designated, quiet, closed-off room (No distraction)<br>• Some crowding at the third workplace, but you have a small area to yourself or with chosen coworkers (Low distraction)<br>• The third workplace is crowded and you are in close proximity to quiet strangers (Low distraction)<br>• The third workplace is crowded and you are in close proximity to loud strangers (High distraction) |
| **Commute Time** | • Shorter than your outside-of-home workplace commute<br>• Same length as your outside-of-home commute to the workplace |
| ***General Attributes*** | |
| **COVID Risk Level** | • There is a new strand of the virus and current vaccines are ineffective. Risk for the new strand is HIGH.<br>• Both the vaccine's effectiveness against all current strands, and the % of people vaccinated are unknown. Risk is unknown.<br>• 60% of people are vaccinated and the vaccine is effective for all current strands. Risk is low.<br>• 80% of people are vaccinated and the vaccine is effective for all current strands. Risk is extremely low. |
| **Shifting Work Hours** | • Allowed<br>• Not allowed |
| **Splitting Work Hours** | • Allowed<br>• Not allowed |

| COVID Risk Level | 60% of people are vaccinated and the vaccine is effective for all current strands. Risk is low. | | |
|---|---|---|---|
| ***Attributes*** | ***Work from Home*** | ***Work from the Workplace*** | ***Work from a 3rd Workplace*** |
| **Distraction level** | Low distraction | Low distraction | High distraction |
| **Commute time** | - | 7.5 minutes longer than before | Shorter than your out-of-home workplace commute |
| **Level of crowding** | - | The out-of-home workplace is crowded and you are in close proximity to quiet coworkers | The third workplace is crowded and you are in close proximity to loud strangers |
| **Workplace safety implementation for COVID** | - | Only one safety measure is implemented | - |
| **Splitting Work Hour** | Allowed | Not allowed | Allowed |
| **Shifting Work Hours** | Allowed | Not allowed | Allowed |

You reported to work 22 days last month. For this scenario, please distribute the number of days you would work at each workplace so that they all add up to 22. You can put 0 days for one or two of the alternatives as long as it adds up to 22.

Remember, a third workplace is a remote workplace outside of the home such as a coffee shop, cafe, hotel, or co-working space.

| | |
|---|---|
| Work from home | 0 |
| Work from the workplace | 0 |
| Work from a 3rd workplace (teleworking from a location that is not your home) | 0 |
| Total | 22 |

*Figure 11.1 Example SP Question*

## 11.5. Sample Description and Methodology

We are unable to compare the individual-level demographic characteristics with the Census Bureau data or the five-year American Community Survey, because these latter databases do not distinguish between employed and non-employed individuals. But, in terms of geographic WPL attributes and job characteristics, we are able to compare our sample statistics with those drawn from the 2020 Texas Census (Texas Demographic Center, 2022). Our sample slightly overrepresents the self-employed population in Texas (16.8% of the sample relative to 7% self-employed in Texas as identified in the 2020 Texas Census). But our sample is pretty representative of industry types. Also, in terms of

commute times, the average one-way commute time in Texas is 26.4 minutes, while our sample's average commute time is 25.2 minutes. Similarly, the average number of days an employee works in a month is 22 days, and our sample reported working an average of 21.5 days. Additionally, before COVID, about 5% of Texans worked from home every day, while 9.3% reported doing so to in our sample. These numbers increase to 22% and 19.4%, respectively, when considering if an employee worked from home at least once a week. The above statistics do suggest that our sample reasonably represents characteristics of the employed population in Texas; the desired WPL status in the future as expressed in our sample may be considered a good reflection of the future WPL desires of the Texas employed population.

Across all the 2,272 choice occasions, the mean number of days of participation in each of the three WPLs are as follows: home (10.5), work office (10.0), and third WPL (1.0), totaling up to the mean number of 21.5 work days per month in the sample.

In this paper, a panel version of the mixed multiple discrete-continuous extreme value (MMDCEV) model (see Bhat (2008)) is implemented to analyze individual's monthly split of workplace location choices in the following three categories: (1) Work from home, (2) Work from in-person work office, and (3) Work from a third work place.

## 11.6. Model results

The full model results for the effects of variables in the MMDCEV model are available at: https://www.caee.utexas.edu/prof/bhat/ABSTRACTS/WPLSP.pdf . In this section, we will focus on the implications of the model results. However, we will point out that our estimated model provided a much better data fit than a constants-only model (in which we only allow constants in the baseline preferences and in the satiation parameters of the alternatives). The log-likelihood at convergence for our panel model is -6740.25, compared to the constants-only log-likelihood value of -7113.62. A likelihood ratio test yields a value of 746.74, which is much higher than the chi-squared table value with 63 degrees of freedom at any reasonable level of significance (there are 68 parameters in our model, compared to five parameters in the constants-only model)[35]. In addition, we also

[35]When evaluating the data-fit of an estimated model, we can compare several goodness-of-fit measures of the estimated model to those of a second model. In this case, we compare our estimated model (which includes an array of exogenous variables) to a model where only alternative-specific constants are present. When comparing log-likelihood values, the model with a value closer to zero reflects a "better model". Also, a higher average probability of correct predictions indicates a better model.

computed the average probability of correct predictions for the two models, which returned a value of 0.192 for our model relative to 0.137 for the constants only model.

## 11.7. Implications

The estimation results, by themselves, do not provide an intuitive picture of the effects of variables, and the relative magnitude of the effects of variables, on the actual days of work from each WPL. To do so, compute Average Treatment Effects (ATE effect; see Heckman and Vytlacil (2000)), which is a general method to estimate the impact on a downstream posterior variable of interest (the number of days of participation in each WPL in our case) due to a treatment that alters the state of an antecedent variable (exogenous variable) from A to B. For example, if the intent is to estimate the "treatment" effect of distraction levels at the home office on WPL allocations, A can be the state where there is low distraction level when working from home, and B can be the state where there is high distraction level when working from home. The impact of this change in state is measured in terms of the change in the shares of the outcomes of interest between the case where all individuals in the dataset are in state A and the case where all the individuals in the dataset are in state B. This has the effect of holding all other exogenous variables fixed at those in the sample, so that the ATE can be viewed as the average change in WPL due to an individual being in state B rather than state A.

Note that the model can provide the WPL splits for any combination of the many exogenous variables. For example, just on the basis of the gendered lifecycle variables, there would be a total of 20 gendered lifecycle variables that exhaust the population (based on the significant gender and household structure variables in the MMDCEV model estimation). In our ATE computations, we focus on just three of these combinations for presentation compactness:

1. Man with partner
2. Woman with a young child 0-4 years (with no young children in other age categories) and with a live-in partner (simply "women with young child with partner" from here on).
3. Woman with a young child 0-4 years (with no young children in other age categories) and without a live-in partner ("labeled as "women with young children without partner").

We confine our ATE analysis to these three groupings (from the original 20) to focus on the lifecycle period that corresponds to having young children; this

lifecycle period is known to be the most challenging for parents in terms of time availability (see, for example, Del Boca et al. (2020)) Also, our results indicate that the presence or not of young children has no impact on a man's WPL choices, and the differences for men with a live-in partner or without was not too substantial in the lifecycle grouping. A more comprehensive ATE analysis of additional lifecycle groupings (including women without children) is available in an online supplement at: https://www.caee.utexas.edu/prof/bhat/ABSTRACTS/WPLSP/OnlineSupp.pdf. In addition to limiting to the three gendered lifecycle groupings just identified, for the ATE computations in this paper, we consider the case of only full-time work with 22 work days a month. For each of the three gendered lifecycle categorizations, we undertake several single-variate analyses, and determine the WPL effects of several exogenous variables. In the remainder of this section, we discuss the ATE effects corresponding to sociodemographics (Tables 11.3 and 11.4) and commute times (Tables 11.5 and 11.6), and distraction levels (Tables 11.7, 11.8 and 11.9), and occupation status (Table 11.10).

The results are presented in Tables 11.2 through 11.10. Table 11.2 presents the estimates of the WPL split of the 22 days per month for each gendered lifecycle group, assuming the distributions of all other variables are as in the full sample. That is, the model predicts that the desired average WPL split in the group of individuals who are men living with a partner would be 9.8 days from home, 11.4 days from the work office, and 0.7 days from a third WPL. On the other hand, for women with a young child and living without a partner, the split would be 19.9 days from home, 1.9 days from the work office, and 0.2 days from a third work place (see Table 11.2).

**Table 11.2 Only Gendered Lifecycle Treatment (split of days) ATEs**

| Gendered Lifecycle | WPL | Only Gendered Lifecycle Treatment |
|---|---|---|
| **Men with partner** | Home | 9.8 |
| | Work Office | 11.4 |
| | Third WPL | 0.7 |
| **Women with young child with partner** | Home | 11.6 |
| | Work Office | 8.8 |
| | Third WPL | 1.6 |
| **Women with young child without partner** | Home | 19.9 |
| | Work Office | 1.9 |
| | Third WPL | 0.2 |

Tables 11.3 and 11.4 further breakdown the splits for each of the three gendered lifecycle categories by each additional exogenous variable. Table 11.3 provides the predicted splits by age groupings that indicates, for example, that for men living with a partner, the average WPL splits for those in the 18-29 year age group would be 10.5 days from home, 10.6 days from the work place, and 0.9 days from a third WPL. Table 11.3 provides the percentage change in WPL splits going from the left extreme category (18-29 years, which serves as the base category) to the right extreme category (65 years or older, which serves as the treatment category). This corresponds to the ATE effect. Thus, the boldfaced value of **-15.2**% indicates that, in the group of men who are 65 years of age and living with a partner, one can expect that the average share of days working from home will be about 15% lower than in the group of men who are 18-29 years of age and living with a partner. Another way of interpreting this result is that a random male living with a partner who is 65 years of age will work from home about 15% fewer days per month than a random male living with a partner who is in the 18-29 years of age.

**Table 11.3 Age (split of days) ATEs**

| Gendered Lifecycle | WPL | 18 to 29 | 30 to 64 | 65 and older | Overall % Shift - 18 to 29 to 65 and older |
|---|---|---|---|---|---|
| **Men with partner** | Home | 10.5 | 9.9 | 8.9 | **-15.2%** |
| | Work Office | 10.6 | 11.3 | 12.6 | **18.8%** |
| | Third WPL | 0.9 | 0.8 | 0.5 | **-43.7%** |
| **Women with young child with partner** | Home | 11.9 | 11.7 | 10.8 | **-9.3%** |
| | Work Office | 8.3 | 8.6 | 10.1 | **21.8%** |
| | Third WPL | 1.8 | 1.7 | 1.1 | **-38.2%** |
| **Women with young child without partner** | Home | 20.0 | 20.0 | 19.7 | **-1.4%** |
| | Work Office | 1.8 | 1.8 | 2.2 | **21.8%** |
| | Third WPL | 0.3 | 0.2 | 0.2 | **-40.0%** |

All other numbers in Tables 11.3 through 11.10 may be similarly interpreted. We provide both the predicted splits by each sub-grouping (by age in the discussion above) as well as the ATE, because the ATE magnitude can be deceiving when the base split is low (this happens particularly for the third WPL alternative). The combination of the predicted splits and the ATE provide a more complete picture of WPL shifts due to each exogenous variable for each of the three gendered lifecycle categories.

We now discuss some of the salient observations from the tables, while also discussing implications under four broad topics: (1) Who are the ones who prefer more WPL hybridization?, (2) Geographic or environmental WPL attributes: which impacts hybridization preferences more?, (3) How should employers prepare for and design hybrid workplace structures?, and (4) What are the implications for travel demand?

### 11.7.1. Who are the ones who prefer more WPL hybridization?

Our results provide important insights about WPL hybridization preferences by demographics (see Table 11.2). Regardless of other exogenous characteristics, women would like to have a higher split of work days from home than men. This elevated desire to work from home is particularly acute for single mothers with very young children, to the point where, regardless of other characteristics, such workers prefer working from home a staggering 19-20 days of the 22 days, with only 1-3 days from the work office and rarely from a third workplace. Overall, based on demographics seen in Tables 11.3 and 11.4, young women (18-29 years of age) living alone with young children and in the highest household income bracket have the highest preference for working from home. On the other hand, for the work office WPL, men older than 65 years in the lowest household income bracket have the highest preference. And, for the third WPL, it is the third demographic grouping of young women (18-29 years of age) with very young children, living with a partner, and with low household income who have the highest desire (presumably as a way of getting "protected" work time while also not having to go into the work office).

**Table 11.4 Income (split of days) ATEs**

| Gendered Lifecycle | WPL | <$100K | $100 to $250K | ≥ $250K | Overall % Shift - <$100K to ≥ $250K |
|---|---|---|---|---|---|
| **Men with partner** | Home | 9.0 | 10.3 | 10.4 | **15.2%** |
| | Work Office | To | 10.9 | 11.1 | **-9.2%** |
| | Third WPL | 0.8 | 0.8 | 0.5 | **-31.2%** |
| | Home | 10.8 | 12.0 | 12.3 | **13.4%** |

| | | | | | |
|---|---|---|---|---|---|
| **Women with young child with partner** | Work Office | 9.5 | 8.3 | 8.6 | **-9.7%** |
| | Third WPL | 1.7 | 1.7 | 1.1 | **-31.4%** |
| **Women with young child without partner** | Home | 19.7 | 20.1 | 20.2 | **2.5%** |
| | Work Office | 2.1 | 1.7 | 1.7 | **-19.4%** |
| | Third WPL | 0.2 | 0.2 | 0.1 | **-37.3%** |

The results above can help cities and other regional entities understand and prepare for the desired mix of office and third WPL locations. We discuss these issues later in the context of travel demand and employer policies, but insights on the distribution of work locations can also be useful for city planners, developers, retailers, home builders, and restauranteurs in terms of strategic decision-making to achieve desired states. For example, home builders may want to design homes with a relatively good sound-proof study room to provide a distraction-free work environment as a means to increase home sales, especially in areas with a high fraction of young single mothers. Child care businesses may want to penetrate into traditionally residential areas, given the critical mass of home workers who may want to have focused work time without distraction from young children.

### 11.7.2. Geographic or environmental attributes: which impacts hybridization preferences more?

Table 11.5 indicates that commute time to the work office (a geographic/location WPL attribute) has the most impact for women, with work office instances reducing by 15.6% for women with young children living with a partner and by 25.4% for women with young children not living with a partner. The corresponding reduction for men living with a partner is only 7.3% (these reductions are for an increase in commute time from shorter than current by 50% to longer than current by 50%). Table 11.6 indicates similar trends for commute time to the third WPL.

**Table 11.5 Work Office Commute Time (split of days) ATEs**

| Gendered Lifecycle | WPL | 50% shorter (13.2 minutes) | Average (26.4 minutes) | 50% longer (39.6 minutes) | Overall % Shift - 50% shorter to 50% longer |
|---|---|---|---|---|---|
| **Men with partner** | Home | 9.5 | 9.9 | 10.3 | **8.3%** |
| | Work Office | 11.8 | 11.4 | 10.9 | **-7.3%** |
| | Third WPL | 0.7 | 0.8 | 0.8 | **9.9%** |
| **Women with young child with partner** | Home | 11.1 | 11.7 | 12.3 | **11.3%** |
| | Work Office | 9.4 | 8.6 | 7.9 | **-15.6%** |
| | Third WPL | 1.6 | 1.7 | 1.8 | **13.6%** |
| **Women with young child without partner** | Home | 19.8 | 20.1 | 20.3 | **2.5%** |
| | Work Office | 2.0 | 1.7 | 1.5 | **-25.4%** |
| | Third WPL | 0.2 | 0.2 | 0.2 | **4.0%** |

**Table 11.6 Third WPL Commute Time (split of days) ATEs**

| Gendered Lifecycle | WPL | 50% shorter than com. to WO | Same as comm. to WO | Overall % Shift - Shorter to Same |
|---|---|---|---|---|
| **Men with partner** | Home | 9.8 | 9.8 | **0.3%** |
| | Work Office | 11.4 | 11.4 | **0.3%** |
| | Third WPL | 0.8 | 0.7 | **-7.8%** |
| **Women with young child with partner** | Home | 11.5 | 11.6 | **1.1%** |
| | Work Office | 8.8 | 8.8 | **0.9%** |
| | Third WPL | 1.7 | 1.5 | **-12.2%** |
| **Women with young child without partner** | Home | 19.9 | 20.0 | **0.1%** |
| | Work Office | 1.9 | 1.9 | **0.1%** |
| | Third WPL | 0.2 | 0.2 | **-12.4%** |

Moving on to the environmental WPL attribute of distraction levels (see Tables 11.7, 11.8, and 11.9), Table 11.9 reveals that distraction at the third WPL has the most adverse effect on working from there (almost a 50% drop in frequency). The corresponding decreases due to distraction effects at the home and work office are not as substantial (see Tables 11.7 and 11.8, respectively), suggesting that distraction may be more easily worked through at home or in the work office with familiar co-workers. More generally, women appear to be more sensitive to distraction at the work office relative to distraction at home.

**Table 11.7 Distraction Level at Home (split of days) ATEs**

| Gendered Lifecycle | WPL | No | Low | High | Overall % Shift – No to High |
|---|---|---|---|---|---|
| **Men with partner** | Home | 10.6 | 10.0 | 8.9 | **-15.8%** |
| | Work Office | 10.7 | 11.3 | 12.3 | **14.4%** |
| | Third WPL | 0.7 | 0.7 | 0.8 | **19.5%** |
| **Women with young child with partner** | Home | 12.4 | 11.8 | 10.7 | **-13.5%** |
| | Work Office | 8.2 | 8.7 | 9.5 | **16.6%** |
| | Third WPL | 1.5 | 1.6 | 1.8 | **21.4%** |
| **Women with young child without partner** | Home | 20.2 | 20.0 | 19.6 | **-3.2%** |
| | Work Office | 1.6 | 1.8 | 2.2 | **36.5%** |
| | Third WPL | 0.2 | 0.2 | 0.2 | **40.7%** |

**Table 11.8 Distraction Level at Work Office (split of days) ATEs**

| Gendered Lifecycle | WPL | No | Low | High | Overall % Shift – No to High |
|---|---|---|---|---|---|
| **Men with partner** | Home | 9.5 | 10.7 | 10.7 | **13.3%** |
| | Work Office | 11.8 | 10.4 | 10.4 | **-11.6%** |
| | Third WPL | 0.7 | 0.8 | 0.8 | **16.0%** |
| **Women with young child with partner** | Home | 10.9 | 12.3 | 12.3 | **12.9%** |
| | Work Office | 9.6 | 8.0 | 8.0 | **-17.1%** |
| | Third WPL | 1.5 | 1.7 | 1.7 | **16.1%** |
| **Women with young child without partner** | Home | 19.7 | 20.2 | 20.2 | **3.0%** |
| | Work Office | 2.1 | 1.5 | 1.5 | **-27.9%** |
| | Third WPL | 0.2 | 0.2 | 0.2 | **4.9%** |

**Table 11.9 Distraction Level at Third WPL (split of days) ATEs**

| Gendered Lifecycle | WPL | No | Low | High | Overall % Shift – No to High |
|---|---|---|---|---|---|
| **Men with partner** | Home | 9.7 | 9.9 | 9.9 | **2.5%** |
| | Work Office | 11.3 | 11.5 | 11.6 | **2.2%** |
| | Third WPL | 1.0 | 0.6 | 0.5 | **-50.8%** |
| **Women with young child with partner** | Home | 11.3 | 11.8 | 11.9 | **5.1%** |
| | Work Office | 8.6 | 9.0 | 9.0 | **5.0%** |
| | Third WPL | 2.1 | 1.2 | 1.1 | **-48.5%** |
| **Women with young child without partner** | Home | 19.9 | 20.0 | 20.0 | **0.6%** |
| | Work Office | 1.8 | 1.9 | 1.9 | **0.9%** |
| | Third WPL | 0.3 | 0.2 | 0.1 | **-52.3%** |

It is admittedly challenging to compare the magnitude effects of commute times and distraction levels, as these variables are fundamentally different in nature (commute time is on a cardinal quantitative scale, while distraction level is on an ordinal qualitative scale). But, given the assumed change from the low extreme to the high extreme for each, we may make some general observations. For each of the three gendered lifecycle groups and for each of the work office and third WPL alternatives, the commute time effect is lower than the distraction level effect. This result suggests that the environmental attribute of distraction level at WPL is more important than the geographic attribute of commute time to the WPL. This is especially so for men and for the third WPL. The implication is that, to promote the work office WPL, corporate institutions may want to invest on reducing distraction in the environment of the work office (such as utilizing staggered work hour policies and/or dedicated cubicle set ups with some noise-proofing) at least as much (if not much more) than the location of their facility buildings.

### 11.7.3. How should employers prepare for and design hybrid workplace structures?

For most employers, the question of how to retain employees has arisen amidst this period of the ‘Great Resignation’ or the ‘Big Quit’. Therefore, there is a pressing need among employers to rethink their WPL-related policies so they are more congruent with the desires of their employees. The column labeled “Only Gendered Lifecycle Treatment (days)” in Table 11.2 displays the average split across the three alternatives based on only gendered lifecycle; with the exception of women with a young child and without a partner, all gendered lifecycles display an almost even split of days between working from home and from the work office (with an average of 9.0 days and 8.4 respectively). In fact, it is quite evident that the hybrid work structure is preferred for all gendered lifecycle categories, regardless of the sociodemographic, geographic- and location-based attributes of the three workplaces. Even in terms of job occupations (bottom row panel of Table 11.10), there is a clear desire for hybrid work arrangements, even

if there are variations across the occupations. Those in the essential services (health case/retail sales/education) recognize the importance of their in-person presence for societal functioning, reporting the highest split for work from the work office, while those in the information/finance, professional/managerial/technical, and public administration occupations express the highest preference for working remote.

