Analysis of Online Shopping and Shopping Travel Behaviors in West Seattle

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TABLE OF CONTENTS

The purpose of this research is to explore consumers' online shopping and in-person shopping travel behaviors and the factors affecting these behaviors within the geographical context of the study area of West Seattle.

West Seattle is a peninsula located southwest of downtown Seattle, Washington State. In March 2020, the West Seattle High Bridge, the main bridge connecting the peninsula to the rest of the city, was closed to traffic due to its increased rate of structural deterioration. The closure resulted in most of the traffic being re-distributed across other bridges, forcing many travellers to re-route their trips in and out of the peninsula. At about the same time, the COVID-19 pandemic caused business-shuttering lock downs. Both events fundamentally changed the nature of shopping and the urban logistics system of the study area.

The Seattle Department of Transportation (SDOT) engaged the Urban Freight Lab (UFL) center at the University of Washington to conduct research to understand current freight movements and goods demands in West Seattle and identify challenges related to the bridge closure to inform data-driven mitigation strategies. The study took place in two phases: the first phase documented the challenges experienced by local businesses and carriers through a series of interviews and quantified the freight trip generated by land use in the case study area[1]; the second phase, described in the current report, performed an online survey to understand online shopping and in-person shopping travel behaviors for West Seattle residents.

The main objectives of the current study are twofold.

1.   Describe online shopping and shopping travel consumer behaviors for West Seattle residents.

2.   Understand what factors influence consumer shopping behaviors, from accessibility to local stores, to the characteristics of goods purchased, to socio-economic factors.

To address these objectives, the research team designed an online questionnaire that was advertised through a West Seattle Bridge Closure-related SDOT newsletter and other local online media outlets during the spring and summer of 2022. The questionnaire asked respondents about their socioeconomic conditions (age, income, education, etc.), where they live and their access to transportation (vehicle ownership and types of vehicles), their online shopping behavior, the impact of the West Seattle High Bridge closure on their shopping habits, and about their most recent purchase for a given category of goods among clothing items, groceries, restaurant food, and household supplies. The questionnaire was collected anonymously, and no personally identifiable information was collected. A total of 1,262 responses were collected, and after data processing, the final sample data consisted of 919 responses, corresponding approximately to 1 percent of the study area population.

Comparing the socioeconomic characteristics of the sample with those of the West Seattle study population it should be noted that individuals identifying themselves as white and female and of older age were oversampled, while individuals with lower than a college degree and with annual income less than $50,000 were under-sampled. Therefore, the sample in general is more representative of a more affluent, older population.

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1   See the phase 1 final report *A. Goodchild, G. Dalla Chiara, N. Goulianou, and S. Gunes, "Understanding and Mitigating Freight-Related Impacts from the West Seattle Bridge Closure," Seattle, WA, U.S., 2021,* available at http://depts.washington.edu/sctlctr/sites/default/files/research_pub_files/UFL_WSea-Bridge.pdf

The key findings are summarized as follows.

1. Online shopping is widespread for clothing items and restaurant food

Respondents receive on average 5 deliveries per week, across all goods categories. 38.7 percent of the respondents reported performing their most recent shopping activity online, considering all goods categories. However, the frequency of online shopping varied across different goods categories. Most of the respondents that purchased groceries or household supplies reported having shopped in person (89 and 75 percent of the respondents respectively), while, in contrast, for those that purchased restaurant food and clothing items, two-thirds of respondents reported buying online in both categories. Online shopping is widespread in the clothing and restaurant food markets, but less in grocery and household supplies markets. Of the consumers that shopped online for restaurant food, 76 percent of them decided to travel to take out (also referred to as curbside pickup), and only 24 percent of them chose to have the meal delivered directly to their home.

2. Online shopping is more widespread among mobility-impaired individuals

Participants were asked whether they had a disability that limited physical activities such as carrying, walking, lifting, etc. Of the 918 participants, 98 (11%) responded that they did have a disability that fit this description. The share of respondents that shop online was higher among mobility-impaired individuals (30 percent online for delivery and 19 percent online for pick-up) compared to individuals that did not report any mobility impairment (23 percent online for delivery and 12 percent online for pick-up).

3. Driving is the predominant shopping travel mode

Of the sample of respondents, 96 percent reported having access to a motorized vehicle within their household. Driving is also the most common shopping mode of in-person travel, with 81.3 percent of respondents reporting that they drove to a store to shop. Walking is a distant second preferred shopping travel mode, with 13.1 percent of respondents reporting having walked to a store. Biking and public transit were rarely adopted as a shopping travel mode, together they were observed 5.6 percent of the time. Though included as a travel option, only 1 participant reported using a rideshare vehicle to shop.

4. Electrification in West Seattle

Of the respondents that have access to a motorized vehicle in their households, 9.8 percent of them reported owning an electric vehicle. Car ownership is much more widespread than bike ownership, with 51.6 percent of the respondents reporting having access to a bike. Among these, 15.5 percent of them said that at least one of their bikes is electric.

5. The 10-minute city

The average walking time across all types of goods purchased was 10 minutes. The average driving time, for those respondents that reported driving to a store, was also about 10 minutes, except for those who reported purchasing clothing items, which reported on average of 27-minute trip time (both using a private car or using public transit). The longest travel times are seen mostly for respondents that took public transit as a shopping travel mode.

6. Living in proximity to stores reduces driving and online deliveries

A higher number of stores within a 10-minute walking distance (0.5 miles) is correlated with a higher number of consumers choosing to walk to a store, compared to those that chose to drive to a store or that shopped online. This is true across all goods types, but it is more significantly seen in grocery shopping. Moreover, accessibility to commercial establishments at a walking distance has a stronger impact on reducing the likelihood of driving, and at a lesser magnitude, reduces the propensity of shopping online.