**Table 11.10 Occupation (split of days) ATEs**

| Gendered Lifecycle | WPL | Healthcare | Retail Sales/ Food Services | Education | Public Administration | Information/ Finance | Professional/ Managerial/ Technical job |
|---|---|---|---|---|---|---|---|
| **Men with partner** | Home | 7.3 | 7.2 | 8.3 | 12.3 | 14.6 | 10.2 |
| | Work Office | 14.1 | 14.2 | 13.2 | 8.6 | 6.4 | 10.9 |
| | Third WPL | 0.6 | 0.6 | 0.6 | 1.1 | 1.0 | 0.9 |
| **Women with young child with partner** | Home | 9.3 | 9.2 | 10.3 | 13.6 | 15.7 | 12.0 |
| | Work Office | 11.3 | 11.4 | 10.4 | 6.2 | 4.4 | 8.2 |
| | Third WPL | 1.4 | 1.4 | 1.3 | 2.2 | 1.9 | 1.9 |
| **Women with young child without partner** | Home | 19.0 | 19.0 | 19.5 | 20.8 | 21.2 | 20.2 |
| | Work Office | 2.8 | 2.8 | 2.3 | 1.0 | 0.6 | 1.5 |
| | Third WPL | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Our results on WPL allocation patterns provide a valuable glimpse into employee WPL preferences into the future, which employers can use for future company planning, recruitment policies, as well as possible investment strategy in both office spaces and office resources. Our results also recommend that employers not view future WPL arrangements as a "this or that" (only from work office or only remote) proposition. Indeed, arguments regarding in-person work office culture vs. remote work culture often tread on the extreme cases; for example, individuals promoting in-person work culture often argue about the benefits of professional interactions, unplanned communications, and "team mentality" development within co-workers to improve productivity. On the other hand, individuals who favor the remote work option often invoke considerations of increased flexibility, commute time savings, and social-environmental benefits. A hybrid work structure, on the other hand, helps harness the best of both worlds. Employers and corporate institutions have little choice than to take a more open-minded stance toward a hybrid arrangement, so as to avoid any dissonance with workers.

### 11.7.4. What are the implications for travel demand?

The sociodemographic ATEs and the job-related ATEs reveal that there are variations in work hybridization preferences by sociodemographics. At the same time, the results point to the fact that work hybridization will be the norm as the job market adjusts to employee WPL preferences. Thus, it is imperative that work hybridization, and the variations in such patterns, be accounted for in travel demand modeling.

To be sure, there is a long history of literature focusing on work-related effects on broader activity-travel patterns of individuals. For example, many activity-based travel models use the work activity as a peg around which to "build" the remaining elements that make up the overall activity-travel pattern of an individual (for example, see Cambridge Systematics (2021)) But these studies focus on a single day of analysis, and so consider teleworking only in the context of a binary "switch" of whether or not an individual travels to the work office on a given day. However, it is critical today to consider hybrid work arrangements over longer periods of time, and its consequent impacts on activity-travel patterns. This, of course, raises a series of questions on how to "consummate" a longer term (such as a month-based) WPL split model with models that use a typical weekday as the unit of analysis. One simple approach would be to include the monthly WPL pattern (in the form of fractional splits of different WPLs) as an explanatory variable in the weekday-based modeling timeframe of current models. But this would not consider the intra-individual variations in activity-travel patterns across days. An alternative modeling approach would be to fundamentally change to a multi-day unit of analysis in travel demand modeling. For example, a recent effort by Haddad et al. (2022)) uses the WPL monthly split as an exogenous variable to study evening dining frequency over the period of a month. These and related considerations offer intriguing new challenges, as the profession works toward adapting travel demand models to a new era of work arrangements.

In summary, the important effects of hybrid work arrangements not only on peak traffic congestion, but also on land-use patterns and the broader activity-travel patterns of individuals, are critical to consider in travel demand modeling. In this regard, the estimated remote and non-remote monthly temporal split of different sociodemographic groups can serve as an input to several modules of land-use and travel demand models.

## 11.8. Conclusions

In this paper, we have examined WPL preferences of workers in an unpredictable and evolving post-COVID future by investigating how workers would prefer to allocate their monthly working days among the three WPL alternatives of working from home, from the work office, and from a variable third WPL. The novelty of our approach is that, for the first time to our knowledge, we recognize that the three work location arrangements may not be perfect substitutes of each other, but satisfy different functional, social, productivity, emotional, privacy, visibility, networking, financial and other personal/professional objectives to varying extents.

The results from our model indicate that single young women with very young children, those with long commutes and "intolerable" traffic congestion to the work office, individuals with a private study in their homes, self-employed workers, and those in non-essential service occupations have the highest preference for working from home. On the other hand, older men, individuals from low income households, those residing in rural areas, and workers in essential service occupations have the highest preference for the work office. And, for the third WPL, young non-single women with very young children, individuals from low income households, part-time employees, and those in professional, managerial or finance occupations have the highest predisposition.

Our results also point to the immediate work environment being at least as important (if not more important) than geographic WPL location attributes such as commute time, with the recommendation that corporate institutions invest more on ways to reduce distraction in the environment of the work office if they plan to encourage employees to work from the office too at times for organizational productivity. From a data collection standpoint, our study underscores the need to collect much more detailed information in activity-travel surveys about work patterns, including typical work hours on working days, variations in work hours across work days, weekly number of work hours, and the monthly number of work days (rather than a simple part-time versus full-time categorization based on number of work hours per week).

To conclude, as the effects of COVID-era on society continue to wane, it will be interesting to see how society adjusts to returning to various physical environments. Our study provides what we believe is a solid foundation in this direction in the specific context of WPL choices, though much more about our activity-travel patterns and our very ways of life remain to be explored, leaving open a challenging and exciting time for human behavioral research as we continue into an uncertain and unprecedented future.

# References


Appel-Meulenbroek, R., Kemperman, A., van de Water, A., Weijs-Perrée, M., and Verhaegh, J. (2022). How to attract employees back to the office? A stated choice study on hybrid working preferences. *Journal of Environmental Psychology*, 101784.

Bernheim, B. D., Bjorkegren, D., Naecker, J., and Pollmann, M. (2022). *Causal Inference from Hypothetical Evaluations* (No. w29616). National Bureau of Economic Research.

Bernheim, B.D., Bjorkegren, D., Naecker, J., and Pollmann, M. (2022). *Causal Inference from Hypothetical Evaluations* (No. w29616). National Bureau of Economic Research.

Bhat, C. R., & Castelar, S. (2002). A unified mixed logit framework for modeling revealed and stated preferences: formulation and application to congestion pricing analysis in the San Francisco Bay area. *Transportation Research Part B: Methodological, 36(*7), 593-616.

Bhat, C.R. (2008). The multiple discrete-continuous extreme value (MDCEV) model: role of utility function parameters, identification considerations, and model extensions. *Transportation Research Part B: Methodological*, *42*(3), 274-303.

Bruinen de Bruin, Y., Lequarre, A. S., McCourt, J., Clevestig, P., Pigazzani, F., Jeddi, M. Z., Colosio, C., & Goulart, M. (2020). Initial impacts of global risk mitigation measures taken during the combatting of the COVID-19 pandemic. Retrieved 10 22, 2020, from https://www.sciencedirect.com/science/article/pii/S0925753520301703#b0235

Cambridge Systematics (2021). New York Best Practice Model 2012: Base Year Model Validation Report. New York Metropolitan Transportation Council. Available at https://www.nymtc.org/LinkClick.aspx?fileticket=HxckPR9iDnA%3D&portalid=0. Accessed March 20, 2022.

Cambridge Systematics, Inc. PSRC 2006 Household Activity Survey Analysis Report. PSRC 2006 Household Activity Survey Analysis Report, 2007. Puget Sound Regional Council, Seattle, WA; WSDOT. Available at: https://www.psrc.org/our-work/household-travel-survey-program. Accessed March 25, 2020.

CDM Smith. Connecticut I-95 Corridor Congestion Relief Study, 2016. Connecticut Department of Transportation, National Highway Administration. Available at: https://www.dotdata.ct.gov/ct_congestion_site/documents/final/FULL%20PDF%20OF%20FINAL%20REPORT.pdf. Accessed March 25, 2020.

Del Boca, D., Oggero, N., Profeta, P., and Rossi, M. (2020). Women's and men's work, housework and childcare, before and during COVID-19. *Review of Economics of the Household*, *18*(4), 1001-1017.

Foroudi, P., Gupta, S., Sivarajah, U., and Broderick, A. (2018). Investigating the effects of smart technology on customer dynamics and customer experience. *Computers in Human Behavior*, *80*, 271-282.

Gebbels, M., Pantelidis, I.S., and Goss-Turner, S. (2019). Conceptualising patterns of career commitment: the leaving process in hospitality. *International Journal of Contemporary Hospitality Management*.

Gunden, N., Morosan, C., and DeFranco, A. (2020). Consumers' intentions to use online food delivery systems in the USA. *International Journal of Contemporary Hospitality Management*, *32*(3), 1325-1345.

Haddad, A., Mondal, A., Bhat, C.R. (2022). Understanding Individual's Non-Domestically Cooked Meal Preference. *Technical paper,* Department of Civil, Architectural and Environmental Engineering, The University of Texas at Austin.

Heckman, J.J., and Vytlacil, E.J. (2000). The relationship between treatment parameters within a latent variable framework. *Economics Letters* 66(1), 33-39.

Jain, T., Currie, G., and Aston, L. (2022). COVID and working from home: Long-term impacts and psycho-social determinants. *Transportation Research Part A: Policy and Practice*, *156*, 52-68.

Jin, X. and Shams, K. (2016) Examining the Value of Travel Time Reliability for Freight Transportation to Support Fright Planning and Decision-Making. Florida Department of Transportation.

Loomis, J. (2011). What's to Know About Hypothetical Bias in Stated Preference Valuation Studies? Journal of Economic Surveys 25, 363–370. https://doi.org/10.1111/j.1467-6419.2010.00675.x

López-Igual, P., & Rodríguez-Modroño, P. (2020). Who is teleworking and where from? exploring the main determinants of telework in Europe. *Sustainability, 12(*21), 8797. Retrieved 2 22, 2021, from https://www.mdpi.com/2071-1050/12/21/8797

Marikyan, D., Papagiannidis, S., and Alamanos, E. (2019). A systematic review of the smart home literature: A user perspective. *Technological Forecasting and Social Change*, *138*, 139-154.

Marikyan, D., Papagiannidis, S., and Alamanos, E. (2019). A systematic review of the smart home literature: A user perspective. *Technological Forecasting and Social Change*,*138*, 139-154

Morosan, C. and DeFranco, A. (2016). It's about time: revisiting UTAUT2 to examine consumers' intentions to use NFC mobile payments in hotels. *International Journal of Hospitality Management*, *53*, 17-29.

Nayak, S., and Pandit, D. (2021). Potential of telecommuting for different employees in the Indian context beyond COVID-19 lockdown. *Transport Policy*, *111*, 98-110.

OECD (2022). The impact of COVID-19 on employment and jobs. OECD. Retrieved January 6, 2022, from https://www.oecd.org/employment/covid-19.htm

Patrick, J. O. (2019). Why Won't My Manager Allow Me to Telework? Factors that Influence

RSG. Atlanta Regional: Managed Lane System Plan, 2007. Georgia Department of Transportation. Available at: http://www.dot.ga.gov/BuildSmart/Studies/ManagedLanesDocuments/Stated%20Preference%20Survey.pdf. Accessed March 22, 2020.

RSG. Denver-Boulder Stated Preference Survey Report - Appendix A, 2010. CODOT. Available at: https://www.codot.gov/content/projects/C470ExpressLanes/Level%20II%20Traffic%20and%20Revenue%20Data/Denver-Boulder_AppendixA_Questionnaire.docx. Accessed March 25, 2020.

RSG. Heartland in Motion Transit Study, 2013. Madison County Council of Governments, Madison, IN. Available at: http://irp.cdn-website.com/65a760a0/files/uploaded/HIM-CITS%20Report_28July2014.pdf. Accessed March 22, 2020.

RSG. I-5 Columbia River Crossing Stated Preference Travel Study Report, 2013. WSDOT. Available at: http://data.wsdot.wa.gov/accountability/ssb5806/Repository/4_Finance/Investment%20Grade%20Analysis/CRC%20Stated%20Preference%20Survey%20Draft%20Report%202013-11-01.pdf. Accessed March 25, 2020.

RSG. Puget Sound Regional Travel Study, 2014. Puget Sound Regional Council, Seattle, WA. Available at: http://www.psrc.org/media/6343. Accessed March 20, 2020.

RSG. Puget Sound Regional Travel Study, 2017. Puget Sound Regional Council, Seattle, WA. Available at: https://www.psrc.org/household-travel-survey-program. Accessed March 26, 2020.

RSG. SH 183 Stated Preference Travel Study, 2010. Wilbur Smith Associates. Available at: https://ftp.txdot.gov/pub/txdot-info/dal/sh183_managed/traffic_revenue/sp%20survey%20data/sh%20183%20stated%20preference%20report_1-28-10.pdf

RSG. Utah Travel Survey, 2013. Wasatch Front Regional Council; Cache Metropolitan Planning Organization; Dixie Metropolitan Planning Organization; Mountainland Association of Governments; Utah

Department of Transportation; Utah Transit Authority. Available at: https://wfrc.org/MapsData/UtahTravelStudy/UtahTravelStudy_FinalReport_130228.pdf. Accessed March 22, 2020.

Slotnick, D. (2020). *Some of the world's airlines could go bankrupt because of the COVID-19 crisis, according to an aviation consultancy. See the carriers that have already collapsed because of the pandemic.* Business Insider. Retrieved October 23, 2020, from https://www.businessinsider.com/coronavirus-airlines-that-failed-bankrupt-covid19-pandemic-2020-3

Smith, S.L. (1990). *Dictionary of concepts in recreation and leisure studies* (No. 9). Greenwood.

Texas Demographic Center (2022). 2020 Census. Available at: https://demographics.texas.gov/. Accessed March 12, 2022.

Cison (2020). *The Impact of COVID-19 on Multinational Companies MNCs - Long Term, Companies Will Need to Investigate Their Supply Chains to Improve Their Resilience to Shocks*. Retrieved October 23, 2020, from https://www.prnewswire.com/news-releases/the-impact-of-covid-19-on-multinational-companies-mncs---long-term-companies-will-need-to-investigate-their-supply-chains-to-improve-their-resilience-to-shocks-301026249.html

Texas A&M Transportation Institute (TTI) (2017) *Transportation Network Company (TNC) Legislation*. Texas A&M Transportation Institute website. Retrieved October 23, 2020, from https://policy.tti.tamu.edu/technology/tnc-legislation/#:~:text=Transportation%20Network%20Companies%20(TNCs)%20such,authorize%20and%20regulate%20TNC%20operations.

Toussaint, K. (2020). *Your e-commerce addiction means delivery emissions could increase 30% by 2030*. Fast Company. Retrieved October 23, 2020, from https://www.fastcompany.com/90451457/your-e-commerce-addiction-means-delivery-emissions-could-increase-30-by-2030

TRB. NCHRP Research Report 925: Estimating the Value of Truck Travel Time Reliability: Appendix A, 2019. Available at: https://www.nap.edu/read/25655/chapter/11. Accessed April 22, 2020.

Urbanism Next (2020) *Transportation Network Companies*. Urbanism Next website. Retrieved October 23, 2020, from https://www.urbanismnext.org/covid-19/transportation-network-companies

Wilbur Smith Associates. Dulles Toll Road Rate Adjustment Review, 2005. VDOT; Metropolitan Washington Council of Governments. Available at: http://www.virginiadot.org/projects/resources/Appendix.pdf. Accessed March 26, 2020.

Wu, Z., & McGoogan, J. M. (2020). Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China. Summary of a Report of 72 314 Cases from the Chinese Center for Disease Control and Prevention. Retrieved October 22, 2020, from https://jamanetwork.com/journals/jama/article-abstract/2762130.

Zhang, L., Cirillo, C., Xiong, C. Hetrakul, P., 2011. Feasibility and Benefit of Advanced Four-Step and Activity-Based Travel Demand Models for Maryland. Report MD-11-SP009B4S, Maryland State Highway Administration. Available at: https://roads.maryland.gov/OPR_Research/MD-11-SP009B4S_Advanced-Four-Step-and-Activity-Based-Travel-Demand-Models-Report.pdf. Accessed March 22, 2020.

# Appendix A: COVID-19 Transportation-related SP Surveys Reviewed

## Survey 1

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **Investigating the impacts of COVID-19 pandemic on travel behaviors** | Chicago Area | University of Illinois at Chicago (Mohammadian) | 915 | April 25, 2020 - June 2, 2020 | Online with Qualtrics | Contingent Behavior | NA |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q113 | Only show if respondent is a student | Assume that COVID-19 is no longer a threat: How frequently do you prefer to take online classes, if each class that you wish to take is available online and in-person (traditional approaches)? | COVID | School | COVID-19 is no longer a threat | 1 | 5 | I prefer to take online classes, even more often than now; I prefer to take online classes as frequent as now; I prefer to take online classes less frequent than now, yet more frequent than the normal conditions before the COVID-19 outbreak; I prefer to take online classes as frequent as the normal conditions before the COVID-19 outbreak; I prefer to take online classes less frequent than the normal conditions before the COVID-19 outbreak | NA | NA | |
| Q108 | Show if respondent has worked from home AND if the respondent falls into one of the following categories: working full-time, working part-time, working as a self-employed | Assume that COVID-19 is no longer a threat: How do you prefer to continue working from home, if you have the option to do so? | COVID | Teleworking | COVID-19 is no longer a threat | 1 | 5 | I prefer to work from home, even more often than now; I prefer to work from home as frequent as now; I prefer to work from home less frequent than now, yet more frequent than the normal conditions before the COVID-19 outbreak; I prefer to work from home as frequent as the normal conditions before the COVID-19 outbreak; I prefer to work from home less frequent than the normal conditions before the COVID-19 outbreak | NA | NA | |
| Q95 | None | How much do you expect your airplane travel for leisure/personal purposes to change once COVID-19 is no longer a threat? | COVID | Air Travel, Long Distance Travel | COVID-19 is no longer a threat | 1 | 5 | Significantly less than the conditions before COVID-19 outbreak; Somewhat less than the conditions before COVID-19 outbreak; Around the same as the conditions before COVID-19 outbreak; Somewhat more than the conditions before COVID-19 outbreak; Significantly more than the conditions before COVID-19 outbreak | NA | NA | This question was followed up with an RP question asking "why do you anticipate a change in your airplane travel?" |
| Q96 | None | How much do you expect your airplane travel for business purposes to change once COVID-19 is no longer a threat? | COVID | Air Travel, Long Distance Travel | COVID-19 is no longer a threat | 1 | 5 | Significantly less than the conditions before COVID-19 outbreak; Somewhat less than the conditions before COVID-19 outbreak; Around the same as the conditions before COVID-19 outbreak; Somewhat more than the conditions before COVID-19 outbreak; Significantly more than the conditions before COVID-19 outbreak | NA | NA | This question was followed up with an RP question asking "why do you anticipate a change in your airplane travel?" |
| Q53 | Only show if respondent answered YES to having used any online grocery shopping services (e.g., Amazon Fresh, Instacart, and Walmart) | How likely are you to more frequently shop for groceries online during the first few months after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | COVID | E-commerce | First few months after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | 1 | 7 | Highly likely; Likely; Somewhat Likely; Neutral; Somewhat unlikely; Unlikely; Highly Unlikely | NA | NA | |
| Q54 | Only show if respondent answered YES to having used any online grocery shopping services (e.g., Amazon Fresh, Instacart, and Walmart) | How likely are you to more frequently shop for groceries online in the future far after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | COVID | E-commerce | Far after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | 1 | 7 | Highly likely; Likely; Somewhat Likely; Neutral; Somewhat unlikely; Unlikely; Highly Unlikely | NA | NA | |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q64 | Only show if respondent answered YES to having ever ordered food online (e.g. restaurant delivery, Uber Eats, Grubhub) and had it delivered | Will you order food online more frequently in the first few months after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | COVID | E-commerce | First few months after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | 1 | 7 | Highly likely; Likely; Somewhat Likely; Neutral; Somewhat unlikely; Unlikely; Highly Unlikely | NA | NA | |
| Q65 | Only show if respondent answered YES to having ever ordered food online (e.g. restaurant delivery, Uber Eats, Grubhub) and had it delivered | Will you order food online more frequently in the future far after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | COVID | E-commerce | Far after the COVID-19 outbreak, as compared to before the outbreak (normal conditions)? | 1 | 7 | Highly likely; Likely; Somewhat Likely; Neutral; Somewhat unlikely; Unlikely; Highly Unlikely | NA | NA | |
| Q83 | None | Once the effect of the COVID-19 pandemic is over (after federal/local authority advisory), which mode will you choose most frequently for the following activities? The activities include: work/school, routine shopping, in-town recreation activities, out-of-town recreation activities, eat out, civic or religious, doctor office visits, visit family and friends. | COVID | Public Transit/Mode Choice; TNCs | Once the effect of the pandemic COVID-19 is over (after federal/local authority advisory) | 8 (there were 8 different scenarios, where the respondent was asked to choose mode they would choose to travel there (or the varying alternative)) | Unknown | Personal vehicle, ….. , Have not conducted this activity | NA | NA | |

## Survey 2

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **Impacts of COVID-19 Pandemic on Mobility, Telecommuting and E-shopping Patterns in the United States** | The United States | UC Davis (Circella) | 10,958 | May-20 | Online with Qualtrics | Contingent Behavior | NA |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Section C Q13 | Display d, h, i, j to all. Display a, b, c, e if respondent's employment status is one (or more) of the following: full-time, part-time, has two or more jobs, am furloughed with pay from their previous job, am furloughed without pay from their previous job, was let go from their job during the COVID-19 pandemic, was working fewer hours during the COVID-19 pandemic, was working more hours during the COVID-19 pandemic. Display e, f, g if the respondent is a part-time student or is taking some online courses for professional development or personal interest, but is not a student pursuing a degree. | Please think of your life a few months from now, in October 2020: how often do you expect to do the following activities compared to now? By October 2020, I expect to do this… a. Work at a regular workplace(s), b. Telecommute and/or work from home, c. Make long-distance trips for work/business purposes, d. Make long-distance trips for leisure/personal purposes, e. Attend business-related online meetings, f. Study at regular school/campus location, g. Study from home (e.g. listen to lectures online), h. Exercise outdoors, i. Go to the gym or any indoor sport facility | COVID | Teleworking (a, b, e), Long Distance Travel (c, d), School (f, g), Misc. (h, i) | The recent COVID-19 pandemic has heavily impacted the way people work, organize their household activities, socialize and travel; Please think of your life in a few months from now, in October 2020. | 9 (there were 9 different scenarios, where the respondents was asked their likelihood (or the varying alternative) to do each activity) | 5 | Much less often, Somewhat less often; About the same; Somewhat more often; Much more often | NA | NA | |
| Section E Q7 | None | Please think of your life a few months from now, in October 2020: how often do you expect to do the following activities compared to now? By October 2020, I expect to do this… a. Visit grocery stores, b. Order grocery items online, c. Eat out at restaurants/bars, d. Pick up food from restaurants/bars, e. Have food delivered from restaurants/bars, f. Have someone else shop for me | COVID | E-commerce | The recent COVID-19 pandemic has heavily impacted the way people work, organize their household activities, socialize and travel; Please think of your life in a few months from now, in October 2020. | 6 (there were 6 different scenarios, where the respondents was asked their likelihood (or the varying alternative) to do each activity ) | 5 | Much less often, Somewhat less often; About the same; Somewhat more often; Much more often | NA | NA | |
| Section H Q5 | None | Based on what you have experienced during the COVID-19 pandemic, what do you expect will happen to your household's vehicle ownership within the next six months? | COVID | Public Transit/Mode Choice | The recent COVID-19 pandemic has heavily impacted the way people work, organize their household activities, socialize and travel; Based on what you have experienced during the COIVD-19 pandemic. | 1 | 4 | Increase the number of vehicles; Decrease the number of vehicles, Keep the same total but replace one or more vehicles; No change - will not add, get rid of, or replace a vehicle | NA | NA | |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Section H Q7 | None | As the final transportation topic in this survey, we would like to ask what you expect to do a few months from now, in October 2020, regarding choosing your means of transportation. Please rate your level of agreement with each of the following statements: a. I will feel uncomfortable using public transportation due to concerns about pathogens (e.g. COVID-19 or other); b. I would be OK renting out my car to strangers; c. I will use ride hailing services (e.g. UberX or Lyft) as often as I did before the pandemic; d. If I felt protected from car traffic, I would ride a bicycle more often; e. I will feel uncomfortable using ride hailing services (e.g. UberX, Lyft) due to concerns about pathogens (e.g. COVID-19 or other); f. I will feel comfortable using ride hailing if equipped with disinfectant sprays to sanitize the vehicle after each ride; g. I will feel uncomfortable sharing a ride with strangers (e.g. on UberPOOL, Lyft Share) due to concerns about pathogens (e.g. COVID-19 or other); h. I will be comfortable using public transportation only if wearing a mask is mandatory; i. I will feel comfortable using ride hailing if the vehicles provide disposable surgical gloves and mask; j. The real-time knowledge of the on-board crowdedness (e.g. with a smartphone app) would encourage me to use public transportation; k. I will use bikes haring (e.g. JUMP) as a useful travel option for me to increase social distancing; l. I will feel comfortable sharing a ride with strangers (e.g. on UberPOOL, Lyft Share) only if "self-distancing" car design including physical dividers between seats becomes available; m. I am against giving more space to pedestrians and cyclists on the road network if it implies less space for cars; n. I will travel more by car because it makes me feel safer from the transmission of pathogens (e.g. COVID-19 or other); o. I will feel uncomfortable putting my hands on the handlebar of a shared e-bike, e-scooter, e-moped recently used by someone else; p. I am more in favor of autonomous driving technology now than before the COVID-19 pandemic; q. Providing disposable gloves every time one uses a shared bike or e-scooter should become standard practice. | COVID | Public Transit/Mode Choice; TNCs | The recent COVID-19 pandemic has heavily impacted the way people work, organize their household activities, socialize and travel. | 17 (there were 17 different scenarios, where the respondents was asked their level of agreement (or the varying alternative) to each statement) | 5 | Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree | NA | NA | |

## Survey 3

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **COVID-19 Transport Choices (MWC owner)** | The United States | Arizona State University (Salon) | 1,213 | Apr-20 | Online with Qualtrics | Contingent Behavior | NA |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| wfh_expect | Display if before the COVID-19 pandemic the respondent was employed or if they are working now | After COVID-19 is no longer a threat, do you expect to be able to work from home, at least some of the time? | COVID | Teleworking | After COVID-19 is no longer a threat | 1 | 2 | Yes; No | NA | NA | |
| wfh_freq_exp | Display if before the COVID-19 pandemic the respondent was employed or if they are working now and if they answered YES to expecting to still be able to work from home after the COVID-19 pandemic | After COVID-19 is no longer a threat, how often might you work from home? | COVID | Teleworking | After COVID-19 is no longer a threat | 1 | 5 | Never; A few times/year; A few times/month; A few times/week; Every day | NA | NA | |
| bzvm_exp | Display if before the COVID-19 pandemic the respondent was employed or if they are working now | After COVID-19 is no longer a threat, how often might you conduct online meetings for work purposes? | COVID | Teleworking | After COVID-19 is no longer a threat | 1 | 5 | Never; A few times/year; A few times/month; A few times/week; Every day | NA | NA | |
| ocla_exp | Display if the respondent is a student | After COVID-19 is no longer a threat, how frequently would you like to take online classes, relative to your experience before COVID-19? Assume that classes you wish to take are available both online and in-person. | COVID | School | After COVID-19 is no longer a threat | 1 | 3 | I would like to take fewer online classes than I took before COVID-19; I would like to take about the same number of online classes that I took before COVID-19; I would like to take more online classes than I took before COVID-19 | NA | NA | |
| shdi_exp | None | After COVID-19 is no longer a threat, how might your participation in the activities below change relative to what you did before COVID-19? These activates include: shop for groceries in a store; order groceries for pick up; order groceries for delivery; eat a meal in a restaurant; order food for pick up at a restaurant; order food for delivery from a restaurant; order other items online for delivery. | COVID | E-commerce | After COVID-19 is no longer a threat | 7 (there were 7 different scenarios, where the respondents was asked their likelihood (or the varying alternative) to change participation in an activity) | 5 | Much less than before; Somewhat less than before; About the same; Somewhat more than before; Substantially more than before | NA | NA | |
| soci_exp | None | After COVID-19 is no longer a threat, how often do you expect to use the following virtual interaction technologies relative to before the COVID-19 pandemic? The technologies include: Social media (Facebook, Twitter, Snapchat, Instagram, etc.); Text messaging/WhatsApp; Video calling (Skype, FaceTime, Zoom, etc.); Multiplayer online gaming; Chat software (Slack, IRC, etc.) | COVID | Misc. | After COVID-19 is no longer a threat | 6 (there were 7 different scenarios, where the respondents was asked their likelihood (or the varying alternative) to change use of each technology) | 5 | Much less; Somewhat less; About the same; Somewhat more; Much more | NA | NA | |
| tr_freq_exp | None | After COVID-19 is no longer a threat, how do you expect your use of the following means of transportation to change, relative to before the COVID-19 pandemic (not including walks or bike rides around your neighborhood for exercise, fresh air, dog walking, etc.)? These means include: drive alone; carpool; ride hail/Taxi; transit; bicycle; walking. | COVID | Public Transit/Mode Choice | After COVID-19 is no longer a threat | 6 (there were 6 different scenarios, where the respondents was asked their likelihood (or the varying alternative) to change usage of each means of transportation) | 5 | Much less than before; Somewhat less than before; About the same; Somewhat more than before; Substantially more than before | NA | NA | |
| ld_per_change | None | How much do you expect your airplane travel for leisure/personal purposes to change once COVID-19 is no longer a threat, compared to your level of travel before the COVID-19 pandemic? | COVID | Air Travel, Long Distance Travel | After COVID-19 is no longer a threat | 1 | 5 | Much less; Somewhat less; About the same; Somewhat more; Much more | NA | NA | This question was followed up with an RP question asking "Why do you anticipate a change in your long-distance travel for leisure/personal purposes after COVID-19 is no longer a threat?" |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ld_bz_change | Display if before the COVID-19 pandemic the respondent was employed or if they are working now | How much do you expect your airplane travel for business purposes to change once COVID-19 is no longer a threat, compared to your level of travel before the COVID-19 pandemic? | COVID | Air Travel, Long Distance Travel | After COVID-19 is no longer a threat | 1 | 5 | Much less; Somewhat less; About the same; Somewhat more; Much more | NA | NA | This question was followed up with an RP question asking "Why do you anticipate a change in your long-distance travel for leisure/personal purposes after COVID-19 is no longer a threat?" |

## Survey 4

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **COVID-19 impact on residential location choice in the Greater Toronto Area** | Toronto, Ontario | University of Toronto (Habib; Shakib) | 886 | | Online with Qualtrics | Contingent Behavior | NA |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q53 | None | Once COVID-19 is no longer considered a threat, compared to your shopping behavior before the COVID-19 pandemic, how do you expect your shopping frequency to change (For both "Visiting a store in person and Using an online store): Electronic Products (computers, laptops, mobile phones and etc.); Groceries; Books, Music, Videos, Video-games and etc.; Health and Beauty Products; Home furniture, Tools, garden products and etc.; Clothing and footwear; Toys and kid/baby-related products. | COVID | E-commerce | Once COVID-19 is no longer considered a threat | 12 (there were 6 different scenarios, where the respondents was asked their likelihood (or the varying alternative) to change shopping frequency; then there were two different scenarios of where this shopping would take place (in person or online)) | 5 | Much less; Less; About the same; More; Much more | NA | NA | |
| Multiple | None | In this scenario, you have four different options to relocate your household residential location, please carefully review your options. Please choose your preferred option under the conditions of Scenario 1: COVID-19 is no longer considered a threat due to mass vaccination, and everything goes back to the normal status. | COVID | Misc. | An interactive map of the Toronto Region was provided, as well as the description of conditions in the provided scenario | 9 (out of 18 total) | 5 | Detached House; Semi-detached House; Condo/Apartment; Townhouse; Not to relocate (choose this one if you prefer your current dwelling over all available options) | 11 | Region; Tenure type; Price; Dwelling area compared to current dwelling; Neighborhood quality; Parking availability; Access to public transit; Access to the highway network; Walk access to schools; Office hours flexibility; Telecommuting option | This question was followed by the RP question: "How confident are you in your choices?" |
| Multiple | None | In this scenario, you have four different options to relocate your household residential location, please carefully review your options. Please choose your preferred option under the conditions of Scenario 2: The world's health care system fails to find a vaccine for COVID-19 which means we cannot go back to the normal status. We adapt to a new normal where our interactions are based on social distancing. | COVID | Misc. | An interactive map of the Toronto Region was provided, as well as the description of conditions in the provided scenario | 9 (out of 18 total) | 5 | Detached House; Semi-detached House; Condo/Apartment; Townhouse; Not to relocate (choose this one if you prefer your current dwelling over all available options) | 11 | Region; Tenure type; Price; Dwelling area compared to current dwelling; Neighborhood quality; Parking availability; Access to public transit; Access to the highway network; Walk access to schools; Office hours flexibility; Telecommuting option | This question was followed by the RP question: "How confident are you in your choices?" |
| Multiple | None | In this scenario, you have four different options to relocate your household residential location, please carefully review your options. Please choose your preferred option under the conditions of Scenario 3: COVID-19's second wave or another pandemic hits our community, and we should go back to the strict lockdown phase once again. | COVID | Misc. | An interactive map of the Toronto Region was provided, as well as the description of conditions in the provided scenario | 9 (out of 18 total) | 5 | Detached House; Semi-detached House; Condo/Apartment; Townhouse; Not to relocate (choose this one if you prefer your current dwelling over all available options) | 11 | Region; Tenure type; Price; Dwelling area compared to current dwelling; Neighborhood quality; Parking availability; Access to public transit; Access to the highway network; Walk access to schools; Office hours flexibility; Telecommuting option | This question was followed by the RP question: "How confident are you in your choices?" |

## Survey 5

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **Investigating impact of COVID-19 on transit demand in the GTA** | Toronto, Ontario | University of Toronto (Habib; Mashrur) | 905 | July 10, 2020 - July 24, 2020 | Online with Qualtrics | Choice Experiment | D-Efficient Experiment Design |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple | Some alternatives were not revealed to a respondent, depending on if they had access to a private vehicle or not | In the next section, we will present six (6) hypothetical scenarios to you. In each scenario, please imagine yourself in completing either a commuting trip (i.e. trip to work/school) or a non-commuting trip (i.e. trips to grocery store, restaurant, doctor's office etc.) within the city. You will have a set of travel modes based on the trip distance, and have to choose the mode that you most likely to take. Please choose your most preferred option to complete the trip given the pandemic situation in the table. | COVID | Public Transit/Mode Choice; TNCs | In-depth descriptions of each of the alternatives and the varying attributes, as well as a note that Ontario is currently averaging 173 new cases of the COVID-19 daily for the past 14 days and about public safety measures. | 6 (out of 24 total) | 6 | Taxi/Ride-hailing (i.e. Uber, Lyft); Carpool (i.e. shared ride with non-household member(s)); Local transit (i.e. Miway, TTC) with walk access; Local transit with transfer (i.e. from Bus/streetcar to Subway); Cycle; Walk | 15 | Trip purpose; Distance from current location; Daily new cases for the past 14 days in Ontario; Vaccine availability; In-vehicle travel time; Total waiting time; Total walking time; Travel cost; Parking cost; Mandatory face covering (Y/N); Installation of hand-sanitizer (Y/N); Temperature scan prior to boarding (Y/N); Boarding and alighting at different doors (Y/N); Contactless payment (Y/N); Enforcing strict passenger limits on vehicles (Y/N). | This question was followed by the RP question: "How confident are you in your choices?" |
| Multiple | Some alternatives were not revealed to a respondent, depending on if they had access to a private vehicle or not | In the next section, we will present six (6) hypothetical scenarios to you. In each scenario, please imagine yourself in completing either a commuting trip (i.e. trip to work/school) or a non-commuting trip (i.e. trips to grocery store, restaurant, doctor's office etc.) from one regional municipality to another. You will have a set of travel modes depending on the location of GO station from your origin, and have to choose the mode that you most likely to take. | COVID | Public Transit/Mode Choice; TNCs | In-depth descriptions of each of the alternatives and the varying attributes, as well as a note that Ontario is currently averaging 173 new cases of the COVID-19 daily for the past 14 days and about public safety measures. | 6 (out of 24 total) | 6 | Taxi/Ride-hailing (i.e. Uber, Lyft); Carpool (i.e. shared ride with non-household member(s)); Local transit (i.e. Miway, TTC) with walk access; Local transit with transfer (i.e. from Bus/streetcar to Subway); Cycle; Walk | 15 | Trip purpose; Distance from current location; Daily new cases for the past 14 days in Ontario; Vaccine availability; In-vehicle travel time; Total waiting time; Total walking time; Travel cost; Parking cost; Mandatory face covering (Y/N); Installation of hand-sanitizer (Y/N); Temperature scan prior to boarding (Y/N); Boarding and alighting at different doors (Y/N); Contactless payment (Y/N); Enforcing strict passenger limits on vehicles (Y/N). | This question was followed by the RP question: "How confident are you in your choices?" |

## Survey 6: Contingent Behavior

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **SiSTM COVID-19 Survey** | Toronto, Ontario | University of Toronto (Habib; Loa) | 1,001 | Jul-20 | Online with Qualtrics | Contingent Behavior | NA |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q54 | None | Please indicate the impact that the development of a vaccine or effective method of treating COVID-19 would have on your willingness to use ridesourcing services. | COVID | TNCs | | 1 | 3 | I would be more willing to use ridesourcing services than I was before the CVOID-19 pandemic; I would be as willing to use ridesourcing services than I was before the CVOID-19 pandemic; I would be less willing to use ridesourcing services than I was before the CVOID-19 pandemic | NA | NA | |
| Q55 | Show if the respondent has used either exclusive or shared ridesourcing services in the past | Will you continue to use exclusive ridesourcing services after the COVID-19 pandemic? | COVID | TNCs | | 1 | 2 | Yes; No | NA | NA | |
| Q56 | Show if the respondent has used exclusive ridesourcing services in the past | Will you change the frequency with which you use exclusive ridesourcing services after the COVID-19 pandemic? | COVID | TNCs | | 1 | 3 | I will use exclusive ridesourcing more frequently than I did before the pandemic; I will use exclusive ridesourcing as frequently as I did before the pandemic; I will use exclusive ridesourcing less frequently than I did before the pandemic | NA | NA | |
| Q57 | Show if the respondent will do less exclusive ridesourcing after the pandemic than they were doing before the pandemic | If you will make fewer trips using exclusive ridesourcing services than you did before the COVID-19 pandemic, what mode(s) will you use to make these trips instead? (Select all that apply) * | COVID | TNCs | | 1 | 7 | I will drive myself; I will be driven by someone that I know; I will use public transit; I will use taxis; I will ride a bicycle; I will walk; I will not make some or all of these trips | NA | NA | |
| Q58 | Show if the respondent has used either exclusive or shared ridesourcing services in the past | Will you continue to use shared ridesourcing services after the COVID-19 pandemic? | COVID | TNCs | | 1 | 2 | Yes; No | NA | NA | |
| Q59 | Show if the respondent has used shared ridesourcing services in the past | Will you change the frequency with which you use shared ridesourcing services after the COVID-19 pandemic? | COVID | TNCs | | 1 | 3 | I will use shared ridesourcing more frequently than I did before the pandemic; I will use shared ridesourcing as frequently as I did before the pandemic; I will use shared ridesourcing less frequently than I did before the pandemic | NA | NA | |
| Q60 | Show if the respondent will do less shared ridesourcing after the pandemic than they were doing before the pandemic | If you will make fewer trips using shared ridesourcing services than you did before the COVID-19 pandemic, what mode(s) will you use to make these trips instead? (Select all that apply) * | COVID | Public Transit/Mode Choice; TNCs | | 1 | 7 | I will drive myself; I will be driven by someone that I know; I will use public transit; I will use taxis; I will ride a bicycle; I will walk; I will not make some or all of these trips | NA | NA | |
| Q67 | None | Once COVID-19 is no longer considered a public health threat, what mode(s) of transportation would you use for your commuting trips (i.e. trips to work or school)? | COVID | Public Transit/Mode Choice; TNCs | | 1 | 9 | I would drive myself; I would be driven by someone that I know; I would take public transit; I would use an exclusive ridesourcing services; I would use a shared ridesourcing service; I would take a taxi; I would ride a bicycle; I would walk; I would not make commuting trips | NA | NA | |
| Q68 | None | Once COVID-19 is no longer considered a public health threat, what mode(s) of transportation would you use for your non-commuting trips? | COVID | Public Transit/Mode Choice; TNCs | | 1 | 9 | I would drive myself; I would be driven by someone that I know; I would take public transit; I would use an exclusive ridesourcing services; I would use a shared ridesourcing service; I would take a taxi; I would ride a bicycle; I would walk; I would not make non-commuting trips | NA | NA | |

## Survey 6: Choice Experiment

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **SiSTM COVID-19 Survey** | Toronto, Ontario | University of Toronto (Habib; Loa) | 1,001 | Jul-20 | Online with Qualtrics | Choice Experiment | D-Efficient Experiment Design |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple | None | Based on the options above, please choose the mode of transport that you would prefer to use for a *non-commuting trip while COVID-19 is still considered a public health threa*t. A non-commuting trip is defined as a trip made to a place other than work or school. | COVID | Public Transit/Mode Choice; TNCs | | 3 | 8 | Drive yourself; Driven by someone you know; Public transit; Exclusive ridesourcing services; Shared ridesourcing service; Taxi; Bicycle; Walk | 2 | Travel time; Trip Distance | This question was followed by the RP question: "How confident are you in your choice?" |
| Multiple | None | Based on the options above, please choose the mode of transport that you would prefer to use for your typical *commuting trip when COVID-19 is no longer considered a public health threat*. A commuting trip is defined as a trip made to work or school. | COVID | Public Transit/Mode Choice; TNCs | | 3 | 8 | Drive yourself; Driven by someone you know; Public transit; Exclusive ridesourcing services; Shared ridesourcing service; Taxi; Bicycle; Walk | 2 | Travel time; Trip Distance | This question was followed by the RP question: "How confident are you in your choice?" |
| Multiple | None | Based on the options above, please choose the mode of transport that you would prefer to use for your typical *non-commuting trip when COVID-19 is no longer considered a public health threat*. A non-commuting trip is defined as a trip made to a place other than work or school. | COVID | Public Transit/Mode Choice; TNCs | | 3 | 8 | Drive yourself; Driven by someone you know; Public transit; Exclusive ridesourcing services; Shared ridesourcing service; Taxi; Bicycle; Walk | 2 | Travel time; Trip Distance | This question was followed by the RP question: "How confident are you in your choice?" |