7. Delivery to the doorstep is the most common destination for online deliveries

For those that chose to buy online, the most common delivery destination was at the respondents' home doorstep (84 percent of respondents reported receiving online deliveries at home). The second most frequently used delivery destination was parcel lockers (15 percent of respondents), with 12 percent of respondents making use of private lockers, while only 3 percent made use of public lockers. The remaining one percent received deliveries at other destinations (e.g. office or nearby store).

8. The West Seattle High bridge closure incentivized local shopping

When asked about the impacts of the West Seattle bridge closure on individual online and shopping travel behaviors, more respondents reported buying more locally and online, vs. traveling farther for shopping and buying in person.

1

Introduction

1   INTRODUCTION

1.1 E-commerce and consumer behavior

The purpose of this research is to explore consumers' online shopping and shopping travel behaviors and the factors affecting these behaviors within the geographical context of West Seattle (WS). Consumers are the key stakeholders in urban supply chains, as their aggregated choices of what, how, and when to buy, affect the local economy, the transportation system, and the environment. Consequently, understanding how consumers shop, and how their behavior affects the urban transportation and land use system, is necessary for urban planners to make data-driven decisions on how to support more sustainable behaviors.

In the last decade, consumer behaviors in the U.S. have been deeply transformed. Since the advent of the internet, the share of retail sales from online channels has continuously gained ground. In 2012, ten years ago from the writing of this report, retail sales from online channels represented 5.4 percent of total retail sales in the U.S. [1]. This share grew to 14.8 percent in 2022 [2], as shown in Figure 1.

Figure 1. Estimated Quarterly U.S. retail e-commerce sales as a percentage of total quarterly sales. Source: U.S. Census Bureau News, Quarterly retail e-commerce sales, 3rd quarter 2022 [2]
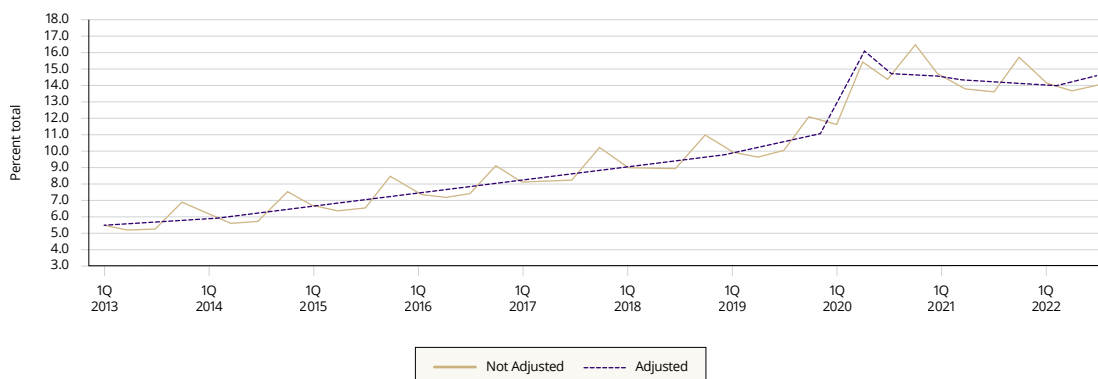
Online shopping has profoundly affected consumer shopping travel. Traditionally, consumers travelled only to commercial establishments to shop. Online shopping has disrupted this model by introducing home deliveries, with most online shoppers requesting for the goods to be delivered to their doorstep. Home deliveries have increased the number of residential freight trips, i.e. trips often performed by cargo vans and smaller trucks directly to residential buildings.

Even with the increase in online shopping, and the consequent increase in residential deliveries, consumers still travel to purchase goods in person. According to the 2017 National Household Travel Survey, 41.2 percent of person trips performed with private vehicles are performed for shopping [3].

Online shopping has also provided hybrid shopping options, where consumers purchase the goods online but pick them up at stores or locations different than their residences. According to a 2018 U.S. study, 50 percent of the respondents reported that they had their online purchases shipped to a retail storefront at least once in the last year [4]. 52 percent of the respondents declared an interest in shipping their online purchases to locations other than their homes if extended hours and/or reduced delivery fees were an option [4].

Consumer behaviors are not only affected by global trends such as urbanization, online retail channels, and home-delivery services. Individual socioeconomic factors, and contextual factors, play a key role in affecting these behaviors. Socio-economics factors, such as gender, income, personal mobility, and access to vehicles, among others, deeply affect how and where consumers shop. Contextual local factors are also influential. Where we live, the characteristics of the urban form around our place of consumption, and access to transportation options, also influence consumers' behaviors.

This report will analyze consumer shopping behaviors by way of data collected through an online survey performed in the West Seattle peninsula.

## 1.2 The West Seattle case study

West Seattle (WS) is an area of the city of Seattle, in the State of Washington, located on a peninsula west of the Duwamish waterway and east of the Puget Sounds (see Figure 2). In March 2020, the West Seattle High Bridge, the main bridge connecting WS to the rest of the city, was closed to traffic due to its increased rate of structural deterioration. The closure resulted in most of the traffic being re-distributed across the 1st Avenue South Bridge and the South Park bridge, forcing many travellers to re-route their trips to travel in and out of the peninsula. At about the same time, the COVID-19 pandemic caused business-shuttering lockdowns and fundamentally changed the nature of shopping.

The Seattle Department of Transportation (SDOT) engaged the Urban Freight Lab (UFL) at the University of Washington, to research to understand current freight movements and freight demands in WS and identify challenges related to the bridge closure to inform data-driven mitigation strategies.

The project was structured in two phases.

- In project Phase 1, the research team performed a freight trip generation (FTG) estimation and conducted interviews with local business establishments, carriers, and the Port of Seattle. As a result of the FTG modeling, the research team estimated that 94 percent of the freight trips generated by WS are destined for residential buildings. Moreover, the interviews with local business owners identified disruptions in the supply chains of small and medium-sized local businesses as well as carriers facing longer travel times to access the peninsula. The results from Phase 1 are described in the report titled "Understanding and Mitigating Freight-Related Impacts from the West Seattle Bridge Closure" [5].

- In project Phase 2, which results are described in the current report, the research team shifted the focus from commercial establishments to consumers and performed an online consumer survey to better understand residential demand and West Seattle consumer online shopping and shopping travel behaviors.

Figure 2. Map of the southern part of the Seattle metropolitan region. Highlighted the West Seattle study area and the three main bridges connecting it to the rest of the city. Source: Phase 1 report of West Seattle study [5]
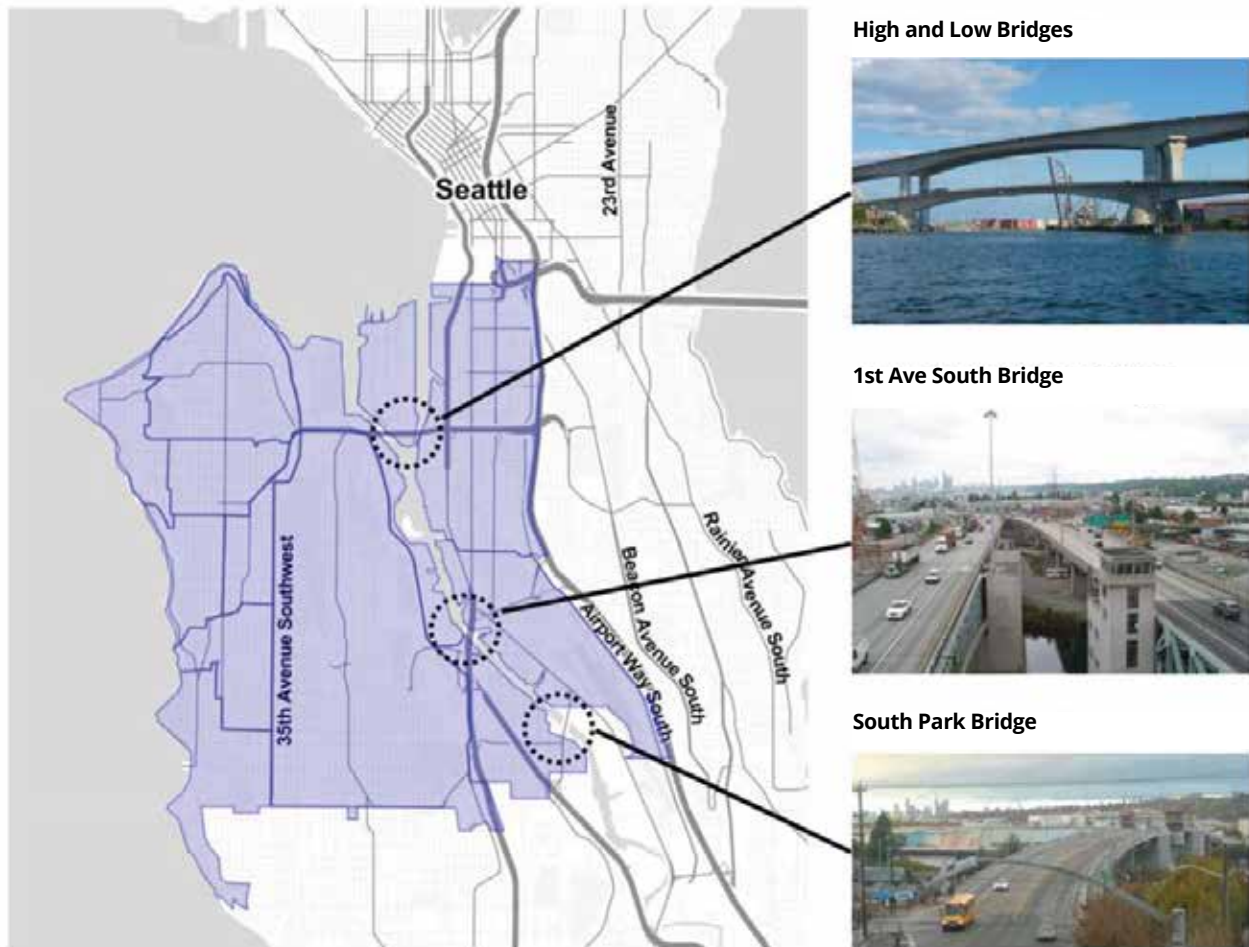
1.3 Research objectives

The current report addresses two objectives.

3. Describe consumer behavior for West Seattle residents, in particular, we will address how (online vs. in-person by travel mode), where (locally or not locally), and how often West Seattle residents shop.

4. Understand what factors influence consumer behavior, and how consumer behavior is impacted by accessibility to local stores within a 15-minute walking range, by characteristics of the goods purchased, and by socio-economic factors.