## Survey 7: Contingent Behavior

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **COVID-19 impact on workplace choice and shopping method** | Toronto, Ontario | University of Toronto (Habib; Dianat) | 918 | July 12, 2020 - July 24, 2020 | Online with Qualtrics | Contingent Behavior | NA |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q59 | None | After conditions return to normal, how often will you choose each of the following alternatives for buying groceries? The alternatives include: Order-at-home + home delivery; Order-at-home + in-person pickup; In-store, small supermarket (e.g. No frills, Food basics, Metro); In-store, large supermarket (e.g. Costco). | COVID | E-commerce | After conditions return to normal | 4 (There were 4 different scenarios, where the respondent is asked to choose the frequency (or the alternative) of buy groceries in the scenario-specific way) | 6 | More than once a day; Once a day; 2-4 times per week; Once a week; Once every two weeks; Once a month; Less than once a month; Never | NA | NA | |
| Q60 | None | After conditions return to normal, how often will you choose each of the following alternatives for buying non-grocery goods (e.g., clothing, electronics, etc.)? The alternatives include: Order-at-home + home delivery; Order-at-home + in-person pickup; In-store, local stores; In-store, shopping centers. | COVID | E-commerce | After conditions return to normal | 4 (There were 4 different scenarios, where the respondent is asked to choose the frequency (or the alternative) of buy on-grocery goods in the scenario-specific way) | 6 | More than once a day; Once a day; 2-4 times per week; Once a week; Once every two weeks; Once a month; Less than once a month; Never | NA | NA | |
| Q61 | None | After conditions return to normal, how often will you choose each of the following alternatives for eating meals? The alternatives include: Cooking meal at home; Order-at-home + home delivery; Order-at-home + in-person pickup; Going to a restaurant. | COVID | E-commerce | After conditions return to normal | 4 (There were 4 different scenarios, where the respondent is asked to choose the frequency (or the alternative) of eating meals in the scenario-specific way) | 6 | More than once a day; Once a day; 2-4 times per week; Once a week; Once every two weeks; Once a month; Less than once a month; Never | NA | NA | |
| Q62 | None | After conditions return to normal, how often will you visit family and/or friends? The alternatives include: Gathering in your/their home; Meeting online; By phone call; Meeting at restaurants, bars, coffee shops, etc. | COVID | Misc. | After conditions return to normal | 4 (There were 4 different scenarios, where the respondent is asked to choose the frequency (or the alternative) visiting others in the scenario-specific way) | 6 | More than once a day; Once a day; 2-4 times per week; Once a week; Once every two weeks; Once a month; Less than once a month; Never | NA | NA | |

## Survey 7: Choice Experiment

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **COVID-19 impact on workplace choice and shopping method** | Toronto, Ontario | University of Toronto (Habib; Dianat) | 918 | July 12, 2020 - July 24, 2020 | Online with Qualtrics | Choice Experiment | D-Efficient Experiment Design |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple | None | Let's begin with the workplace choice. Please take a minute to read the description of attributes, which are important factors you should take into consideration when making your decision. In each scenario for workplace choice, you will face 2 different alternatives, working from home and working at the workplace. Each alternative has its own attributes, which have different values across the scenarios. | COVID | Teleworking | In-depth descriptions of each of the attributes for both alternatives and the general attributes | 8 (total number of scenarios is unknown) | 3 | Work from home; Hybrid workplace (2-3 days teleworking); Work at workplace | 8 | COVID risk level; Technologies at home; Furniture at home; Shifting work hour; Splitting work hour; One-way travel time from home to workplace; Level of crowding at workplace; Child caring. | This question was followed by the RP question: "How confident are you in your choice?" |
| Multiple | None | Let's continue with grocery shopping method choice. Please take a minute to read the description of attributes which are important factors you should take into consideration when making your decision. In each scenario for grocery shopping method choice, you will face 3 different alternatives: e-shopping, in-store, small supermarket and in-store, large supermarket. In-store alternatives share attributes, but their attributes are different from the e-shopping attributes. The attributes have different values across the scenarios. | COVID | E-commerce | In-depth descriptions of each of the attributes for both alternatives and the general attributes | 8 (total number of scenarios is unknown) | 3 | E-shopping; In-store, Small supermarket; In-store, Large supermarket | 7 | COVID risk level; Delivery time; Delivery fee; Saving purchase basket; One way travel time; Level of crowding; Waiting time in line to enter the store. | This question was followed by the RP question: "How confident are you in your choice?" |

## Survey 8

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **COVID-19 Survey #1** | Switzerland | ETH Zurich (Axhausen; Georges) | Unknown | Unknown | Online with Qualtrics | Choice Experiment | Unknown |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple | None | You will now receive four different decision-making situations, each with two alternatives, whereby you have to choose one. This is about how you perceive and weigh up your personal risk. In each of the following four decision-making situations, choose your preferred behavior. Please assume that you have a job that requires you to move to a certain place of work. Working from home ("home office") is possible to a limited extent. The question here is whether you will accept and implement the containment measures issued by the government (domestic isolation, social distancing), or reject them and not implement them. | COVID | Misc. | In-depth explanation of what each alternative means, as well as descriptions of each attribute | 4 (total number of scenarios is unknown) | 2 | *Accept measures:* You accept the measures. They remain in domestic isolation, practice social distancing and may have to accept financial losses. You do not expose yourself to any risk of infection by being isolated at home, but you also do not have the opportunity to immunize your body through a COVID-19 disease process; *Discard measures:* You reject the measures. You do not remain in domestic isolation, do not engage in social distancing and do your work as usual at your place of work. Accordingly, you have no financial loss, but become infected with the COVID-19 virus on your way to work. The infection makes you immune to re-infection for a period of time. | 5 | Risk of critical symptoms, Risk of fatal outcome; immunity; Financial losses; Domestic isolation | |
| Multiple | None | You will now receive four different decision-making situations, each with two alternatives, whereby you have to choose one. This is about how you perceive and weigh up the public risk for the general public of the Swiss population. In each of the following four decision-making situations, choose your preferred behavior. Please assume that you are a member of the Federal Council and have to decide whether or not to adopt containment measures (domestic isolation, social distancing). | COVID | Misc. | In-depth explanation of what each alternative means, as well as descriptions of each attribute | 4 (total number of scenarios is unknown) | 2 | *Accept measures:* You issue containment measures for the whole of Switzerland. The Swiss population is thus isolated at home, engages in social distancing and is therefore not exposed to any risk of infection. All Swiss suffer a certain financial loss due to the in-depth economic shutdown; *Do not adopt measures:* You do not issue containment measures and aim at herd immunity (as soon as 70% of the population have become infected and are immune after recovery, the virus will die out in the long term). The Swiss population does not go into domestic isolation and does not engage in social distancing, but this puts them at risk of infection (70% of the population becomes infected). Accordingly, the economy does not have to be shut down, so the Swiss population does not suffer any financial losses. | 3 | Average financial lost; Risk of critical symptoms; Average, risk of fatal illness | |

## Survey 9

| Survey name | Region for deployment | Deploying university (professor) | # of responses | Dates deployed | SP administration | SP elicitation mechanism | Type of experimental design |
|---|---|---|---|---|---|---|---|
| **COVID-19 Survey #2** | Switzerland | ETH Zurich (Axhausen; Georges) | Unknown | Unknown | Online with Qualtrics | Choice Experiment | Unknown |

| Question number in survey | Logic to reveal this question | SP question text | Categorization of hypothetical scenario | Sub-categorization of hypothetical scenario | Specific wording to set up hypothetical scenario | # of experiments or questions per respondent | # of alternatives | Listed alternatives | # of attributes for each alternative | Listed attributes | How analysis was performed (w/ RP?) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple | None | You will now receive four different decision-making situations. Please read the following explanations carefully first. In each of the following four decision-making situations, you choose your preferred grocery shopping option. You can either go to a store / supermarket to shop or order your groceries online. The conditions apply here as they were before the outbreak of COVID-19: There is no risk of infection for either shopping option. | COVID | E-commerce | In-depth explanation of what each alternative means, as well as descriptions of each attribute | 4 (total number of scenarios is unknown) | 2 | *Shop in-person:* You go shopping in a grocery store with your preferred means of transport (e.g. Migros, Coop, Globus, Denner, Aldi, Lidl); *Shop online:* You order your groceries on the Internet from an online retailer (e.g. coop@home.ch, leshop.ch, farmy.ch, etc.). | 6 | Purchasing costs; Shopping time; Traveling expenses; Travel time; Shipping costs; Delivery time | |
| Multiple | None | You will now receive four different decision situations. Please read the following explanations carefully first. The current conditions now apply as we are currently experiencing under COVID-19: The virus has developed into a global pandemic and thus makes any contact with people potentially dangerous (both for you and for your fellow human beings), this is especially true when shopping in the store / supermarket. | COVID | E-commerce | In-depth explanation of what each alternative means, as well as descriptions of each attribute. Also, a description of the contagion and infection risks are very well tabulated | 4 (total number of scenarios is unknown) | 2 | *Shop in-person:* You go shopping in a grocery store with your preferred means of transport (e.g. Migros, Coop, Globus, Denner, Aldi, Lidl). You expose yourself to the risk of infection while shopping and may have to wait in front of the store / supermarket; *Shop online:* You order your groceries on the Internet from an online retailer (e.g. coop@home.ch, leshop.ch, farmy.ch, etc.). You do not expose yourself to any risk of infection when buying online. | 8 | Purchasing costs; Shopping time; Waiting time; Traveling expenses; Travel time; Shipping costs; Delivery time; Risk of infection | |

# Appendix B: All 32 SP Questions

**1**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 30 minutes shorter than before | 30 minutes shorter than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**2**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implmentations | Two or more of these safety implmentations |

**3**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**4**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**5**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | 30 minutes shorter than before | 30 minutes shorter than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**6**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**7**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**8**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**9**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**10**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**11**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**12**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 10 minutes shorter than before | 10 minutes shorter than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**13**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 30 minutes shorter than before | 30 minutes shorter than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**14**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**15**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

**16**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | 10 minutes shorter than before | 10 minutes shorter than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**17**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

**18**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**19**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**20**

| *COVID Risk Level* | 90% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**21**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

**22**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Only one of these safety implementations | Only one of these safety implementations |

**23**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**24**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work earlier | Allowed to begin work earlier | Allowed to begin work earlier |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**25**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**26**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**27**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | No distractions | No distractions | - |
| **Change in commute time** | - | 10 minutes shorter than before | 10 minutes shorter than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**28**

| *COVID Risk Level* | New strand of virus and current vaccines do not work. Risk for new strand is HIGH. | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 10 minutes shorter than before | 10 minutes shorter than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Allowed to begin work later | Allowed to begin work later | Allowed to begin work later |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

**29**

| *COVID Risk Level* | Vaccine levels are unknown | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 10 minutes longer than before | 10 minutes longer than before |
| **Splitting work hour** | Allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

**30**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 30 minutes shorter than before | 30 minutes shorter than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | No crowding, more than 6 feet between workspaces | No crowding, more than 6 feet between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

**31**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | High distraction | High distraction | - |
| **Change in commute time** | - | 30 minutes longer than before | 30 minutes longer than before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | Normal crowding, 6 feet distance is achievable between workspaces | Normal crowding, 6 feet distance is achievable between workspaces |
| **Workplace safety implementations for COVID** | - | No regulations | No regulations |

**32**

| *COVID Risk Level* | 40% of people have been vaccinated | | |
|---|---|---|---|
| **Attributes** | **Work from Home** | **Hybrid Workplace (2-3 Days Teleworking)** | **Work from the Workplace** |
| **Distraction level at home** | Low distraction | Low distraction | - |
| **Change in commute time** | - | Same commute time as before | Same commute time as before |
| **Splitting work hour** | Not allowed | Not allowed | Not allowed |
| **Shifting work hour** | Not allowed to shift start time | Not allowed to shift start time | Not allowed to shift start time |
| **Level of crowding at the workplace** | - | High crowding, 6 feet distance is not achievable between workspaces | High crowding, 6 feet distance is not achievable between workspaces |
| **Workplace safety implementations for COVID** | - | Two or more of these safety implementations | Two or more of these safety implementations |

## Appendix C: The Full Qualtrics Survey Text

It is important to note that the format for the SP questions provided in this appendix appears highly irregular, as formatting is affected when the survey is directly downloaded from Qualtrics. Please reference Appendix B to see the questions as they actually appear to the respondents. Note also that each respondent is presented with only two of the SP questions.

# SP Experiment

---

**Start of Block: Welcome**

Q26 Welcome to the survey! On the next few pages, you will find a set of questions asking information about your workplace location and your commuting patterns before and during the COVID-19 pandemic. We appreciate your participation, and thank you for giving us your time and attention.

**End of Block: Welcome**

---

**Start of Block: Before SP**

Q9 What was your employment status before the COVID-19 pandemic?

- ○ Employed (1)
- ○ Unemployed (2)

---

Q10 What is your employment status now?

- ○ Employed (1)
- ○ Unemployed (2)

Q10a Did you work entirely from home before the COVID-19 pandemic?

- ○ Yes
- ○ No

---

If “Unemployed” is selected for both questions 9 and 10, then the survey ends and the message “Thank you for your interest. We are seeking responses only from those who had a physical workplace outside home and commuted on one or more days to work.” is presented to the respondent. If question 10a is answered with “Yes”, then the survey also ends with the same message.

Q1 During the COVID-19 pandemic, have you been able to work from home?

- ○ Yes (1)
- ○ No (2)

---

Q4 How often do you typically telework during the week now? (*telework*, as used here, refers to working from home during the entire day, without going into an out-of-home office during that day to pursue the same work)

- ○ Never (1)
- ○ Once a week (2)
- ○ Twice a week (3)
- ○ Three times a week (4)
- ○ Four times a week (5)
- ○ Five or more times a week (6)

---

Q5 How often do you typically commute (travel into an out-of-home office) during the week now?

- ○ Never (1)
- ○ Once a week (2)
- ○ Twice a week (3)
- ○ Three times a week (4)
- ○ Four times a week (5)
- ○ Five or more times a week (6)

Q6 How often did you typically telework *before* the pandemic?

- ○ Never (1)
- ○ Once a week (2)
- ○ Twice a week (3)
- ○ Three times a week (4)
- ○ Four times a week (5)
- ○ Five or more times a week (6)

Q7 Before the COVID-19 pandemic, how far was your commute to work? (in miles)

_____

Q8 Before the COVID-19 pandemic, how long was your commute to work? (in minutes)

_____

Q14 Referring to your employment before COVID-19, where was your place of work located? Enter an address, cross street, or zip code.
*If you do not wish to answer, please leave this question blank.*

_____

Q19 Before the COVID-19 pandemic, how did you travel to work?

- ○ By car (1)
- ○ By public transportation (2)
- ○ By bicycle (3)
- ○ By ride-sharing (4)
- ○ By walking (5)
- ○ Other (6) _____

---

Q18 Did you have to pay for parking at work before the COVID-19 pandemic?

- ○ Yes (1)
- ○ No (0)

Q18a Have you changed jobs since the COVID-19 pandemic began?

- ○ Yes (1)
- ○ No (0)

---

Q20 Does your employer currently have COVID-19 safety implementations in place, or plans to implement them in the near future? (please respond even if you are self-employed, in which case you would also be your own employer)

- ○ Yes (1)
- ○ No (2)

---

*Display This Question:*

*If the response to "Does your work currently have COVID-19 safety implementations in place, or plans to implement them in the future" is "Yes"*

Q21 Which ones?

- ☐ Social distancing (1)
- ☐ Mandatory face covering (2)
- ☐ Hand sanitation stations (3)
- ☐ Barriers (4)
- ☐ Mandatory COVID testing (5)
- ☐ Mandatory vaccination (6)

Q12 How many vehicles does your household own?

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 or more (5)

Q13 Has your vehicle availability changed during the COVID-19 pandemic? (i.e., have you bought or sold any vehicles, changing the total number of vehicles in your household; if you bought and sold vehicles such that the total number of vehicles in your household has not changed, please respond "no" below)

- Yes (1)
- No (0)

*Display This Question:*

*If the response to "Has your vehicle availability changed during the COVID-19 pandemic?" is "Yes"*

Q13a How has the total number of vehicles in your household changed?

- ○ Increased by ___ vehicles
- ○ Decreased by ___ vehicles

---

Q17 Have you moved residences since the COVID-19 pandemic began?

- ○ Yes (1)
- ○ No (0)

---

Q15 How many people (including you) live at your current residence?

- ○ I live alone (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 or more (5)

---

*Display This Question:*

*If the response to "How many people (including you) live at your current residence?" is Not Selected*

Q16 Who do you currently live with?

- ○ Significant other (2)
- ○ Family (3)
- ○ Roommates (4)
- ○ Both family and roommates (5)
- ○ Other (6)

**End of Block: Before SP**

---

**Start of Block: SP**

Q23 In this next section, you will be presented with *two* hypothetical scenarios regarding workplace choice. Please take a few minutes to familiarize yourself with the attributes characterizing workplace choice, and please consider the attributes when making your choice.

In each of the following two scenarios, you will have three different alternatives to choose from -- **working from home**, **working from your (out-of-home) workplace**, and **a hybrid of the two**. Each of these alternatives are characterized by the attributes listed below:

**Work from home attributes:**

- **Distraction level at home:** This attribute indicates the amount of distraction occurring at your home, whether from roommates, spouse, children, or general activity that diverts your attention from work.
- **Splitting work hours:** This attribute indicates if you are allowed to split (spread out) the work hours into separate intervals during the day.

**Work at the workplace attributes:**

- **Change in commute time:** This attribute indicates a change in your commute time caused by overall travel pattern shifts from the COVID-19 pandemic.
- **Level of crowding at the workplace:** This attribute indicates how crowded your workplace is and the distance between you and other people and their workspaces.
- **Workplace safety implementation for COVID:** This attribute indicates how your workplace is addressing and implementing COVID-19 safety precautions and regulations. These may include the requirement of face coverings, social distancing, introduction of hand sanitation stations, placement of barriers between workspaces, or the requirement of COVID-19 testing and/or vaccinations.

**General attributes:**

- **COVID risk level:** This attribute indicates to what level COVID-19 is a assumed a threat by defining what percentage of people are vaccinated or if the vaccine turns out to be ineffective.
- **Shifting work hours:** This attribute indicates whether you are allowed to shift the time you begin working.

**End of Block: SP**

---

**Start of Block: SP questions**

Q29 In this scenario, you have three different options for where to work. Please carefully review your options.

REFEREENCETABLES IN APPENDIX B

Please choose your preferred workplace location option based on the information presented in the table.

- ○ Work from home (1)
- ○ Hybrid workplace (2-3 days teleworking a week) (2)
- ○ Work from the workplace (3)

**End of Block: SP questions**

---

**Start of Block: After SP**

Q28 Thank you for answering the set of hypothetical scenarios! We have one more follow-up question for you before you are done.

---

Q2 Would you consider switching your mode choice when commuting to work under any of these hypothetical scenarios?

- ○ Yes (1)
- ○ No (2)

---

*Display This Question:*

*If Would you consider switching your mode choice when commuting to work under any of these hypotheti... = Yes*

Q3 If so, to which mode(s)? *Feel free to select more than one mode.*

- ☐ Public Transportation (1)
- ☐ Bicycle (2)
- ☐ Walk (3)
- ☐ Ride-sharing (4)
- ☐ Drive myself (5)
- ☐ Carpool with others (6)

**End of Block: After SP**

---

**Start of Block: END AND THANK YOU**

Q24 Thank you so much for taking the time to answer our pilot survey. Have a wonderful day!