To address these objectives, an online survey was designed and deployed in local newsletters that kept West Seattle residents informed on the West Seattle bridge repairing operations, and local news outlets. Surveyors were first asked about their socioeconomic characteristics (age, gender, race, annual income, living conditions, etc.), and about their usual shopping behavior (shopping frequency, deliveries received per week, etc.). Then, surveyors answered a series of questions related to one last purchase that they performed, for a given category among groceries, household supplies, restaurant-prepared food, and clothing items. Section 3.1 of the report describes the questionnaire developed, and section 3.2 describes how the survey was deployed.

Data obtained from the survey was then analyzed to address the following questions, which answers are reported in sections 4.1 to 4.8.

- How often do consumers shop?
- How often do consumers shop online vs. in person?
- How do consumers travel for in-person shopping?
- How much time do consumers spend traveling for shopping?
- Does proximity to stores reduce driving?
- How do consumers receive online deliveries?
- Have consumers experienced package theft?
- What factors influence shopping behavior?
- How did the West Seattle High bridge closure impact shopping behavior?

We conclude in section 5 by summarizing the main findings.

2

Study Area

2 STUDY AREA

The study area considered in this research is West Seattle (WS), an area of the city of Seattle, in the State of Washington, located on a peninsula west of the Duwamish waterway and east of the Puget Sounds. The study area is subdivided into 10 neighborhoods: Alki, Delridge, Fairmount Park, Fauntleroy, Gatewood, Genesee, Industrial District West, North Admiral, Seaview, and South Park. Within the study area, there are also two terminal ports, the T-5 and T-115, located on the east coast of the peninsula.

Table 1 displays the main summary statistics of WS. In 2019, a total of 99,072 people lived in WS, distributed over a total of 28,759 buildings (about 3.5 people per building). The population density is 6,857 people per square mile. Figure 3 shows the population density by neighborhood. We note that the northwest part of the peninsula is the most densely populated. From Figure 4 we also note that the West and Center part of the peninsula is mostly residential with some commercial centers, while the east coast of the peninsula along the Duwamish River is mostly industrial. Overall, 86 percent of the land in the study area is dedicated to residential use.

Table 1. Study area population and land use

STATISTICS	VALUE
Land area (square mile)	14.5
Population	99,072.0
Population density (people per square mile)	6,857.0
Number of buildings	28,759.0
Land use type • Industrial • Residential • Commercial • Public buildings	 10.0 % 86.2 % 2.7 % 1.2 %

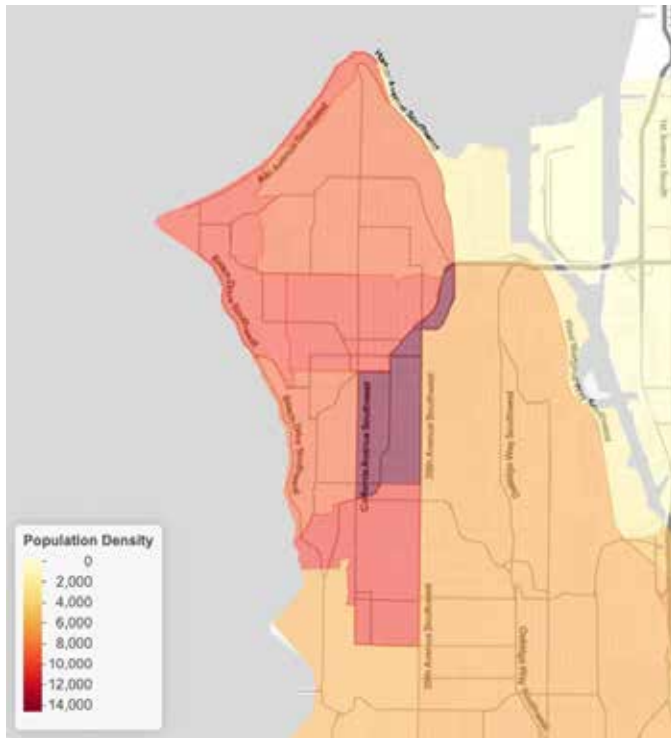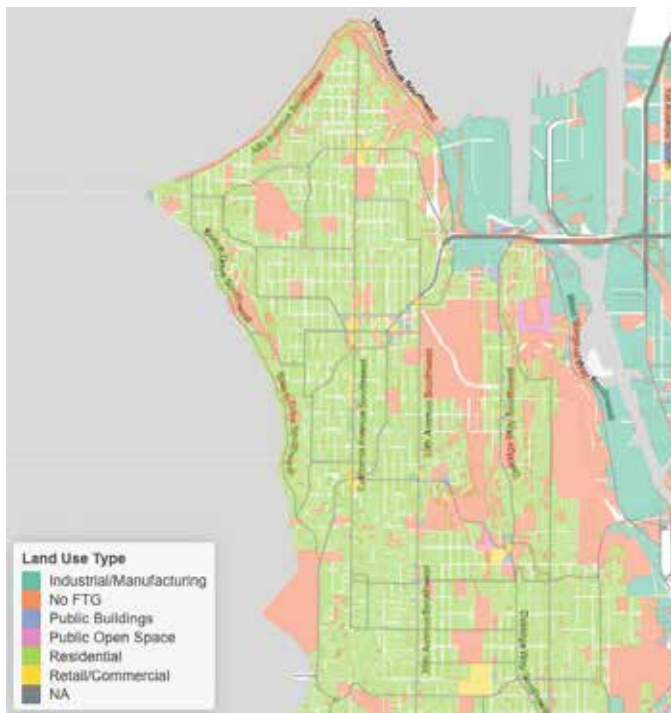**Figure 3. Population density by neighborhood in the study area**

Figure 4. Geographical distribution of land use in the study area

3

Methodology

③ METHODOLOGY

3.1 Survey design

A survey questionnaire was developed to collect data on consumer behavior among West Seattle residents. The full survey can be found in Appendix A – Survey Questionnaire. The questionnaire was structured in five main parts, summarized in Table 2.