**End of Block: END AND THANK YOU**

---

# Appendix D: SP Experimental Design

**Table 1: Orthogonal Design Output for the Subset of Attribute Level Combinations**

| Scenario | Covid-19 risk level | Shifting work hour | Splitting work hour | Distraction level (at home) | Change in commute time | Level of crowding at the outside-of-home workplace | Workplace safety implementation for COVID-19 | Crowding and distraction level at the third workplace | Commute length to third workplace |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Risk is low | Not allowed | Allowed | No distractions | Same commute length as before | High crowding and distractions | No safety regulations | No crowding or distractions | Same length as your other commute |
| **2** | Risk is high | Allowed | Not allowed | No distractions | 75% longer than before | Extremely low crowding and distractions | Only one safety measure | No crowding or distractions | Same length as your other commute |
| **3** | Risk is high | Allowed | Not allowed | High distraction | Same commute length as before | Low crowding and distractions | Only one safety measure | No crowding or distractions | Same length as your other commute |
| **4** | Risk is unknown | Allowed | Not allowed | Low distraction | 75% shorter than before | No crowding or distractions | Two or more safety measures | No crowding or distractions | Same length as your other commute |
| **5** | Risk is extremely low | Not allowed | Allowed | High distraction | 50% longer than before | Low crowding and distractions | Two or more safety measures | No crowding or distractions | Same length as your other commute |
| **6** | Risk is low | Not allowed | Not allowed | No distractions | 50% longer than before | No crowding or distractions | No safety regulations | Extremely low crowding and distractions | Same length as your other commute |
| **7** | Risk is low | Not allowed | Not allowed | Low distraction | 75% longer than before | Low crowding and distractions | No safety regulations | Extremely low crowding and distractions | Same length as your other commute |
| **8** | Risk is high | Not allowed | Allowed | High distraction | 75% shorter than before | High crowding and distractions | No safety regulations | Extremely low crowding and distractions | Same length as your other commute |
| **9** | Risk is extremely low | Allowed | Allowed | High distraction | 50% shorter than before | Extremely low crowding and distractions | Only one safety measure | Extremely low crowding and distractions | Same length as your other commute |
| **10** | Risk is unknow | Allowed | Allowed | No distractions | 75% longer than before | No crowding or distractions | Two or more safety measures | Extremely low crowding and distractions | Same length as your other commute |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **11** | Risk is high | Not allowed | Not allowed | High distraction | 50% shorter than before | No crowding or distractions | Two or more safety measures | Extremely low crowding and distractions | Same length as your other commute |
| **12** | Risk is high | Allowed | Not allowed | Low distraction | 50% longer than before | No crowding or distractions | No safety regulations | Low crowding and distractions | Same length as your other commute |
| **13** | Risk is extremely low | Allowed | Not allowed | No distractions | 75% shorter than before | Extremely low crowding and distractions | No safety regulations | Low crowding and distractions | Same length as your other commute |
| **14** | Risk is unknown | Allowed | Allowed | High distraction | Same commute length as before | No crowding or distractions | Only one safety measure | Low crowding and distractions | Same length as your other commute |
| **15** | Risk is extremely low | Not allowed | Allowed | Low distraction | 75% longer than before | High crowding and distractions | Only one safety measure | Low crowding and distractions | Same length as your other commute |
| **16** | Risk is unknown | Not allowed | Not allowed | Low distraction | 50% shorter than before | High crowding and distractions | Only one safety measure | Low crowding and distractions | Same length as your other commute |
| **17** | Risk is unknown | Not allowed | Not allowed | High distraction | 50% shorter than before | Low crowding and distractions | No safety regulations | High crowding and distractions | Same length as your other commute |
| **18** | Risk is low | Not allowed | Allowed | Low distraction | 50% longer than before | Extremely low crowding and distractions | Only one safety measure | High crowding and distractions | Same length as your other commute |
| **19** | Risk is low | Allowed | Allowed | No distractions | 75% shorter than before | Low crowding and distractions | Only one safety measure | High crowding and distractions | Same length as your other commute |
| **20** | Risk is low | Not allowed | Allowed | High distraction | Same commute length as before | Extremely low crowding and distractions | Two or more safety measures | High crowding and distractions | Same length as your other commute |
| **21** | Risk is extremely low | Allowed | Not allowed | Low distraction | Same commute length as before | High crowding and distractions | Two or more safety measures | High crowding and distractions | Same length as your other commute |
| **22** | Risk is extremely low | Allowed | Not allowed | High distraction | 50% longer than before | Extremely low crowding and distractions | No safety regulations | No crowding or distractions | Shorter than your other commute |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **23** | Risk is unknown | Not allowed | Allowed | Low distraction | 75% shorter than before | Extremely low crowding and distractions | No safety regulations | No crowding or distractions | Shorter than your other commute |
| **24** | Risk is low | Not allowed | Not allowed | High distraction | 75% longer than before | No crowding or distractions | Only one safety measure | No crowding or distractions | Shorter than your other commute |
| **25** | Risk is low | Allowed | Allowed | Low distraction | 50% shorter than before | High crowding and distractions | Only one safety measure | No crowding or distractions | Shorter than your other commute |
| **26** | Risk is high | Not allowed | Allowed | No distractions | 50% shorter than before | Low crowding and distractions | Two or more safety measures | No crowding or distractions | Shorter than your other commute |
| **27** | Risk is high | Allowed | Allowed | Low distraction | Same commute length as before | No crowding or distractions | No safety regulations | Extremely low crowding and distractions | Shorter than your other commute |
| **28** | Risk is unknown | Not allowed | Not allowed | No distractions | Same commute length as before | Extremely low crowding and distractions | Only one safety measure | Extremely low crowding and distractions | Shorter than your other commute |
| **29** | Risk is unknown | Allowed | Allowed | Low distraction | 50% longer than before | Low crowding and distractions | Only one safety measure | Extremely low crowding and distractions | Shorter than your other commute |
| **30** | Risk is low | Allowed | Not allowed | High distraction | 75% shorter than before | High crowding and distractions | Two or more safety measures | Extremely low crowding and distractions | Shorter than your other commute |
| **31** | Risk is low | Allowed | Allowed | High distraction | 75% longer than before | Low crowding and distractions | No safety regulations | Low crowding and distractions | Shorter than your other commute |
| **32** | Risk is high | Not allowed | Allowed | High distraction | 75% shorter than before | No crowding or distractions | Only one safety measure | Low crowding and distractions | Shorter than your other commute |
| **33** | Risk is low | Allowed | Not allowed | No distractions | 50% shorter than before | Extremely low crowding and distractions | Two or more safety measures | Low crowding and distractions | Shorter than your other commute |
| **34** | Risk is extremely low | Not allowed | Not allowed | Low distraction | Same commute length as before | Low crowding and distractions | Two or more safety measures | Low crowding and distractions | Shorter than your other commute |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **35** | Risk is unknown | Not allowed | Allowed | No distractions | 50% longer than before | High crowding and distractions | Two or more safety measures | Low crowding and distractions | Shorter than your other commute |
| **36** | Risk is extremely low | Allowed | Allowed | No distractions | 50% shorter than before | No crowding or distractions | No safety regulations | High crowding and distractions | Shorter than your other commute |
| **37** | Risk is unknown | Allowed | Not allowed | High distraction | 75% longer than before | High crowding and distractions | No safety regulations | High crowding and distractions | Shorter than your other commute |
| **38** | Risk is extremely low | Not allowed | Not allowed | No distractions | 75% shorter than before | No crowding or distractions | Only one safety measure | High crowding and distractions | Shorter than your other commute |
| **39** | Risk is high | Allowed | Not allowed | No distractions | 50% longer than before | High crowding and distractions | Only one safety measure | High crowding and distractions | Shorter than your other commute |
| **40** | Risk is high | Not allowed | Allowed | Low distraction | 75% longer than before | Extremely low crowding and distractions | Two or more safety measures | High crowding and distractions | Shorter than your other commute |

# Appendix E: WPL Survey Outline

Section A: Residential Preferences and Household Vehicles

1. Do you rent or own your current residence?
2. What best describes your current residence? (stand-alone home, townhouse, multi-family apartment, etc.)
3. How may bedrooms are in your household?
4. Do you have access to either a private or shared office/study in your home?
5. Do you have broadband internet access in your home?
6. What year did you move to your current address?
7. What is the zip code of your current address?
8. Which of these best describes the general area where you live? (rural, urban, or suburban)
9. How many automobiles are there in your household?
10. Has your vehicle availability changed during the COVID-19 pandemic?
11. How has the total number of vehicles in your household changed?
12. Please provide details of all motorized vehicles.
13. Are you a licensed driver?
14. About how many miles do you estimate you drove in…
    - 2019?
    - 2020?
    - 2021?

Section B: Employment Information

1. Before the COVID-19 pandemic, you were (student/worker)
2. Before the COVID-19 pandemic, did you attend school online?
3. At this time, you are (student/worker)
4. At this time, you are (full/part time; employed/self-employed)
5. Did you switch jobs during the COVID-19 pandemic?
6. What industry do you currently work in?

Section C: Telecommuting Habits

1. Over the past three years, has your employer allowed you to work from home or from a third workplace?
2. Before the COVID-19 pandemic and until today, have you always worked from home?
3. Did you make a significant change to your commute patterns during the COVID-19 pandemic?
4. How often did/do you telecommute, whether you worked from home or from a third workplace?
    - Before the COVID-19 pandemic [Before March 1, 2020]
    - During the COVID-19 pandemic [March 1, 2020 – June 1, 2021]
    - Now
5. Where did/do you telecommute from?
    - Before the COVID-19 pandemic
    - During the COVID-19 pandemic
    - Now

6. In the previous question, what did you mean by "other" place you have telecommuted from?
7. Please provide some brief details about the third workplace location(s) you worked from before the COVID-19 pandemic.
8. During the COVID-19 pandemic, what was the third workplace location that you worked from?
9. Please provide some details about the third workplace location(s) you work from now.

Section D: Commute Information

1. When did/do you leave for work to head to your workplace?
    - Before the COVID-19 pandemic
    - During the COVID-19 pandemic
    - Now
2. When did/do you leave your workplace after working?
    - Before the COVID-19 pandemic
    - During the COVID-19 pandemic
    - Now
3. How did/do you typically travel to work?
    - Before the COVID-19 pandemic
    - During the COVID-19 pandemic
    - Now
4. How long did/does it take you to get from your residence to your workplace location? (one way)
    - Before the COVID-19 pandemic
    - During the COVID-19 pandemic
    - Now
5. What was/is the approximate distance between your residence and your workplace location? (one way, in miles)
    - Before the COVID-19 pandemic
    - During the COVID-19 pandemic
    - Now

The following questions are about your commute habits during the COVID-19 pandemic, regardless of whether or not you work or study from home now.

6. During the COVID-19 pandemic, did your workplace close its in-person office? This may also include requiring special permission to go into the office.
7. During the COVID-19 pandemic, did you primarily work from home?

The following questions are about your current commuting habits. Remember that a "workplace" includes your company's office or worksite or your school's building or campus

8. What portion of your current job's tasks do you think could be performed away from your main work location?
9. How many hours per day do you usually work?
10. Typically, how many days in a month do you work? Working five days a week averages to 22 days a month.
11. Out of those __ work days in the past month, how many days did you:

- Work from home?
- Work from your workplace?
- Work from a third workplace?

In the previous question, you reported that you spend a few days a month working from a third workplace. The next few questions will ask you about your recent commute to the third workplace. In the past month,…

12. When do you usually leave for work to head to *a third workplace location*?
13. When do you usually leave from *the third workplace location* after working?
14. How long does it take you to get from your residence to your usual third workplace location?
15. What is the approximate distance between your residence and your usual third workplace location?

The next set of questions are about working from your workplace.

16. Knowing more about your current workplace location will help us understand the transportation options available to you. Please provide us the zip code of your current outside-of-home workplace location, even if you primarily telework.
17. How satisfied are you with your current commute to your workplace?

Please state how much you agree/disagree with the following statements about your current workplace:

18. There is too much congestion during my commute too or from work.
19. My workplace is too crowded.
20. I feel unsafe regarding COVID-19 because of the crowding at my workplace.
21. Does your employer currently have COVID-19 safety measures in place, or plans to implement them in the near future? (Please respond even if you are self-employed, in which case you would also be your own employer.)
22. Which COVID-19 safety precautions has your employer implemented at the workplace?

Will your employer provide the option to work from anywhere in the future?

Section E: Workplace Location Preferences

In this next section, you will be presented with *two* hypothetical scenarios regarding workplace choice. Please take a few minutes to familiarize yourself with the attributes characterizing the different workplaces, and please consider the attributes when making your choice.

In each of the following two scenarios, you will have three different options to distribute your monthly worktime across:

- **Work from home**
- **Work from your (outside-of-home) workplace**
- **Work from a third workplace**

Regardless of the options your employer currently offers, assume you have all options available while distributing your time.

Each of these alternatives are characterized by the attributes listed below:

**Work from home attribute:**

**Distraction level at home:** The amount of distraction occurring at your home, whether from roommates, spouse, children, or general activity that diverts your attention from work.

**Work at the workplace attributes:**

**Change in commute time:** A change in your commute time caused by overall travel pattern shifts from the COVID-19 pandemic.

**Level of crowding at the workplace:** How crowded your workplace is and the distance between other people and their workspaces.

**Workplace safety implementation for COVID**: How your workplace is addressing and implementing COVID-19 safety precautions and regulations.

**Work from a third workplace attributes:**

**Crowding and distraction level at the third workplace:** How crowded and distracting the third workplace is.

**Commute length:** The commute to the third workplace, relative to your workplace commute.

**General attributes:**

**COVID risk level:** What level COVID-19 is assumed a threat by defining what percentage of people are vaccinated or if the vaccine is ineffective on new strands of the virus.

**Shifting work hours**: If you are allowed to shift the time you begin working.

**Splitting work hours**: If you are allowed to split (spread out) your work hours into separate intervals during the day.

Remember, a third workplace could include either a coffee shop, a designated co-working location, a hotel, or a restaurant. A third workplace does not include working from a client's site, which would instead be categorized as the (out-of-home) workplace option. The appeals of a third workplace may include less distractions than when working from home and not commuting all the way to the workplace. However, a third workplace may still have crowding and require a commute.

**SP question example:**

In this scenario, you have three different options for where to work for one month. Please carefully review your options.

| **COVID Risk Level** | 60% of people are vaccinated and the vaccine is effective for all current strands. Risk is low. | | |
|---|---|---|---|
| ***Attributes*** | ***Work from Home*** | ***Work from the Workplace*** | ***Work from a 3rd Workplace*** |
| **Distraction level** | Low distraction | Low distraction | High distraction |
| **Commute time** | - | 7.5 minutes longer than before | Shorter than your out-of-home workplace commute |
| **Level of crowding** | - | The out-of-home workplace is crowded and you are in close proximity to quiet coworkers | The third workplace is crowded and you are in close proximity to loud strangers |
| **Workplace safety implementation for COVID** | - | Only one safety measure is implemented | - |
| **Splitting Work Hour** | Allowed | Not allowed | Allowed |
| **Shifting Work Hours** | Allowed | Not allowed | Allowed |

You reported to work __ days last month. For this scenario, please distribute the number of days you would work at each workplace so that they all add up to ___. You can put 0 days for one or two of the alternatives as long as it adds up to ___.

Remember, a third workplace is a remote workplace outside of the home such as a coffee shop, cafe, hotel, or co-working space.

| | |
|---|---|
| Work from home | 0 |
| Work from the workplace | 0 |
| Work from a 3rd workplace (teleworking from a location that is not your home) | 0 |
| Total | 0 |

Section F: Perception of the Threat of COVID-19

1. Rate how much you agree with the following statements:

| | Strongly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agree | Strongly agree |
|---|---|---|---|---|---|
| I felt my personal wellbeing was at risk during the pandemic. | ○ | ○ | ○ | ○ | ○ |
| I perceived COVID-19 as an immediate threat to my loved ones. | ○ | ○ | ○ | ○ | ○ |

2. Would you consider yourself immunocompromised?
3. Is someone you live with or frequently visit immunocompromised?

Section G: Online Behavior

1. Over the past year, have you shopped for groceries online more than you did before the COVID-19 pandemic?
2. Over the past year, have you ordered dinner meals online for home delivery more than you did before the COVID-19 pandemic?
3. Over the past year, have you shopped for non-grocery items online (e.g., clothing, electronics, etc.) for home delivery more than you did before the COVID-19 pandemic?
4. In the past month, across weekdays (that is, not counting weekend trips), how many times have you undertaken the following activities **in person**?

| | |
|---|---|
| Shop at the grocery store | 0 |
| Go out to eat for dinner | 0 |
| Shop for non-grocery items at a store | 0 |
| Total | 0 |

5. In the past month, across weekdays, how many times did you:

| | |
|---|---|
| Order **groceries** online and get them delivered to your house: | 0 |
| Order **groceries** online and pick them up through curbside pickup: | 0 |
| Order **a dinner meal** online and get them delivered to your house: | 0 |
| Order **a dinner meal** online and pick them up through curbside pickup: | 0 |
| Order **non-grocery items** online and get them delivered to your house: | 0 |
| Order **non-grocery items** online and pick them up through curbside pickup: | 0 |
| Total | 0 |

6. Please break down each of your eat-out dinner episodes based on the restaurant type.
    - Fast food/Food truck
    - Café/Coffee shop/Pizza place
    - Casual family-style sit-in restaurant

- Fine/Luxury dining restaurant

7. How often do you browse for items online and then go to the store in person to purchase them?
8. What about the other way around: how often do you browse for stuff in a store and then go home, find it online, and buy it?

Section H: Background Information

1. What year were you born?
2. What gender do you most identify with?
3. Are you Hispanic or Latino?
4. Which of the following categories do you identify with (race)?
5. What is the highest level of education you have completed?
6. How many people (including you) live in your household?
7. Please describe the people who live with you.
8. In 2021, what was your household's total annual income (from all sources) before taxes or other deductions?
9. Would you be willing to tell us more generally about your household's 2021 income? (If above was "prefer not to answer", then display this question)

# Appendix F: WPL Survey – Final Survey Instrument

**Start of Block: Intro_Block**

Q1

***Welcome to our transportation study!***

*The University of Texas at Austin invites you to participate in a research study to better understand Texas residents' travel needs and opinions. Results of the study will be used to guide policy decisions and to design future transportation options. Your participation is voluntary, but very important.* ***If you are unable to participate for any reason, any other adult in the household can complete the survey.*** *We are interested in your answer to every question, including those dealing with topics that might be less familiar to you.*

*Your individual responses will be treated in strict confidence. The results of the study will be published only in summary form, so that your identity and privacy are protected. The survey will take about 15-20 minutes to complete, but we think you'll find it interesting and fun to do.*

*We would appreciate if you can complete the survey by* ***March 15th, 2022.***

*Thank you in advance for your participation in this important study. This study was developed and is being conducted by The University of Texas at Austin, with support from the Texas Department of Transportation (TxDOT).*

*If you have any questions about the study, feel free to contact the study coordinator, Katie Asmussen, at kasmussen29@utexas.edu.*

*Sincerely,*

***Chandra R. Bhat****, PhD, PE*
*University Distinguished Teaching Professor*
*Joe J. King Chair in Engineering*
*Department of Civil, Architectural and Environmental Engineering*
301 E. Dean Keeton St. Stop C1761
Austin, Texas 78712
Phone: (512) 232-6272
bhat@mail.utexas.edu

By clicking on the arrow button below, you agree to participate in this study and verify that you are 18 years or older. This research is conducted by The University of Texas at Austin. This study has been reviewed and approved by The University of Texas at Austin Institutional Review

Board for the protection of study participants. The online survey and the questions asked pose no more risks to you than you would come across in everyday life. All responses will be treated in strict confidence, and your identity and privacy will be protected. You may benefit from this survey through your input and support of this effort to improve the roads you frequently travel, though, since it is a research effort, no benefits can be guaranteed. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you may contact the UT Institutional Review Board at (512) 471 8871 or at orsc@uts.cc.utexas.edu.

**End of Block: Intro_Block**

---

**Start of Block: SECTION A: HH_Demog_Block**

Q2 **Section A: Residential Preferences and Household Vehicles**

Learning about your residential situation and household vehicles will help us better understand your transportation and lifestyle choices.

---

Q3 What is your current housing arrangement?

- ○ Own (outright or with a mortgage) (1)
- ○ Rent (2)
- ○ Provided by job or military (3)
- ○ Live with parents, friends, or others and do NOT pay rent (4)
- ○ Other: (5) _____

Q4 What best describes your current residence?

- ○ Stand-alone home/single-family (detached) house (1)
- ○ Townhouse (attached house) (2)
- ○ Multi-family building (3 or fewer apartments) (3)
- ○ Building with 4 or more apartments/condos (4)
- ○ Mobile home/trailer (5)
- ○ Dorm or institutional housing (6)
- ○ Other: (7) _____

---

Q5 Later in the survey you will be presented with questions about working from home. The following questions ask you to provide details about your current residence to help us contextualize your home-office environment.

---

Q6 How many bedrooms are in your home?

▼ 1 (1) ... 6 or more (9)

---

Q7 Do you have access to either a private or shared office/study in your home?

- ○ No (21)
- ○ Yes (22)

---

Q8 Do you have broadband internet access in your home?

- ○ No (21)
- ○ Yes (22)

Q9 What year did you move to your current address?

▼ 2022 (80) ... 1942 (79)

---

Q10 What is the zip code of your current residence?

_____

---

Q11 Which of these options best describes the general area where you live?

- ○ Rural (1)
- ○ Suburban (2)
- ○ Urban (3)

Q12 How many motorized automobiles are available in your household? Please include cars, trucks, SUVs, and vans (whether owned, leased, or a company vehicle). Your household includes

everyone who lives in the same dwelling unit, including relatives, roommates, friends and household helpers.

- ○ 0 vehicles (0)
- ○ 1 vehicle (1)
- ○ 2 vehicles (2)
- ○ 3 vehicles (3)
- ○ 4 vehicles (4)
- ○ 5 or more vehicles (5)

---

Q13 Has your motorized vehicle availability changed through the purchase or sale of vehicles during the COVID-19 pandemic? Please do not count the return of or visits from family members who own a vehicle toward this change.

- ○ Yes (1)
- ○ No (2)

---

*Display This Question:*

*If Has your motorized vehicle availability changed through the purchase or sale of vehicles during t... = Yes*

Q14 How has the total number of vehicles in your household changed?

- ○ Increased by __ vehicle(s) (1)

  _____

- ○ Decreased by __ vehicle(s) (2)

  _____

*Display This Question:*

*If How many motorized automobiles are available in your household? Please include cars, trucks, SUVs... != 0 vehicles*

Q15
Please provide details of all motorized vehicles available in your household.

Please report the vehicle you use most often as Vehicle 1.

| | **Body Type** | **Model Year** (e.g., 2004) | **Year Acquired** (e.g., 2010) | **Fuel Type** |
|---|---|---|---|---|
| Vehicle 1 (1) | ▼ Sedan (1 ... Pickup Truck (9) | ▼ 2021 (1 ... 2022 (93) | ▼ 2021 (1 ... 2022 (94) | ▼ Gasoline (1 ... Other (6) |
| Vehicle 2 (2) | ▼ Sedan (1 ... Pickup Truck (9) | ▼ 2021 (1 ... 2022 (93) | ▼ 2021 (1 ... 2022 (94) | ▼ Gasoline (1 ... Other (6) |
| Vehicle 3 (3) | ▼ Sedan (1 ... Pickup Truck (9) | ▼ 2021 (1 ... 2022 (93) | ▼ 2021 (1 ... 2022 (94) | ▼ Gasoline (1 ... Other (6) |
| Vehicle 4 (4) | ▼ Sedan (1 ... Pickup Truck (9) | ▼ 2021 (1 ... 2022 (93) | ▼ 2021 (1 ... 2022 (94) | ▼ Gasoline (1 ... Other (6) |
| Vehicle 5 (5) | ▼ Sedan (1 ... Pickup Truck (9) | ▼ 2021 (1 ... 2022 (93) | ▼ 2021 (1 ... 2022 (94) | ▼ Gasoline (1 ... Other (6) |

Q16 Do you have a driver's license?

- ○ No (21)
- ○ Yes (22)

*Display This Question:*

*If How many motorized automobiles are available in your household? Please include cars, trucks, SUVs... != 0 vehicles*

Q17 Answer the following set of questions with respect to your primary vheilce (answered as "Vehicle 1" above).

| | About how many miles do you estimate you drove during... |
|---|---|
| 2019 (before the COVID-19 pandemic) (1) | ▼ I did not drive that year (1 ... More than 15,000 (6) |
| 2020 (during the first year and peak of the COVID-19 pandemic) (2) | ▼ I did not drive that year (1 ... More than 15,000 (6) |
| 2021 (over the past year) (3) | ▼ I did not drive that year (1 ... More than 15,000 (6) |

**End of Block: SECTION A: HH_Demog_Block**

**Start of Block: SECTION B: Employment_Block**

Q18 **Section B: Employment Information**

Learning about your employment status over the past three years will help us better understand your transportation needs and options.

Q19 First, we'd like to know about your employment and educational status in 2019, before the COVID-19 pandemic.

Q20 Before the COVID-19 pandemic, you were:

- ○ Both employed and a student (1)
- ○ Employed (part-time or full-time) (2)
- ○ A student (part-time or full-time) (3)
- ○ Neither employed nor a student (4)

*Display This Question:*

*If Before the COVID-19 pandemic, you were: = Both employed and a student*

*Or Before the COVID-19 pandemic, you were: = A student (part-time or full-time)*

Q21 Before the COVID-19 pandemic, did you attend school online?

- ○ No (21)
- ○ Yes (22)

---

Q22 Now, we'd like to know about your employment status today.

---

Q23 At this time, you are:

- ○ Both employed and a student (1)
- ○ Employed (part-time or full-time) (2)
- ○ A student (part-time or full-time) (3)
- ○ Neither employed nor a student (4)

---

*Display This Question:*

*If At this time, you are: = Both employed and a student*

*Or At this time, you are: = Employed (part-time or full-time)*

Q24 At this time, you are:

- ○ Self-employed, working full time (30 or more hours per week) (3)
- ○ Self-employed, working part time (less than 30 hours per week) (4)
- ○ Not self-employed, working full time (30 or more hours per week) (1)
- ○ Not self-employed, working part time (less than 30 hours per week) (2)

---

*Display This Question:*

*If Before the COVID-19 pandemic, you were: = Both employed and a student*

*Or Before the COVID-19 pandemic, you were: = Employed (part-time or full-time)*

Q25 Did you switch jobs during the COVID-19 pandemic?

- ○ No (21)
- ○ Yes (22)

---

*Display This Question:*

*If At this time, you are: = Both employed and a student*

*Or At this time, you are: = Employed (part-time or full-time)*

Q26 What industry do you currently work in?

▼ Agriculture, forestry, fishing and hunting, mining (1) ... Not applicable (unemployed, student, retired) (16)

**End of Block: SECTION B: Employment_Block**

---

**Start of Block: SECTION C: Telecommuting**

Q27 **Section C: Telecommuting Habits**

Learning about your telecommuting habits over the past two years will help us better understand how the pandemic has impacted working arrangements and commutes.

---

Q28 **Telecommuting** is the act of working from home or from a convenient place instead of traveling to your regular workplace.

Note: The following activities **do not** count as telecommuting:

- performing "overtime" work at home on evenings or weekends,
- self-employed work that is not your main job,
- working at home a few hours per day to shift your commute time

A more recent popular telecommuting trend is working from a ***third workplace*** (also known as hoteling). A *third workplace* is an outside-of-home, remote workplace (such as a coffee shop, café, hotel, or co-working space). The general appeal of a third workplace option is that it may offer less distractions compared to working from home, while not requiring an employee to

commute all the way to their workplace, or for those who do not have an in-person workplace.

---

Q29 At any point over the past five years, has your employer allowed you to work from home or from a third workplace?

- ○ No (1)
- ○ Yes (2)

---

Q30 Over the past five years, have you always worked from home? By answering yes, you are indicating that, in this time, you have never regularly commuted to an in-person workplace for your job.

- ○ No (1)
- ○ Yes (2)

---

Q31 Did you make a significant change to your commute patterns during the COVID-19 pandemic before vaccinations became widely available (between March 1, 2020, and May 30, 2021)? Select all that apply.

- ☐ Yes, I worked from home every day (1)
- ☐ Yes, I worked from home often, but not every day (2)
- ☐ Yes, I worked remotely from a third workplace (3)
- ☐ I made no change to my commute patterns (4)
- ☐ I made other commute changes, including: (5) _____

---

Q32 During the pandemic prior to the broad availability of vaccines, did your workplace close its in-person office or require special permission to go into the office?

- ○ No (21)
- ○ Yes (22)

**End of Block: SECTION C: Telecommuting**

---

**Start of Block: SECTION C: Telecommute YES**

Q33 The next set of questions asks you about your telecommuting habits before and during the COVID-19 pandemic, as well as your current and future telecommuting habits.

| | How often did/do/will you telecommute, whether from home or a third workplace? | | | | |
|---|---|---|---|---|---|
| | Never (1) | A few times per month (2) | Once per week (3) | 2-4 days per week (4) | 5 days a week (everyday) (5) |
| Before the COVID-19 pandemic: (1) | ○ | ○ | ○ | ○ | ○ |
| During the first peak of the COVID-19 pandemic [March 2020 - May 2021]: (2) | ○ | ○ | ○ | ○ | ○ |
| Now, and since vaccines became widely available [June 2021 until today]: (3) | ○ | ○ | ○ | ○ | ○ |
| In a not-too-distant future when the impact of the pandemic wanes considerably: (4) | ○ | ○ | ○ | ○ | ○ |

Q34 On the previous page, you responded that you telecommuted. Where did or will you telework from? Check all that apply.

| | Where did/do/will you telecommute from? | | |
|---|---|---|---|
| | From your home (1) | From a third workplace (2) | Other (3) |
| Before the COVID-19 pandemic: (1) | ☐ | ☐ | ☐ |
| During the first peak of the COVID-19 pandemic [March 2020 - May 2021]: (2) | ☐ | ☐ | ☐ |
| Now, and since vaccines became widely available [June 2021 until today]: (3) | ☐ | ☐ | ☐ |
| In a not-too-distant future when the impact of the pandemic wanes considerably: (5) | ☐ | ☐ | ☐ |

*Display This Question:*

*If On the previous page, you responded that you telecommuted. Where did or will you telework from? C... : Where did/do/will you telecommute from? = Other*

Q35 Please explain what other place(s) you have teleworked from.

_____

*Display This Question:*

*If On the previous page, you responded that you telecommuted. Where did or will you telework from? C... : Where did/do/will you telecommute from? = <u>Before</u> the COVID-19 pandemic: [ From a third workplace ]*

Q36 Please identify the third workplace location(s) you worked from before the COVID-19 pandemic. Select all that apply.

- ☐ Coffee shop or café (4)
- ☐ WeWork or similar co-working space (5)
- ☐ Airbnb or another short-term rental (6)
- ☐ Hotel (7)
- ☐ Friend or family's home (9)
- ☐ Somewhere else: (8) _____

*Display This Question:*

*If On the previous page, you responded that you telecommuted. Where did or will you telework from? C... : Where did/do/will you telecommute from? = <u>During</u> the first peak of the COVID-19 pandemic [March 2020 - May 2021]: [ From a third workplace ]*

Q37 During the COVID-19 pandemic prior to vaccine availability [March 2020 - May 2021], what third workplace location(s) did you work from? Select all that apply.

- ☐ Coffee shop or café (4)
- ☐ WeWork or similar co-working space (5)
- ☐ Airbnb or another short-term rental (6)
- ☐ Hotel (7)
- ☐ Friend or family's home (9)
- ☐ Somewhere else: (8) _____

*Display This Question:*

*If On the previous page, you responded that you telecommuted. Where did or will you telework from? C... : Where did/do/will you telecommute from? = <u>Now</u>, and since vaccines became widely available [June 2021 until today]: [ From a third workplace ]*

Q38 Please provide some details about the third workplace location(s) you work from now. Select all that apply.

- ☐ Coffee shop or café (4)
- ☐ WeWork or similar co-working space (5)
- ☐ Airbnb or another short-term rental (6)
- ☐ Hotel (7)
- ☐ Friend or family's home (8)
- ☐ Somewhere else: (9) _____

**End of Block: SECTION C: Telecommute YES**

**Start of Block: SECTION D: Intro Commute**

Q39 **Section D: Commute Information**

Learning about your commute over the past three years will help us better understand your transportation needs and options. Please note that an in-person workplace includes: Your company's office or worksite Your school's building or campusA client's site

Q40 The following questions are about your commuting habits when you work from your in-person workplace.

| | When did/do you leave for work to head to your workplace? | When did/do you leave from your workplace after working? | How did/do you typically travel to work? |
|---|---|---|---|
| Before the COVID-19 pandemic: (1) | ▼ 1 am (1 ... I only worked/work from home (25) | ▼ 1 am (1 ... I only worked/work from home (25) | ▼ By car (1 ... I only worked/work from home (7) |
| During the first peak of the COVID-19 pandemic [March 2020 - May 2021]: (2) | ▼ 1 am (1 ... I only worked/work from home (25) | ▼ 1 am (1 ... I only worked/work from home (25) | ▼ By car (1 ... I only worked/work from home (7) |
| Now, and since vaccines became widely available [June 2021 until today]: (3) | ▼ 1 am (1 ... I only worked/work from home (25) | ▼ 1 am (1 ... I only worked/work from home (25) | ▼ By car (1 ... I only worked/work from home (7) |

Q41 The following questions will ask more about your commuting habits to your employer's in-person workplace, even if you do not regularly commute there.

| | How long did/does it take you to get from your residence to your workplace location (one way)? | What was/is the approximate distance between your residence and your workplace location (one way, in miles)? |
|---|---|---|
| | | (1) |
| Before the COVID-19 pandemic: (1) | ▼ I worked from home (1 ... 75 minutes or longer (75) | |
| During the first peak of the COVID-19 pandemic [March 2020 - May 2021]: (2) | ▼ I worked from home (1 ... 75 minutes or longer (75) | |
| Now, and since vaccines became widely available [June 2021 until today]: (3) | ▼ I worked from home (1 ... 75 minutes or longer (75) | |

**End of Block: SECTION D: Intro Commute**

**Start of Block: SECTION E: NOW Workplace_Block**

Q42 **Section E: Workplace Information** The following questions are about your current workplace situation. Remember that an in-person workplace refers to:

Your company's office or worksite Your school's building or campus A client's site

Q43 What portion of your current job's tasks do you think could be performed away from your main in-person work location?

- ○ None, my job depends entirely on me being at my work location (1)
- ○ Some of my work could be done from home or remotely (2)
- ○ Most of my work could be done from home or remotely (3)
- ○ All of my work could be done from home or remotely (4)

---

Q44 How many hours per day do you usually work?

_____

---

Q45 Typically, how many days in a month do you work? A five-day work week corresponds to an average of 22 days a month.

▼ 1 (73) ... 31 (132)

Q46 Out of those ${Q45/ChoiceGroup/SelectedChoices} work days in the past month, how many days did you:
Work from home : _____ (1)
Work from your in-person workplace (including from a client's site) : _____ (2)
Work from a third workplace : _____ (3)
Total : _____

*Display This Question:*

*If Out of those ${q://QID369/ChoiceGroup/SelectedChoices} work days in the past month, how many days... [ Work from a third workplace ] > 0*

Q47 In the previous question, you reported that you spend a few days a month working from a third workplace. The next few questions will ask you about your recent commute to the third workplace.

| | When do you usually leave for work at a third workplace location? | When do you usually leave from the third workplace location after working? | How long does it take you to get from your residence to your usual third workplace location? | What is the approximate distance between your residence and your usual third workplace location? |
|---|---|---|---|---|
| | | | one way, in minutes (1) | one way, in miles (1) |
| In the past month, (1) | ▼ 1 am (1 ... 12 am (midnight) (24) | ▼ 1 am (1 ... 12 am (midnight) (24) | | |

Q48 The next set of questions are about working from your in-person workplace.

Knowing more about your current in-person workplace location will help us understand the transportation options available to you. Please provide the zip code of your current in-person workplace location, even if you primarily telework.

○ Zip Code (4) _____

*Display This Question:*

*If Out of those ${q://QID369/ChoiceGroup/SelectedChoices} work days in the past month, how many days... [ Work from your in-person workplace (including from a client's site) ] > 0*

Q49 How satisfied are you with your current commute to your in-person workplace?

- Extremely dissatisfied (9)
- Somewhat dissatisfied (10)
- Neither satisfied nor dissatisfied (11)
- Somewhat satisfied (12)
- Extremely satisfied (13)

**End of Block: SECTION E: NOW Workplace_Block**

---

**Start of Block: SECTION E: Workplace_COMMUTE_IP**

Q50 How much do you agree/disagree with the following statements about your in-person workplace, regardless of whether or not you currently work entirely remote?

---

Q51 There is too much congestion during my commute to or from work.

- Strongly disagree (4)
- Somewhat disagree (5)
- Neither agree nor disagree (6)
- Somewhat agree (7)
- Strongly agree (8)

---

Q52 My workplace is too crowded.

- Strongly disagree (4)
- Somewhat disagree (5)
- Neither agree nor disagree (6)
- Somewhat agree (7)
- Strongly agree (8)

---

Q53 I feel unsafe regarding COVID-19 because of the crowding at my workplace.

- Strongly disagree (4)
- Somewhat disagree (5)
- Neither agree nor disagree (6)
- Somewhat agree (7)
- Strongly agree (8)

---

Q54 Does your employer currently have COVID-19 safety measures in place, or plans to implement them in the near future? (Please respond even if you are self-employed, in which case you would be your own employer)

- No (1)
- Yes (2)

---

*Display This Question:*

*If Does your employer currently have COVID-19 safety measures in place, or plans to implement them i... = Yes*

Q55 Which COVID-19 safety measures has your employer implemented at the workplace?

- [ ] Social distancing (1)
- [ ] Mandatory or strongly encouraged face coverings (2)
- [ ] Hand sanitation stations (3)
- [ ] Barriers (4)
- [ ] Mandatory frequent COVID testing (5)
- [ ] Mandatory or strongly encouraged COVID vaccination (6)
- [ ] Staggered workdays (8)

---

Q56 In the future, will your employer provide the flexibility to work remotely from a location outside the regular, in-person workplace?

- ○ No (23)
- ○ Yes (24)
- ○ I don't know (25)

**End of Block: SECTION E: Workplace_COMMUTE_IP**

---

**Start of Block: SECTION F: Workplace SP Experiment**

Q57 **Section F: Workplace Location Preferences**

Over the past few years, both employees and students have been shifting how and where they work. Determining how your commuting and teleworking patterns may shift in the future will help us understand future transportation environments.

---

Q58 In this next section, you will be presented with two hypothetical scenarios regarding workplace choice. Please take a few minutes to familiarize yourself with the characteristics of the different workplaces, and please consider their attributes when making your choice.

In the following two scenarios, you will have three different options between which to distribute your total monthly workdays:

- **Work from home**
- **Work from your (in-person) workplace**
- **Work from a third workplace**

Again, regardless of the options your employer currently offers, assume you have all options available while distributing your time.

---

Q59 The scenarios will be characterized by the variables listed below, in general and for each work location.

**Your home:**
**Distraction level:** The amount of distraction occurring at your home, whether from roommates, spouse, children, or general activity that diverts your attention from work.

**Your in-person workplace:**
**Change in commute time:** A change in your commute time caused by overall travel pattern shifts from the COVID-19 pandemic.

**Level of crowding:** How crowded your workplace is and the distance between you and other people and their workspaces.

**COVID safety measures**: How your workplace is addressing and implementing COVID-19 safety precautions and regulations.

**A third workplace:**
**Levels of crowding and distraction:** How crowded and distracting the third workplace is.

**Commute length:** The commute to the third workplace, relative to your workplace commute.
**General variables:**
**COVID risk level:** Here, this is defined by what percentage of people are vaccinated and if whether the vaccine is effective against new strands of the virus.

**Shifting work hours**: If you are allowed to shift the time you begin working.

**Splitting work hours**: If you are allowed to split (spread out) your work hours into separate intervals during the day.

Q60 Remember, a third workplace could include locations like a coffee shop, a designated co-working space, a hotel, or a restaurant, but does not include working from a client's site, which would instead be categorized as the in-person workplace. The appeals of a third workplace may include less distractions than when working from home and not having to commute all the way to the regular workplace. However, a third workplace may still have crowding and require a commute.

**End of Block: SECTION F: Workplace SP Experiment**

**Start of Block: SECTION F: Average Commute**

Q61 You have reported that, in the past few months, you have not commuted to an in-person workplace. Therefore, in the two scenarios below, your "base" commute is set to 26.4 minutes (the average commute length in the state of Texas).

**End of Block: SECTION F: Average Commute**

**Start of Block: SECTION F: SP Questions**

Q62 In this scenario, you have three different options for where to work from over the period of one month. Again, regardless of the options your employer currently offers, assume you have all options available when distributing your time. Please carefully review your options.

| COVID risk level | 60% of people are vaccinated and the vaccine is effective for all current strands. Risk is low. | | |
|---|---|---|---|
| ***Attributes*** | ***Work from Home*** | ***Work from the Workplace*** | ***Work from a Third Workplace*** |
| **Distraction level** | No distractions | High distraction | No distractions |
| **Commute time** | - | ${e://Field/commute%20time} minutes, same commute as before | Same length as your commute to the in-person workplace |
| **Level of crowding** | - | The in-person workplace is crowded and you are in close proximity to loud coworkers | No crowding at the third workplace; you have your own designated, quiet, closed-off room |
| **Workplace safety implementation for COVID** | - | No safety regulations | - |
| **Splitting work hours** | Allowed | Not allowed | Allowed |
| **Shifting work hours** | Not allowed | Not allowed | Not allowed |

You reported working ${Q45/ChoiceGroup/SelectedChoices} days last month. For this scenario, please distribute the number of days you would prefer to work at each workplace location so that they all add up to ${Q45/ChoiceGroup/SelectedChoices}. You can put 0 days for one or two of the alternatives, but the sum across all the alternatives should add up to ${Q45/ChoiceGroup/SelectedChoices}.

- Work from home : _____ (1)
- Work from the workplace : _____ (2)
- Work from a third workplace (teleworking from a location that is not your home) : _____ (3)

Total : _____

**End of Block: SECTION F: SP Questions**

---

**Start of Block: SECTION G:COVID Threat_Block**

Q102 **Section G: Perception of the Threat of COVID-19**

We would like to learn about your attitudes and opinions about the COVID-19 pandemic. For each of the following statements, please choose the response that most closely matches your feelings.

---

Q103 Rate how much you agree with the following statements:

| | Strongly disagree (6) | Somewhat disagree (7) | Neither agree nor disagree (8) | Somewhat agree (9) | Strongly agree (10) |
|---|---|---|---|---|---|
| My personal wellbeing was or still is at risk during the pandemic. (1) | ○ | ○ | ○ | ○ | ○ |
| COVID-19 was or still is an immediate threat to my loved ones. (2) | ○ | ○ | ○ | ○ | ○ |

---

Q104 Would you consider yourself immunocompromised?

○ No (21)

○ Yes (22)

---

Q105 Would you consider someone you live with or frequently visit immunocompromised?

- ○ No (21)
- ○ Yes (22)

**End of Block: SECTION G:COVID Threat_Block**

---

**Start of Block: SECTION H: Online Shopping_Block**

Q106 **Section H: Online Behavior**

Almost done! The next set of questions asks you about your shopping and other habits, both online and in person over the past week.

---

Q107 Over the past year, have you shopped for groceries online for home delivery more or less frequently than you did before the COVID-19 pandemic?

- ○ Significantly less (23)
- ○ A little bit less (24)
- ○ No change (18)
- ○ A little bit more (19)
- ○ Significantly more (20)

---

Q108 Over the past year, have you ordered prepared meals online for home delivery (such as takeout from a restaurant) more or less frequently than you did before the COVID-19 pandemic?

- Significantly less (4)
- A little bit less (5)
- No change (1)
- A little bit more (2)
- Significantly more (3)

---

Q109 Over the past year, have you shopped for non-grocery items online (e.g., clothing, electronics, etc.) for home delivery more or less frequently than you did before the COVID-19 pandemic?

- Significantly less (23)
- A little bit more (24)
- No change (18)
- A little bit more (19)
- Significantly more (20)

---

Q110 In the past month, across weekdays (that is, not counting weekend trips), how many times have you undertaken the following activities **in person**?
Shop at the grocery store : _____ (1)
Go out to eat for dinner : _____ (4)
Shop for non-grocery items at a store : _____ (3)
Total : _____

---

*Display This Question:*

*If In the past month, across weekdays (that is, not counting weekend trips), how many times have you... [ Go out to eat for dinner ] > 0*

Q111 Please breakdown your ${Q110/ChoiceNumericEntryValue/4} eat-out dinner occasions by restaurant type.
Fast food/food truck : _____ (1)
Café/coffee shop/pizza place : _____ (2)
Casual sit-in restaurant : _____ (3)
Fine/luxury dining restaurant : _____ (4)
Total : _____

---

Q112 In the past month, across weekdays (that is, not including weekend days), how many times did you:
Order **groceries** online and get them delivered to your house: : _____ (1)
Order **groceries** online and pick them up through curbside pickup: : _____ (2)
Order **a dinner meal** (takeout) online and get it delivered to your house: : _____ (3)
Order **a dinner meal** (takeout) online and pick it up through curbside pickup: : _____ (4)
Order **non-grocery items** online and get them delivered to your house: : _____ (5)
Order **non-grocery items** online and pick them up through curbside pickup: : _____ (6)
Total : _____

Q113 How often do you browse for non-grocery items online and then go to the store in-person to purchase them?

- Never (17)
- Rarely (18)
- Sometimes (19)
- Most of the time (20)
- Always (21)

---

Q114 What about the other way around: how often do you browse for non-grocery items at a store and then buy them online?

- ○ Never (17)
- ○ Rarely (18)
- ○ Sometimes (19)
- ○ Most of the time (20)
- ○ Always (21)

**End of Block: SECTION H: Online Shopping_Block**

---

**Start of Block: SECTION I: Final_Demog_Block**

Q115 **Section I: Background Information**

You have reached the last section of this survey! To help us generalize the responses to this survey to the population as a whole, we would like to ask you a few background questions. Rest assured that your privacy is guaranteed.

---

Q116 What year were you born?

▼ 2005 (1) ... 1900 (106)

---

Q117 What gender do you most identify with?

- ○ Male (1)
- ○ Female (2)
- ○ Non-binary (3)

Q118 Are you Hispanic or Latino?

- ○ No (0)
- ○ Yes (1)

Q119 Which of the following categories do you identify with?

- ☐ White/Caucasian (1)
- ☐ Black/African American (2)
- ☐ Native American (3)
- ☐ Asian or Pacific Islander (4)
- ☐ Other (please specify) (5) _____

---

Q120 What is the highest level of education you have completed?