- Part 1: Socioeconomic factors
- Part 2: Dwelling and transportation
- Part 3: Delivery shopping behavior
- Part 4: Most recent shopping activity
- Part 5: Impacts of West Seattle High Bridge closure

Table 2. Summary of questionnaire

SECTION	TOPICS COVERED
Part 1: Socioeconomic factors	• General demographics (Age, Gender, Race, etc.) • Socioeconomic status (Household size, Income, Mobility disability, etc.)
Part 2: Dwelling & transportation	• Access and type of vehicle • Access to micromobility (Bicycles, scooters, etc.) • Nearest intersection to the residence
Part 3: Delivery behavior	• Residential package security (lockers, reception) • Usual behavior (frequency, delivery location)
Part 4: Most recent shopping activity	One goods type was randomly assigned (among groceries, household supplies, restaurant food, and clothing items) to each surveyor, reporting: • Time of most recent shopping activity • Quantity purchased • Shopping choice (in-person/online) • If shopped in-person: transport mode and travel time • Delivery Location
Part 5: West Seattle Bridge closure impacts	• Behavior changes (shopping distance, in-person/online preference, etc.) • Other bridge closure effects

Part 1 | Socioeconomic factors: The survey begins with demographic questions to understand the distribution of our respondents. Included in this section are questions about race, income, education level, and other standard demographic questions used by the U.S. Census and Seattle Department of Transportation.

Part 2 | Dwelling and transportation: The demographic section is followed by the home and transportation section, where we ask about the respondent's access to personal vehicles. Rather than ask whether the respondent personally owns a vehicle, we ask at the household level to measure access instead of ownership.

We further ask about micromobility, e.g. bicycles, scooters, and other types of transportation that do not require a driver's license with the option for the respondent to fill in an unlisted micromobility type. We make the distinction between bicycles, electric bicycles, and cargo bicycles here since the different types of cycles have different ranges and payload capacities and could significantly affect the activities for which it is used. To measure each respondent's access to nearby stores and restaurants, we needed to determine their location; however, this presented a privacy concern. Instead, we asked about the nearest intersection to their home so respondents would not need to share their home addresses. Using the nearest intersection, we are still able to calculate distances to various stores without collecting identifying information. However, after concern was expressed during our review process that some participants may feel uncomfortable sharing the nearest intersection, we added a note to the question suggesting that participants share a nearby landmark or bus stop if they preferred.

Part 3 | Delivery shopping behavior: Following the home and transportation section is the delivery section. Here we ask whether respondents have a secure way to receive packages at their residences like a locker or reception area, how they typically receive deliveries, their experience with package theft, and how often they receive deliveries. Our later questions ask specifically about the most recent shopping experience, but here we ask about usual behavior to understand what delivery service options respondents have access to.

Part 4 | Most recent shopping activity: After completing each of the above sections, survey respondents were assigned to one of the following four sections randomly: Groceries, Household Supplies, Restaurant Food, and Clothes. These categories were defined to the respondents as follows:

- Groceries: "[Items]... bought from a grocery store, for example: "fresh produce, milk, and eggs from Safeway". Food items bought from a convenience store, like "snacks from 7-11" are not included in the term "groceries" "
- Household Supplies: "cleaning products, trash bags, laundry detergent, toothpaste, etc."
- Restaurant Food: "...any meal prepared by someone in food service/from a food establishment that you travelled to from home, or ordered for delivery to your home. Please do not include restaurant food that you ordered/travelled to from work or any location other than home."
- Clothes: "... any clothes, footwear, outerwear, underwear, etc."

Though the survey was originally designed to have respondents answer questions in every category, the random selection of one out of the four categories was made to achieve the target time of 5 minutes for survey completion. Within each of these categories, we ask how often the respondent has shopped for the goods type within the last 3 months. If the respondent had not shopped for this goods type in the last 3 months, we did not ask any further questions in the section, as we believed that too long had elapsed to get accurate information. Otherwise, we proceed to ask about the most recent time they shopped for the goods type. We ask what volume of goods they bought, whether they shopped in-person, ordered online for pickup, or ordered online for delivery. If respondents shopped in person or picked up their goods, we ask about transportation type, transit time, and trip chaining. If the goods were delivered, we asked about how they received their delivery. The responses to these questions form the backbone of our analysis in 0 where we investigate the relationship between goods type and shopping behavior.

Part 5 | Impacts of West Seattle High bridge closure:. Questions about the impact of the West Seattle High Bridge closure were included in the following section. We ask about how the bridge closure may have affected their preference for in-person versus online shopping, how it may have affected the distance they travel to shop, and how it may have affected their choice of transit option. We also ask this as an open-ended question to allow participants to provide perspectives the researchers may not have thought of.

3.2 Survey implementation

This survey was developed throughout Spring 2022, and it was deployed from 20 May to 18 August 2022 (91 days), using the JotForm Platform. The primary distribution channels were the Seattle Department of Transportation (SDOT) newsletter which has wide reach over West Seattle (WS) communities. The primary newsletter has approximately 10,000 recipients, and the "Flip Your Trip" newsletter (a program that provides trip planning assistance to WS residents) has approximately 8,000 recipients, though there is some overlap between the two. In addition, the research team made social media posts and reached out to several WS community groups, and distributed the survey on the West Seattle Blog and West Seattle Transport Coalition. While the primary focus was on WS residents, also people living in Seattle metropolitan area were able to access the survey.