- ○ Some grade/high school (1)
- ○ High school or GED (2)
- ○ Technical school/associates degree (3)
- ○ Undergraduate degree (4)
- ○ Master's (or equivalent) degree (5)
- ○ Doctorate (or equivalent) (6)

Q121 How many people (including you) live in your household?

▼ 1 person (1) ... 10 or more people (10)

*Display This Question:*

*If How many people (including you) live in your household? != 1 person*

Q122 Please describe the people who live with you.

| | Relationship to you | Age category | Occupation status | Gender |
|---|---|---|---|---|
| Person 2 (F8_2) | ▼ My partner/spouse (1 ... Other (5) | ▼ 0-4 years old (1 ... 65 or more years old (7) | ▼ Part-time worker (1 ... Neither worker nor student (6) | ▼ Male (1 ... Non-binary (3) |
| Person 3 (F8_3) | ▼ My partner/spouse (1 ... Other (5) | ▼ 0-4 years old (1 ... 65 or more years old (7) | ▼ Part-time worker (1 ... Neither worker nor student (6) | ▼ Male (1 ... Non-binary (3) |
| Person 4 (F8_4) | ▼ My partner/spouse (1 ... Other (5) | ▼ 0-4 years old (1 ... 65 or more years old (7) | ▼ Part-time worker (1 ... Neither worker nor student (6) | ▼ Male (1 ... Non-binary (3) |

Q123 In 2021, what was your household's total income (from all sources) before taxes or other deductions? Your household includes everyone who lives in the same dwelling unit, including relatives, roommates and friends.

- Under $10,000 (12)
- $10,000 - $24,999 (13)
- $25,000 - $34,999 (14)
- $35,000 - $49,999 (15)
- $50,000 - $74,999 (16)
- $75,000 - $99,999 (17)
- $100,000 - $149,999 (18)
- $150,000 - $199,999 (19)
- $200,000 - $249,999 (20)
- $250,000 or more (21)
- Prefer not to answer (22)

---

*Display This Question:*

*If In 2021, what was your household's total income (from all sources) before taxes or other deductio... = Prefer not to answer*

Q124 Would you be willing to identify your household's 2021 income in one of the following broad categories?

- ○ Under $25,000 (1)
- ○ $25,000 - $49,999 (2)
- ○ $50,000 - $74,999 (3)
- ○ $75,000 - $99,999 (4)
- ○ $100,000 or more (5)
- ○ Prefer not to answer (6)

**End of Block: SECTION I: Final_Demog_Block**

---

**Start of Block: End_Block**

Q125
Thank you for completing this survey!

Please let us know if you have any additional thoughts or comments:

_____

_____

_____

_____

_____

**End of Block: End_Block**

---

# Appendix G: Master Key for SP Experiment Questions' Attribute Levels

| Question number in dataset | Scenario | COVID-19 risk level | Shifting work hour | Splitting work hour | Distraction level (at home) | Change in commute time | Level of crowding at the outside-of-home workplace | Workplace safety implementation for COVID | Crowding and distraction level at the third workplace | Commute length to third workplace |
|---|---|---|---|---|---|---|---|---|---|---|
| **62** | **1** | Risk is low | Not allowed | Allowed | No distractions | Same commute length as before | High crowding and distractions | No safety regulations | No crowding or distractions | Same length as your other commute |
| **63** | **2** | Risk is high | Allowed | Not allowed | No distractions | 75% longer than before | Extremely low crowding and distractions | Only one safety measure | No crowding or distractions | Same length as your other commute |
| **64** | **3** | Risk is high | Allowed | Not allowed | High distraction | Same commute length as before | Low crowding and distractions | Only one safety measure | No crowding or distractions | Same length as your other commute |
| **65** | **4** | Risk is unknown | Allowed | Not allowed | Low distraction | 75% shorter than before | No crowding or distractions | Two or more safety measures | No crowding or distractions | Same length as your other commute |
| **66** | **5** | Risk is extremely low | Not allowed | Allowed | High distraction | 50% longer than before | Low crowding and distractions | Two or more safety measures | No crowding or distractions | Same length as your other commute |
| **67** | **6** | Risk is low | Not allowed | Not allowed | No distractions | 50% longer than before | No crowding or distractions | No safety regulations | Extremely low crowding and distractions | Same length as your other commute |
| **68** | **7** | Risk is low | Not allowed | Not allowed | Low distraction | 75% longer than before | Low crowding and distractions | No safety regulations | Extremely low crowding and distractions | Same length as your other commute |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **69** | **8** | Risk is high | Not allowed | Allowed | High distraction | 75% shorter than before | High crowding and distractions | No safety regulations | Extremely low crowding and distractions | Same length as your other commute |
| **70** | **9** | Risk is extremely low | Allowed | Allowed | High distraction | 50% shorter than before | Extremely low crowding and distractions | Only one safety measure | Extremely low crowding and distractions | Same length as your other commute |
| **71** | **10** | Risk is unknown | Allowed | Allowed | No distractions | 75% longer than before | No crowding or distractions | Two or more safety measures | Extremely low crowding and distractions | Same length as your other commute |
| **72** | **11** | Risk is high | Not allowed | Not allowed | High distraction | 50% shorter than before | No crowding or distractions | Two or more safety measures | Extremely low crowding and distractions | Same length as your other commute |
| **73** | **12** | Risk is high | Allowed | Not allowed | Low distraction | 50% longer than before | No crowding or distractions | No safety regulations | Low crowding and distractions | Same length as your other commute |
| **74** | **13** | Risk is extremely low | Allowed | Not allowed | No distractions | 75% shorter than before | Extremely low crowding and distractions | No safety regulations | Low crowding and distractions | Same length as your other commute |
| **75** | **14** | Risk is unknown | Allowed | Allowed | High distraction | Same commute length as before | No crowding or distractions | Only one safety measure | Low crowding and distractions | Same length as your other commute |
| **76** | **15** | Risk is extremely low | Not allowed | Allowed | Low distraction | 75% longer than before | High crowding and distractions | Only one safety measure | Low crowding and distractions | Same length as your other commute |
| **77** | **16** | Risk is unknown | Not allowed | Not allowed | Low distraction | 50% shorter than before | High crowding and distractions | Only one safety measure | Low crowding and distractions | Same length as your other commute |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **78** | **17** | Risk is unknown | Not allowed | Not allowed | High distraction | 50% shorter than before | Low crowding and distractions | No safety regulations | High crowding and distractions | Same length as your other commute |
| **79** | **18** | Risk is low | Not allowed | Allowed | Low distraction | 50% longer than before | Extremely low crowding and distractions | Only one safety measure | High crowding and distractions | Same length as your other commute |
| **80** | **19** | Risk is low | Allowed | Allowed | No distractions | 75% shorter than before | Low crowding and distractions | Only one safety measure | High crowding and distractions | Same length as your other commute |
| **81** | **20** | Risk is low | Not allowed | Allowed | High distraction | Same commute length as before | Extremely low crowding and distractions | Two or more safety measures | High crowding and distractions | Same length as your other commute |
| **82** | **21** | Risk is extremely low | Allowed | Not allowed | Low distraction | Same commute length as before | High crowding and distractions | Two or more safety measures | High crowding and distractions | Same length as your other commute |
| **83** | **22** | Risk is extremely low | Allowed | Not allowed | High distraction | 50% longer than before | Extremely low crowding and distractions | No safety regulations | No crowding or distractions | Shorter than your other commute |
| **84** | **23** | Risk is unknown | Not allowed | Allowed | Low distraction | 75% shorter than before | Extremely low crowding and distractions | No safety regulations | No crowding or distractions | Shorter than your other commute |
| **85** | **24** | Risk is low | Not allowed | Not allowed | High distraction | 75% longer than before | No crowding or distractions | Only one safety measure | No crowding or distractions | Shorter than your other commute |
| **86** | **25** | Risk is low | Allowed | Allowed | Low distraction | 50% shorter than before | High crowding and distractions | Only one safety measure | No crowding or distractions | Shorter than your other commute |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **87** | **26** | Risk is high | Not allowed | Allowed | No distractions | 50% shorter than before | Low crowding and distractions | Two or more safety measures | No crowding or distractions | Shorter than your other commute |
| **88** | **27** | Risk is high | Allowed | Allowed | Low distraction | Same commute length as before | No crowding or distractions | No safety regulations | Extremely low crowding and distractions | Shorter than your other commute |
| **89** | **28** | Risk is unknown | Not allowed | Not allowed | No distractions | Same commute length as before | Extremely low crowding and distractions | Only one safety measure | Extremely low crowding and distractions | Shorter than your other commute |
| **90** | **29** | Risk is unknown | Allowed | Allowed | Low distraction | 50% longer than before | Low crowding and distractions | Only one safety measure | Extremely low crowding and distractions | Shorter than your other commute |
| **91** | **30** | Risk is low | Allowed | Not allowed | High distraction | 75% shorter than before | High crowding and distractions | Two or more safety measures | Extremely low crowding and distractions | Shorter than your other commute |
| **92** | **31** | Risk is low | Allowed | Allowed | High distraction | 75% longer than before | Low crowding and distractions | No safety regulations | Low crowding and distractions | Shorter than your other commute |
| **93** | **32** | Risk is high | Not allowed | Allowed | High distraction | 75% shorter than before | No crowding or distractions | Only one safety measure | Low crowding and distractions | Shorter than your other commute |
| **94** | **33** | Risk is low | Allowed | Not allowed | No distractions | 50% shorter than before | Extremely low crowding and distractions | Two or more safety measures | Low crowding and distractions | Shorter than your other commute |
| **95** | **34** | Risk is extremely low | Not allowed | Not allowed | Low distraction | Same commute length as before | Low crowding and distractions | Two or more safety measures | Low crowding and distractions | Shorter than your other commute |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **96** | **35** | Risk is unknown | Not allowed | Allowed | No distractions | 50% longer than before | High crowding and distractions | Two or more safety measures | Low crowding and distractions | Shorter than your other commute |
| **97** | **36** | Risk is extremely low | Allowed | Allowed | No distractions | 50% shorter than before | No crowding or distractions | No safety regulations | High crowding and distractions | Shorter than your other commute |
| **98** | **37** | Risk is unknown | Allowed | Not allowed | High distraction | 75% longer than before | High crowding and distractions | No safety regulations | High crowding and distractions | Shorter than your other commute |
| **99** | **38** | Risk is extremely low | Not allowed | Not allowed | No distractions | 75% shorter than before | No crowding or distractions | Only one safety measure | High crowding and distractions | Shorter than your other commute |
| **100** | **39** | Risk is high | Allowed | Not allowed | No distractions | 50% longer than before | High crowding and distractions | Only one safety measure | High crowding and distractions | Shorter than your other commute |
| **101** | **40** | Risk is high | Not allowed | Allowed | Low distraction | 75% longer than before | Extremely low crowding and distractions | Two or more safety measures | High crowding and distractions | Shorter than your other commute |

# Appendix H: SP Question Organizing

```
####[36] CODE BEGINS
df_nas <- my_data[,seq(182,301)]

##This removes everybody who did not answer any questions
df <- df_nas[!apply(df_nas == "", 1, all), ]


#This creates a sequence of repeated question numbers
q <- numeric()

for(i in 62:101) {
  q <- c(q,(rep(i, times=3)))
}

#This identifies the index of the columns that do not have NA with the question number - this may not be needed with the editing already done on the dataset in previous steps
column <- 1:120

#This combines the two into a dataframe
ref <- as.data.frame(cbind(q,column))

#This shows the question numbers the respondent was presented
Qs <- matrix(NA, nrow = nrow(df), ncol = 2)

for (i in 1:nrow(df)) {
  j <- as.numeric(df[i,])
  Qs[i,] <- unique(ref$q[which(!is.na(j))])
}

As <- matrix(NA, nrow = nrow(df), ncol = 6)

#This shows their answers to those questions
for (i in 1:nrow(df)) {
  j <- as.numeric(df[i,])
  As[i,] <- j[!is.na(j)]
}

#Q1 is the first question a respondent was shown, and Q2 is the second
```

[36] In all code sections the symbol "#" (and any text in bold and underlined) means that the following phrases has been "commented out" or is just there as a description and will not be run as part of the code.

```
df1 <- as.data.frame((cbind(Qs, As))) %>% rename("Q1"= "V1",
                                                 "Q2"= "V2",
                                                 "A1_Q1"= "V3",
                                                 "A2_Q1"= "V4",
                                                 "A3_Q1"= "V5",
                                                 "A1_Q2"= "V6",
                                                 "A2_Q2"= "V7",
                                                 "A3_Q2"= "V8")
```

**#This combines the organized dataset with the SP questions and answers (8 columns total added to the end of the dataset)**

```
dt = cbind(my_data, df1)
```

# Appendix I: Header guide for MAINDATASET.csv

| Header in Dataset | Header description |
|---|---|
| caseID | Response number |
| ResponseId | Response ID |
| Q15.1_1 | Please provide details of all motorized vehicles available in your household. - Body Type - Vehicle 1 |
| Q15.1_2 | Please provide details of all motorized vehicles available in your household. - Body Type - Vehicle 2 |
| Q15.1_3 | Please provide details of all motorized vehicles available in your household. - Body Type - Vehicle 3 |
| Q15.1_4 | Please provide details of all motorized vehicles available in your household. - Body Type - Vehicle 4 |
| Q15.1_5 | Please provide details of all motorized vehicles available in your household. - Body Type - Vehicle 5 |
| Q15.2_1 | Please provide details of all motorized vehicles available in your household. - Fuel Type - Vehicle 1 |
| Q15.2_2 | Please provide details of all motorized vehicles available in your household. - Fuel Type - Vehicle 2 |
| Q15.2_3 | Please provide details of all motorized vehicles available in your household. - Fuel Type - Vehicle 3 |
| Q15.2_4 | Please provide details of all motorized vehicles available in your household. - Fuel Type - Vehicle 4 |
| Q15.2_5 | Please provide details of all motorized vehicles available in your household. - Fuel Type - Vehicle 5 |
| Q15.3_1 | Please provide details of all motorized vehicles available in your household. - Model Year  (e.g., 2004) - Vehicle 1 |
| Q15.3_2 | Please provide details of all motorized vehicles available in your household. - Model Year (e.g., 2004) - Vehicle 2 |
| Q15.3_3 | Please provide details of all motorized vehicles available in your household. - Model Year (e.g., 2004) - Vehicle 3 |
| Q15.3_4 | Please provide details of all motorized vehicles available in your household. - Model Year (e.g., 2004) - Vehicle 4 |
| Q15.3_5 | Please provide details of all motorized vehicles available in your household. - Model Year (e.g., 2004) - Vehicle 5 |
| Q15.4_1 | Please provide details of all motorized vehicles available in your household. - Year Acquired(e.g., 2010) - Vehicle 1 |
| Q15.4_2 | Please provide details of all motorized vehicles available in your household. - Year Acquired(e.g., 2010) - Vehicle 2 |
| Q15.4_3 | Please provide details of all motorized vehicles available in your household. - Year Acquired(e.g., 2010) - Vehicle 3 |
| Q15.4_4 | Please provide details of all motorized vehicles available in your household. - Year Acquired(e.g., 2010) - Vehicle 4 |

| Header in Dataset | Header description |
|---|---|
| Q15.4_5 | Please provide details of all motorized vehicles available in your household. - Year Acquired(e.g., 2010) - Vehicle 5 |
| F8_2_1 | Please describe the people who live with you. - Relationship to you - Person 2 |
| F8_3_1 | Please describe the people who live with you. - Relationship to you - Person 3 |
| F8_4_1 | Please describe the people who live with you. - Relationship to you - Person 4 |
| F8_5_1 | Please describe the people who live with you. - Relationship to you - Person 5 |
| F8_6_1 | Please describe the people who live with you. - Relationship to you - Person 6 |
| F8_7_1 | Please describe the people who live with you. - Relationship to you - Person 7 |
| F8_8_1 | Please describe the people who live with you. - Relationship to you - Person 8 |
| F8_9_1 | Please describe the people who live with you. - Relationship to you - Person 9 |
| F8_10_1 | Please describe the people who live with you. - Relationship to you - Person 10 |
| F8_2_2 | Please describe the people who live with you. - Age category - Person 2 |
| F8_3_2 | Please describe the people who live with you. - Age category - Person 3 |
| F8_4_2 | Please describe the people who live with you. - Age category - Person 4 |
| F8_5_2 | Please describe the people who live with you. - Age category - Person 5 |
| F8_6_2 | Please describe the people who live with you. - Age category - Person 6 |
| F8_7_2 | Please describe the people who live with you. - Age category - Person 7 |
| F8_8_2 | Please describe the people who live with you. - Age category - Person 8 |
| F8_9_2 | Please describe the people who live with you. - Age category - Person 9 |
| F8_10_2 | Please describe the people who live with you. - Age category - Person 10 |
| F8_2_3 | Please describe the people who live with you. - Occupation status - Person 2 |
| F8_3_3 | Please describe the people who live with you. - Occupation status - Person 3 |
| F8_4_3 | Please describe the people who live with you. - Occupation status - Person 4 |
| F8_5_3 | Please describe the people who live with you. - Occupation status - Person 5 |
| F8_6_3 | Please describe the people who live with you. - Occupation status - Person 6 |
| F8_7_3 | Please describe the people who live with you. - Occupation status - Person 7 |
| F8_8_3 | Please describe the people who live with you. - Occupation status - Person 8 |
| F8_9_3 | Please describe the people who live with you. - Occupation status - Person 9 |

| Header in Dataset | Header description |
|---|---|
| F8_10_3 | Please describe the people who live with you. - Occupation status - Person 10 |
| F8_2_4 | Please describe the people who live with you. - Gender - Person 2 |
| F8_3_4 | Please describe the people who live with you. - Gender - Person 3 |
| F8_4_4 | Please describe the people who live with you. - Gender - Person 4 |
| F8_5_4 | Please describe the people who live with you. - Gender - Person 5 |
| F8_6_4 | Please describe the people who live with you. - Gender - Person 6 |
| F8_7_4 | Please describe the people who live with you. - Gender - Person 7 |
| F8_8_4 | Please describe the people who live with you. - Gender - Person 8 |
| F8_9_4 | Please describe the people who live with you. - Gender - Person 9 |
| F8_10_4 | Please describe the people who live with you. - Gender - Person 10 |
| commute.time | Commute time |
| age | Age of respondent |
| ageGroup | Age group of respondent |
| age1829 | Respondent is 18 to 29 years old |
| age3049 | Respondent is 30 to 49 years old |
| age5064 | Respondent is 50 to 64 years old |
| age3064 | Respondent is 30 to 64 years old |
| age65 | Respondent is 65 years or older |
| gender | Gender of respondent |
| female | Respondent is female |
| male | Respondent is male |
| nonBinary | Respondent is non-binary |
| education | Education level of respondent |
| HS | Respondent has a high school level education or lower |
| highEd | Respondent has a higher education (any schooling higher than high school) |
| Bach | Respondent has a Bachelor's degree |
| Grad | Respondent has a graduate degree |
| HHSize | Household Size |
| HH2 | Household size is 2 people |
| HH3 | Household size is 3 people |
| HH4 | Household size is 4 people |
| HH3more | Household size is 3 or more people |
| HH4more | Household size is 4 or more people |
| HHSize1 | Household size is 1 person (respondent lives alone) |
| race | Race of respondent |
| white | Respondent is white |
| black | Respondent is black |
| asian | Respondent is Asian |
| nativeA | Respondent is Native American |

| Header in Dataset | Header description |
|---|---|
| hispanic | respondent is Hispanic |
| emplStatus_pc | Respondent's employment status before COVID |
| stud_pc | Respondent was a student before COVID |
| employ_pc | Respondent was employed before COVID |
| nonEmp_pc | Respondent was not employed before COVID |
| studonline_pc | During COVID, respondent's school went online |
| emplStatus_sc | Respondent's employment status NOW |
| worker | Respondent is employed NOW |
| student | Respondent is a student NOW |
| nonEmpl | Respondent is not employed NOW |
| workTime | Respondent's work structure NOW |
| fullself_sc | Respondent is a full time, self-employed worker NOW |
| partself_sc | Respondent is a part time, self-employed worker NOW |
| fullemp_sc | Respondent is a full time, not self-employed worker NOW |
| partemp_sc | Respondent is a part time, not self-employed worker NOW |
| switchjob | Did the respondent switch jobs during COVID |
| industry | What industry/occupation does the respondent work in |
| mcmf | Occupation type: Manufacturing, construction, agriculture sector |
| trade | Occupation type: Trade |
| info | Occupation type: Information |
| health | Occupation type: Health sector |
| pub | Occupation Type: Public administration |
| pro | Occupation type: Professional services |
| trans | Occupation type: Transportation |
| food | Occupation type: Food services or Retail |
| edc | Occupation type: Education sector |
| oser | Occupation type: "other" services |
| kids | Respondent has children |
| nkids | Respondent does not have children |
| kid04 | Respondent has child(ren) aged 0 to 4 |
| kid512 | Respondent has child(ren) aged 4 to 12 |
| kid1317 | Respondent has child(ren) aged 13 to 17 |
| partner | Respondent lives with a partner |
| roommate | Respondent lives with a roommate |
| parent | Respondent lives with a parent |
| anthWork | Respondent's household is multi-worker household |
| numWorkers | Number of workers in the household |
| inc1 | Income grouping 1 |
| inc2 | Income grouping 2 |
| twenty5 | Income level : <$25,000 |

| Header in Dataset | Header description |
|---|---|
| fifty | Income level : $25,000 to $49,999 |
| seventy5 | Income level : $50,000 to $74,999 |
| onehundred | Income level : $75,000 to $99,999 |
| onefifty | Income level : $100,000 to $149,999 |
| two | Income level : $150,000 to $199,999 |
| twofifty | Income level : $200,000 to $249,999 |
| plustwofifty | Income level : >=$250,000 |
| plustwo | Income level : >=$200,000 |
| less50 | Income level : <$50,000 |
| less100 | Income level : $50,000 to $99,999 |
| less250 | Income level : $100,000 to $249,999 |
| over250 | Income level : >=$250,000 |
| over100 | Income level : >=$100,000 |
| numveh | Number of vehicle in household |
| decVeh | Household decreased number of vehicles during COVID |
| incVeh | Household increased number of vehicles during COVID |
| vehBT | Primary vehicle's body type |
| vehFT | Primary vehicle's fuel type |
| vehMY | Primary vehicle's model year |
| vehBY | Primary vehicle's purchase year |
| vmt_pc | Annual vehicle miles traveled by respondent before COVID |
| vmtpc | Annual vehicle miles traveled by respondent before COVID |
| vmt_c | Annual vehicle miles traveled by respondent during COVID |
| vmtc | Annual vehicle miles traveled by respondent during COVID |
| vmt_sc | Annual vehicle miles traveled by respondent NOW |
| vmtsc | Annual vehicle miles traveled by respondent NOW |
| moreVMT1 | VMT during COVID > VMT before COVID |
| moreVMT2 | VMT now > VMT during COVID |
| moreVMT3 | VMT before COVID > VMT now |
| lessVMT1 | VMT during COVID < VMT before COVID |
| lessVMT2 | VMT now < VMT during COVID |
| lessVMT3 | VMT before COVID < VMT now |
| sameVMT1 | VMT during COVID = VMT before COVID |
| sameVMT2 | VMT now = VMT during COVID |
| sameVMT3 | VMT before COVID = VMT now |
| houseType | Residence type |
| ownHome | Respondent owns their home |
| rentHome | Respondent rents their home |
| familyHome | Residence is a stand-alone, family home |
| aptHome | Residence is an apartment |

| Header in Dataset | Header description |
|---|---|
| townHome | Residence is a town home |
| houseLoc | Population density of residential area |
| rural | Residential region rural |
| suburban | Residential region suburban |
| urban | Residential region urban |
| bedrooms | Number of bedrooms in respondent's household |
| bedpPers | Number of bedrooms per household member in respondent's home |
| privatestudy | Respondent has a private study in their home |
| privatestudyNO | Respondent does not have a private study in their home |
| internetYES | Responded has internet at their home |
| internetNO | Respondent does not have internet at their home |
| homeMove | Did the respondent move during COVID |
| homeZIP | Zip code of respondent's residence |
| comChange | How did the respondent's commute change during COVID |
| comChangeNone | Respondent's commute did not change |
| comChangeYes | Respondent's commute changed |
| leaveFORwork_pc | What time did the respondent leave for work before COVID |
| leaveFORwork_c | What time did the respondent leave for work during COVID |
| leaveFORwork_sc | What time does the respondent leave for work NOW |
| leaveFROMwork_pc | What time did the respondent leave from work before COVID |
| leaveFROMwork_c | What time did the respondent leave from work during COVID |
| leaveFROMwork_sc | What time does the respondent leave from work NOW |
| modeTOwork_pc | What mode of transportation did the respondent take to work before COVID |
| modeTOwork_c | What mode of transportation did the respondent take to work during COVID |
| modeTOwork_sc | What mode of transportation does the respondent take to work NOW |
| commuteTimeTOwork_pc | Commute time to work before COVID |
| commuteTimeTOwork_c | Commute time to work during COVID |
| commuteTimeTOwork_sc | Commute time to work NOW |
| commuteDistTOwork_pc | Commute distance to work before COVID |
| commuteDistTOwork_c | Commute distance to work during COVID |
| commuteDistTOwork_sc | Commute distance to work NOW |
| dailyHoursWork | Hour worked per day |
| monthlyDaysWork | Number of days worked a month |
| home_sc | Number of days worked from home in the past month |
| workplace_sc | Number of days worked from in-person work office in the past month |
| third_sc | Number of days worked from a third work place in the past month |
| home11 | Fraction of days worked from home in the past month |
| work11 | Fraction of days worked from in-person work office in the past month |
| third11 | Fraction of days worked from a third work place in the past month |

| Header in Dataset | Header description |
|---|---|
| allHome_sc | Worked all past month at HOME |
| allWorkplace_sc | Worked all past month at in-person work office |
| allThird_sc | Worked all past month at third workplace |
| majHome_sc | Worked the majority of the past month at HOME |
| majWorkplace_sc | Worked the majority of the past month at in-person work office |
| majThird_sc | Worked the majority of the past month at third workplace |
| nevHome_sc | Worked none of the past month at HOME |
| nevWorkplace_sc | Worked none of the past month at in-person work office |
| nevThird_sc | Worked none of the past month at third workplace |
| WPclosed | Did you workplace close its office or require special permission? |
| WPclosed1 | Your work DID workplace close its office or require special permission |
| comSat | How satisfied are you with your current commute to your in-person workplace? |
| comSat1 | Yes satisfied with commute |
| comCong | There is too much congestion during my commute to or from work. |
| WP_congestion | Yes congestion |
| WP_crowded | My workplace is too crowded. |
| WP_crowded1 | Yes workplace is crowded |
| WP_safe | I feel unsafe regarding COVID-19 because of the crowding at my workplace. |
| WP_safe1 | Yes I feel unsafe in workplace due to crowing and COVID |
| WP_safetyM | Are there safety measures in place? |
| WP_safetyM1 | Yes there are safety measures in place at my workplace |
| WP_safetyM.1 | What safety measures are in place at your workplace? |
| WP_handSan | Safety measures: Hand sanitizer stations |
| WP_barrier | Safety measures: Barriers |
| WP_stagDay | Safety measures: Staggered work days |
| WP_testing | Safety measures: Regular COVID testing |
| WP_vaccine | Safety measures: Vaccine requirements |
| WP_masks | Safety measures: Mandatory masks |
| WP_socialDist | Safety measures: Social distancing |
| remoteTasks | What portion of your work tasks can be performed remote? |
| remoteFuture | Will your employer allow you to work remote in the future? |
| remotePast | In the past 5 years, has your employer allowed you to work remotely? |
| remoteAlways | In the past 5 years have you always worked remote |
| remoteFreq_pc | Telework frequency: BEFORE COVID |
| WFH_pc_never | Telework frequency: BEFORE COVID - never |
| WFH_pc_all | Telework frequency: BEFORE COVID - every day |
| WFH_pc_few | Telework frequency: BEFORE COVID - few times a week |
| WFH_pc_rare | Telework frequency: BEFORE COVID - rarely |
| remoteFreq_c | Telework frequency: DURING COVID |

| Header in Dataset | Header description |
|---|---|
| remoteFreq_sc | Telework frequency: NOW |
| remoteFreq_f | Telework frequency: FUTURE |
| WFH_f_never | Telework frequency: FUTURE - never |
| WFH_f_all | Telework frequency: FUTURE - every day |
| WFH_f_few | Telework frequency: FUTURE - few times a week |
| WFH_f_rare | Telework frequency: FUTURE - rarely |
| remoteWhere_pc | Telework location: BEFORE COVID |
| WFH_pc_home | Telework location: BEFORE COVID - home |
| WFH_pc_third | Telework location: BEFORE COVID - third workplace |
| remoteWhere_c | Telework location: DURING COVID |
| WFH_c_home | Telework location: DURING COVID - home |
| WFH_c_third | Telework location: DURING COVID - third workplace |
| remoteWhere_sc | Telework location: NOW |
| WFH_sc_home | Telework location: NOW - home |
| WFH_sc_third | Telework location: NOW - third workplace |
| remoteWhere_f | Telework location: FUTURE |
| WFH_f_home | Telework location: FUTURE - home |
| WFH_f_third | Telework location: FUTURE - third workplace |
| thirdWhere_pc | What third workplace did you work from: BEFORE COVID |
| coffeeshop_3_pc | What third workplace did you work from: BEFORE COVID - coffee shop |
| palHome_3_pc | What third workplace did you work from: BEFORE COVID - friend or family's home |
| hotel_3_pc | What third workplace did you work from: BEFORE COVID - hotel |
| airbnb_3_pc | What third workplace did you work from: BEFORE COVID - AirBnB |
| weWork_3_pc | What third workplace did you work from: BEFORE COVID - WeWork |
| other_3_pc | What third workplace did you work from: BEFORE COVID - other |
| thirdWhere_c | What third workplace did you work from: DURING COVID |
| coffeeshop_3_c | What third workplace did you work from: DURING COVID - coffee shop |
| palHome_3_c | What third workplace did you work from: DURING COVID - friend or family's home |
| hotel_3_c | What third workplace did you work from: DURING COVID - hotel |
| airbnb_3_c | What third workplace did you work from: DURING COVID - AirBnB |
| weWork_3_c | What third workplace did you work from: DURING COVID - WeWork |
| other_3_c | What third workplace did you work from: DURING COVID - other |
| thirdWhere_sc | What third workplace did you work from: NOW |
| coffeeshop_3_sc | What third workplace did you work from: NOW - coffee shop |
| palHome_3_sc | What third workplace did you work from: NOW - friend or family's home |
| hotel_3_sc | What third workplace did you work from: NOW - hotel |
| airbnb_3_sc | What third workplace did you work from: NOW - AirBnB |

| Header in Dataset | Header description |
|---|---|
| weWork_3_sc | What third workplace did you work from: NOW - WeWork |
| other_3_sc | What third workplace did you work from: NOW - other |
| leaveFORthird | In the past month, when have you left FOR the third workplace |
| leaveFROMthird | In the past month, when have you left FROM the third workplace |
| timeTOthird | Time to get to third workplace |
| COVIDriskME | Do you believe COVID is still a risk to you? |
| COVIDriskME1 | COVID is a risk to me |
| COVIDriskOTHERS | Do you believe COVID is still a risk to someone you live with or frequently see? |
| COVIDriskOTHERS1 | COVID is a risk to someone I live with or frequently see |
| immunoME | Is respondent immunocompromised? |
| immunoME1 | respondent is immunocompromised |
| immunoOTHERS | Is someone respondent lives with or frequently sees immunocompromised? |
| immunoOTHERS1 | Someone respondent lives with or frequently sees is immunocompromised |
| onlGroc | Over the past year, have you shopped for groceries online for home delivery more or less frequently than you did before the COVID-19 pandemic? |
| onlMeals | Over the past year, have you ordered prepared meals online for home delivery (such as takeout from a restaurant) more or less frequently than you did before the COVID-19 pandemic? |
| onlNonGroc | Over the past year, have you shopped for non-grocery items online (e.g., clothing, electronics, etc.) for home delivery more or less frequently than you did before the COVID-19 pandemic? |
| shopATgroc | In the past month, across weekdays (that is, not counting weekend trips), how many times have you - Shopped at the grocery store |
| shopATNongroc | In the past month, across weekdays (that is, not counting weekend trips), how many times have you - Gone out to eat for dinner |
| fastFood | In the past month, across weekdays (that is, not counting weekend trips), how many times have you - Shopped for non-grocery items at a store |
| cafe | In the past month, how many times have you eaten at a coffee/coffee shop/pizza place |
| casual | In the past month, how many times have you eaten at a casual sit-in restaurant |
| fancy | In the past month, how many times have you eaten at a fine/luxury dining restaurant |
| onlGrocDelFreq | In the past month, how many times did you order groceries online and get them delivered to your house |
| onlGrocCurbFreq | In the past month, how many times did you order groceries online and pick them up through curbside pickup |
| onlMealDelFreq | In the past month, how many times did you order a dinner meal (takeout) online and get it delivered to your house |
| onlMealCurbFreq | In the past month, how many times did you order a dinner meal (takeout) online and pick it up through curbside pickup |
| onlNonGrocDelFreq | In the past month, how many times did you order non-groceries items online and get them delivered to your house |

| Header in Dataset | Header description |
|---|---|
| onlNonGrocCurbFreq | In the past month, how many times did you order non-groceries items online and pick them up through curbside pickup |
| onlToIP | How often do you browse for non-grocery items online and then go to the store in-person to purchase them? |
| ipToOnl | What about the other way around: how often do you browse for non-grocery items at a store and then buy them online? |
| Q1 | Number of first SP question |
| Q2 | Number of second SP question |
| A1_Q1 | Number of days allocated to work from home alternative for first SP question |
| A2_Q1 | Number of days allocated to work from in-person work office alternative for first SP question |
| A3_Q1 | Number of days allocated to work from third workplace alternative for first SP question |
| A1_Q2 | Number of days allocated to work from home alternative for second SP question |
| A2_Q2 | Number of days allocated to work from in-person work office alternative for second SP question |
| A3_Q2 | Number of days allocated to work from third workplace alternative for second SP question |
| COVIDriskLevel_Q1 | COVID risk level attribute of first SP question |
| ShiftingHour | Shifting work hour attribute of first SP question |
| SplittingHour_Q1 | Splitting work hour attribute of first SP question |
| DistractionHome_Q1 | Distraction level at home attribute of first SP question |
| ChangeCom_Q1 | Commute change to in-person work office attribute of first SP question |
| CrowdWork_Q1 | Distraction level at in-person work office attribute of first SP question |
| SafetyImplWork_Q1 | Safety implementation at in-person work office attribute of first SP question |
| CrowdThird_Q1 | Distraction level at third workplace attribute of first SP question |
| ComThird_Q1 | Commute time to third workplace attribute of first SP question |
| COVIDriskLevel_Q2 | COVID risk level attribute of second SP question |
| ShiftingHour_Q2 | Shifting work hour attribute of second SP question |
| SplittingHour_Q2 | Splitting work hour attribute of second SP question |
| DistractionHome_Q2 | Distraction level at home attribute of second SP question |
| ChangeCom_Q2 | Commute change to in-person work office attribute of second SP question |
| CrowdWork_Q2 | Distraction level at in-person work office attribute of second SP question |
| SafetyImplWork_Q2 | Safety implementation at in-person work office attribute of second SP question |
| CrowdThird_Q2 | Distraction level at third workplace attribute of second SP question |
| ComThird_Q2 | Commute time to third workplace attribute of second SP question |

# Appendix J: Value of Research (VoR)

## Introduction

An analysis of the forecasted economic benefits of the TxDOT Research Project 0-7054 is explained in this appendix. The proposed methodology and accompanying recommendations will aid MPOs in the design of a successful RP-SP integrated regional travel survey, and improved model development. The resulting improved forecasts and policy analysis ability will aid TxDOT in appropriate infrastructure investment and proactive decision-making. Even a marginal improvement in forecasting and policy analysis can lead to substantial benefits. For instance, each mile of roadway/bridge construction can cost anywhere from 3 to 20 million dollars. Compared to this level of investment, investment in models that are used to make decisions leading up to transportation investment decisions cost a miniscule amount. Indeed, research in transportation is estimated at about 1% of the transportation sector GDP output, while the comparable figure is about 10% or so for other sectors such as the IT sector. Given that insights from the results of this project impact the land-use, transportation, air quality, greenhouse gas emissions, and energy sectors, the benefit-to-cost ratio for the project is expected to be substantial.

Overall, the results from this study deliver better reliability into the future for predicting land use patterns and travel behavior. The world, and Texas in particular, is approaching a fast-evolving future, especially as society proceeds into a post-COVID world. The application of the insights gathered from the workplace location (WPL) portion of the study and the use of other SP experiments in surveys will enable TxDOT to assess shifts in travel behavior as the rapidly evolving future introduces advancing technology, complex transportation policies, and large-scale infrastructure projects.

The economic benefits from this project are widespread and have the potential to affect almost every realm of the transportation planning process, including:

- Safety
- Equity
- Mobility
- Investment in infrastructure
- Sustainability
- Cost reduction

- Investment cost reduction
- Air quality
- Climate adaption

However, because evaluating the monetary economic effect of each of these qualitative benefits are hard to estimate, this VoR will focus on the cost reduction of road system investments, specifically new construction and maintenance on roadways.

## Cost savings on new construction and maintenance of roadways

Results from both the WPL portion of the study and from travel behavior gathered from future applications of SP experiments will lead to network and travel demand insights that can help prevent unnecessary new roadway construction, as well as minimize road infrastructure maintenance. This will save a considerable amount of money for TxDOT. To illustrate this potential, consider the increased remote work from home brought about by COVID (about 75% of the population, according to Table 10.3, work remotely at least once during the month, according to Table 10.9). These employees will eliminate their commute to the in-person workplace on at least some of the workdays. Such a reduction in vehicles on the roads during peak congestion hours diminishes the demand for new roadways and decreases the wear-and-tear of existing roadways. The degree to which commuting and congestion reduces in different regions across Texas, and within specific sociodemographic groups and occupation sectors, can be extracted to an even more detailed degree from the results of the WPL portion of the study.

To provide a sense of the value of the undertaken research in the context of road investment costs, the following assumptions will be made and the following estimation process will be followed.

1. Assume that the insights from this study will affect the entire transportation roadway network of Texas, which is a total of about **200,000 miles** (according to the 2020 Texas Roadway Inventory Annual Report)
2. However, it can be assumed that these insights will only affect a small % of roadway infrastructure investments, say **1% of roadway construction and maintenance** costs.

3. Determine the percentage of roads impacted each year:
    - **12%** of the 200,000 road miles have maintenance performed on them each year (~24,000 miles) (According to TxDOT's 4-Year Pavement Management Plan (FY2019-FY2022))
    - **0.2%** more new road miles are newly constructed each year (~400 miles) (according to calculations using the same 4-Year Pavement Management Plan (FY2019-FY2022))
4. Evaluate cost per mile for[37]:
    - Maintenance: **$8,333 per road-mile** (according to calculations using the same 4-Year Pavement Management Plan (FY2019-FY2022))
    - New construction: **$3.3 million per road-mile** (according to calculations using the same 2019-2022 four-year plan)
5. Calculate the total cost per year spent on the entire road network in Texas:
    - Maintenance: $8,333 × 12% × 200,000 miles = **$199,992,000 a year** ($200 million, which is the number that aligns with the costs from Texas's most current, 2022 four-year plan ($0.2 billion for maintenance))
    - New construction: $3.3 million × 0.2% × 200,000 miles = **$1,320,000,000 a year** ($1320 million, which is the number that aligns with the costs from Texas's 2022 four-year plan ($1.3 billion for new construction))
    - Total: $1,520,000,000 ($1.5 billion) for the entire Texas road network per year
6. Appraise the money saved from the effect of the project's insight:
    - 5% × $1,520,000,000 = $76,000,000 a year (in 2022)
    - 2% × $1,520,000,000 = $30,400,000 a year (in 2022)
    - 1% × $1,520,000,000 = **$15,200,000 a year** (in 2022)
        - Even with just a 1% impact, the projects' insights will save **$1.52 million in road system investments a year**.

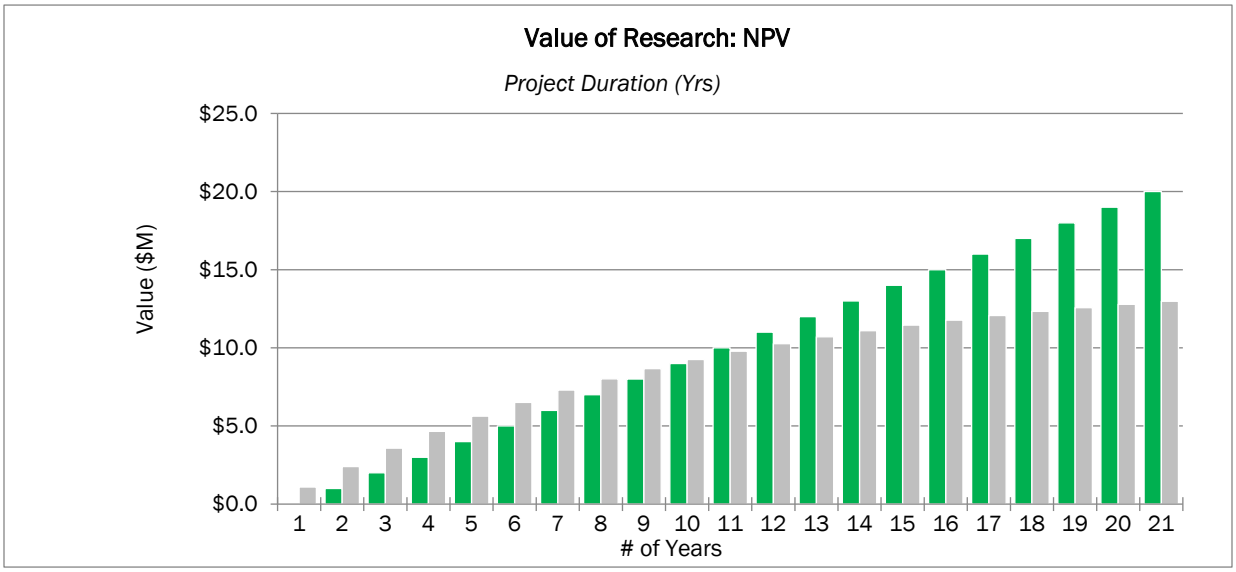
## Final Benefit-Cost Ratio

The total project cost was $376,600.48.

To calculate the benefit-cost ratio on just the study's impact on new construction and maintenance of roadway described in the analysis above, we input the yearly value of saving of $1.52 million into the VoR calculation system.

[37] These cost on account for only the money spent on road and related infrastructure, and excludes overhead or other costs.

In evaluating this over the course of 20 years with a 5% discount rate, the benefit-cost ratio amounts to 34:1, with net present values (NPV) of almost $13 million and total savings of over $19 million. This roughly models a similar impact of the study's WPL insights and the results from other SP experiments included in future TxDOT-designed surveys, each year for over 20 years.




The benefit-cost ratio is for a small, 1% effect of this research on new construction and maintenance of roadways and related infrastructure across the state of Texas. It is important to note that other analyses of the considerable number of economic benefits listed above could be performed, leading to the calculation of an even higher VoR for this study over the next 20 years and beyond for TxDOT.

## References


TxDOT (2020). Roadway Inventory Annual Report. Available at: https://ftp.txdot.gov/pub/txdot-info/tpp/roadway-inventory/2020.pdf.

TxDOT (2018). 4-year Pavement Management Plan (FY2019-FY2022). Available at: https://ftp.dot.state.tx.us/pub/txdot-info/tpp/ters/pavement-management-plan.pdf.