The survey was advertised using the following message:

> "We want to hear about how West Seattle shops - take our survey and you may win $50! The COVID-19 pandemic, the closure of the West Seattle Bridge, and other recent events have changed how we travel, shop in stores, and order things online. The University of Washington's Supply Chain Transportation & Logistics Center invites you to take part in a 5-minute survey about your regular shopping behaviors. Our goal is to understand how people shop, travel to stores, and make online purchases in 2022 and relate this information to the transportation system. All information you provide will be kept anonymous. Also, if you would like to be included in a chance to win a $50 gift card, please fill out your contact information at the end of the survey and your name will be included in a drawing."

Participants were offered the chance to win a $50 gift card at the end of the survey if they provided their contact information and mailing address; this information was only used for identity verification and not as part of any analysis. A total of three gift cards were issued, randomly chosen among the survey respondents.

A graph of responses over time is shown in Figure 5. Most of our responses came in over weekends, especially during the weekend of 19 June 2022. SDOT newsletters were distributed on Fridays, so we assume that most traffic came from there.

Some of the first responses were lost due to a glitch in our survey platform where multiple-choice questions included an expandable text box for the "Other" option, which was promptly solved. In total, 90 responses were affected. Moreover, beginning of July we received a high amount of spam responses that were filtered out before we began the data analysis.

At the time of closing on 18 August, our survey had 1,262 responses; after removing spam, duplicate, and other damaged responses, we had 919 responses, which represents our sample data, which will be analyzed in the rest of the report.

Figure 5. Number of survey responses over survey deployment time (14 May to 15 August 2022)
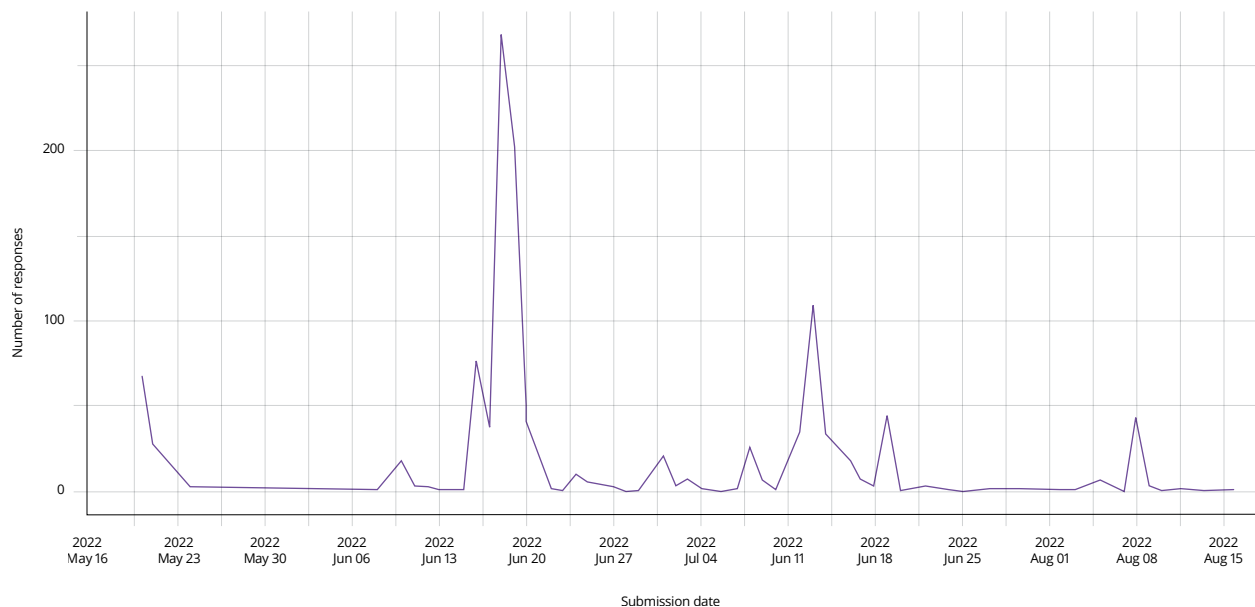
3.3 Sample data description

Data was filtered and processed in R. From the initial 1262 responses obtained, spam responses were filtered out by the mailing address submitted when entering the $50 raffle. In total there were 919 valid responses, which constitute our sample data for the subsequent analysis. This corresponds approximately to 1% of the study area population. In the rest of this section we describe:

- the main socioeconomic variables of the sample collected, and compare it with socioeconomic variables of the population of West Seattle and the Seattle Metropolitan region,
- the geographical distribution of survey respondents,
- and the West Seattle population of commercial establishments.

3.3.1 Socioeconomic variables

For part 4 of the survey, where the respondents were asked questions about a most recent purchase of a given type of goods, the categories each respondent was asked about were randomly selected out of four categories: groceries, household supplies, restaurant food, and clothes. Overall, each category has a similar number of responses: 264 respondents were asked about "Groceries", 231 were asked about "Household Supplies", 197 were asked about "Restaurant Food", and 227 were asked about "Clothes".

Table 3 reports the distribution of the main socioeconomic variables for the sample (sample of respondents), the population of West Seattle, and the population of the Seattle metropolitan region.

We note that in the data collected the white population has been oversampled. People under the age of 44 were under-sampled while people 45 and over were over-sampled. The average age of the respondents was 53.4 with a standard deviation of 14.8. The sample is also skewed towards females. People with bachelor's

degrees and graduate degrees were oversampled in the survey, while people with associate degrees and lower were under-sampled. Finally, people with incomes over $100,000 were significantly oversampled, while people with incomes less than $50,000 were under-sampled.

The full list of variables obtained from the data can be seen in Appendix 2.

Table 3. Population distribution by race

SOCIOECONOMIC VARIABLES		VALUES	
	SEATTLE [a]	WEST SEATTLE [a]	SAMPLE
RACE			
White	65.8%	68.7%	84.3%
Black or African American	7.1%	8.3%	2.05%
American Indian and Alaska Native	0.5%	0.37%	1.1%
Asian	16.3%	9.5%	5.6%
Native Hawaiian and other Pacific Islander	0.3%	0.53%	0.16%
Two or more races/other	7.6%	9.12%	4.3%
Hispanic or Latino	7.1%	9.87%	2.5%
AGE			
18-24 years	10.3%	5.5%	0.9%
25-44 years	40.1%	36.6%	28.2%
45-54 years	12.2%	13.7%	21.7%
55-64 years	10.3%	12.5%	22.0%
65-74 years	7.6%	8.0%	19.7%
75 years and over	4.9%	5.3%	7.5%
GENDER IDENTITY			
Male	50.6%	49.2%	30.2%
Female	49.4%	50.8%	68.4%
Gender not listed/none of these			1.4%
SOCIOECONOMIC VARIABLES		**VALUES**	

	SEATTLE [a]	WEST SEATTLE [a]	SAMPLE
EDUCATIONAL ATTAINMENT			
Less than high school graduate	4.8%	5.6%	0.22%
High school graduate/equivalency	9.5%	12.0%	5.7%
College/associate degree	20.7%	26.2%	13.1%
Bachelor's degree	37.0%	34.6%	43.7%
Graduate/professional degree	28.0%	21.8%	36.4%
ANNUAL HOUSEHOLD INCOME			
Less than $24,999	13.2%[b]	11.8%[b]	3.7%
$25,000 to $49,000	13.3%	14.23%	8.3%
$50,000 to $99,000	24.5%	25%	26.3%
$100,000 to $149,000	18.5%	18.4%	24.1%
$150,000 to $199,000	10.9%	12.25%	16.9%
$200,000 or More	19.6%	18.3%	20.8%

[a] U.S. Census Bureau (2020). *Selected Characteristics of the Total and Native Populations in the United States*
[b] U.S. Census Bureau (2020). *Income in the past 12 months (in 2020 inflation-adjusted dollars)*

3.3.2 Geographical distribution of sample

In the survey respondents were asked to report the nearest intersection to where they reside. We used the Google Maps geocoding API [6] and the R programming language [7] to query the approximate latitude and longitude coordinates for each intersection. Figure 6 shows the geographic distribution of survey participants as a heatmap with contour lines; higher densities of participants are indicated by smaller yellow bounded regions. As mentioned, though our survey was distributed to West Seattle residents it was not restricted, so there were a small number of participants from outside the study area. Furthermore, a small number of participants did not provide their approximate location, either choosing not to answer or entering an incomplete location such as a single street. The data from these responses were still analyzed for uncovering patterns in shopping trends, but it has been filtered out for geospatial analysis and does not appear in Figure 6. In total there were 868 out of 918 responses that provided location information within West Seattle. Most of these responses came from the northern and central regions, with the highest concentrations along California Avenue. As we move southeast the responses become sparser, with none appearing further southeast than Lakewood Park.
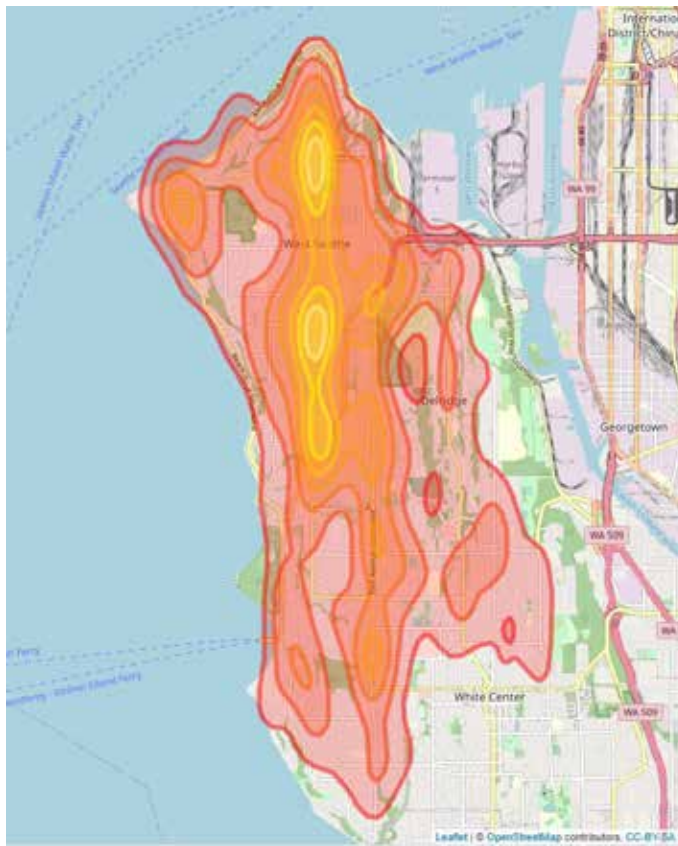
Figure 6. Geographic distribution of survey respondents. Areas highlighted in yellow have a higher density of respondents than areas in orange and red

3.3.3 Geospatial data

In addition, the number of establishments in each goods type that was within specific distances from each participant was collected using the Google Maps Places API [8]. These were decided to be 0.5 miles, 1 mile, and 1.5 miles as reasonable but significantly separated distances that each could be comfortably walked or driven.

For participants that were asked about grocery shopping, we queried the terms "grocery store", "supermarket", "target", and "farmer's market"; for household supplies, we used the queries for grocery stores and added "pharmacy" and "convenience store". For restaurant food, we queried "restaurants" alone. For clothing items, we queried "clothes store", "department store", "fashion", "boutique", "apparel", "target", and "thrift store".

Figure 7 shows the empirical distribution of the number of establishments each survey respondent has access to within a 1-mile radius of the closest intersection to their home residence. We note that on average, the sampled individuals have access to 25 restaurants within 1 mile, 10 household supplies stores, 8 clothing stores, and 6 grocery stores.

Furthermore, we recorded the nearest establishment to each participant for the asked about goods type, as well as the average distance to all establishments of that goods type within 1.5 miles from the nearest intersection of where respondents reside. Finally, we calculated the distance from each participant to the 1st Avenue South Bridge to use in our shopping choice model, since the West Seattle High Bridge was closed.

3.4 Behavioral framework

A random utility model of the shoppers' choices between ordering online for delivery, walking to an establishment for in-person shopping/order pickup, and driving to an establishment for in-person shopping/order pickup was estimated using the sample data. The purpose of the model was to identify factors that statistically significantly affect this choice.

The set of model inputs tested includes:

- socio-economic factors (age, gender, income, etc.)
- purchase-specific variables (type of goods purchased, volume, etc.)
- geospatial variables (accessibility and number of local stores in the proximity of the residents' locations)

We operate under the assumption that someone will first choose what goods they need to purchase, then choose where and how they will buy them. Figure 8 shows the choice described in the model and the categories of input variables tested. Though the survey asked participants to distinguish between in-person shopping and placing an order for online pickup, we combined these into a single category for two reasons. First, placing an order online for pickup still necessitates traveling to and from an establishment. The online order does not replace the need for an in-person trip; rather, it moves the time spend browsing and comparing different products to the shopper's current location rather than the establishment. Secondly, in the goods categories of Groceries, Supplies, and Clothing, placing an order for online pickup made up 25 out of the 697 total shopping choices (<4%). This indicates that ordering for online pickup does not comprise a significant amount of shopping activity for the sample collected. For the Restaurant food category, however, pick-up orders were the majority: 93 out of 184 individuals (~51%). Since our focus is on online deliveries versus shopping options that require traveling, we combined in-person and online pickup orders into a single category for shopping choice: in-person/pickup across all goods categories.

For people that shopped in-person/pickup, our survey asked what form of transportation they used to get to and from the establishment, including options for personal vehicles, walking, bicycling, public transit, and other micromobility options. However, the only transportation options that were used consistently were walking and personal vehicles; other options were minimally used (see section 4.3). Accordingly, our choice model only incorporated walking and personal vehicle driving as alternatives.

Our final assumption was that the decisions of whether to shop in-person versus online for delivery, and whether to walk or drive to an establishment are made simultaneously by each shopper. In our survey, we first asked whether the participant had shopped in person or online before asking about travel modes for in-person shopping.

We also assume that not everyone has access to a vehicle. For shoppers that indicated that they do not have access to a vehicle, we eliminated the personal vehicle mode option when estimating the choice model. Someone could use a carshare or rideshare service; however, ridesharing was a listed option in the survey, and only one shopper listed a carshare as their choice in the "Other" category; as such, we eliminated the option for all other shoppers without vehicle access as to not cause contradictions in the model. The model framework is depicted in Figure 8.

Figure 8. Choice model framework

4

Results

4 RESULTS

4.1 How often do consumers shop?

Survey participants were first asked when they last shopped, either online or in-person, with reference to a specific goods category randomly sampled out of four categories: groceries, household supplies, prepared food, and clothing items.

Figure 9 and Table 4 show the breakdown of when consumers last shopped by goods category. From the sample of respondents, 558 (60.7%) purchased in the past week, 173 (18.58%) purchased 1-2 weeks ago, 88 (9.58%) purchased 3-4 weeks ago, 63 (6.86%) purchased more than 1 month ago, 38 (4.13%) did not purchase in the last 3 months; over 95% of participants had purchased within the past 3 months. Participants who had not purchased the asked-about goods within the past 3 months were not asked any follow-up questions, since we believed that too long had elapsed for them to give us accurate information. The total number of participants asked about each goods category is shown in the bottom row of Table 3. Participants were randomly assigned to a goods category, so there is some variation observed in the sample size for each category.

Comparing the four goods categories, groceries have the highest frequency of being purchased within the last week (87.5%). Clothing in contrast is much more evenly distributed across the different time periods, with 28.19% having shopped within the last week, and slightly decreasing in each successive time frame. Restaurant food and household supplies were both between these extremes, with the maximum still being observed within the past week (72.23% for food and 51.08% for supplies). Perhaps due to its shared non-perishable nature with clothes, supplies had a less dramatic decrease in frequency as the time frames extended, with 30.3% having shopped 1-2 weeks ago (higher than both food and groceries). A Chi-square test was used to understand whether the variation in the frequency of shopping across each goods type is due to random chance, or whether it indicates a significant difference in behavior. With 9 degrees of freedom, the chi-square statistic was $\chi^2 = 6.4 \times 10^{-8}$, $< p = 0.05$. Therefore, we can conclude that the frequency of shopping is dependent on the goods type.

Figure 9. Last time shopped across all four goods categories (groceries, household supplies, prepared food, and clothing items)
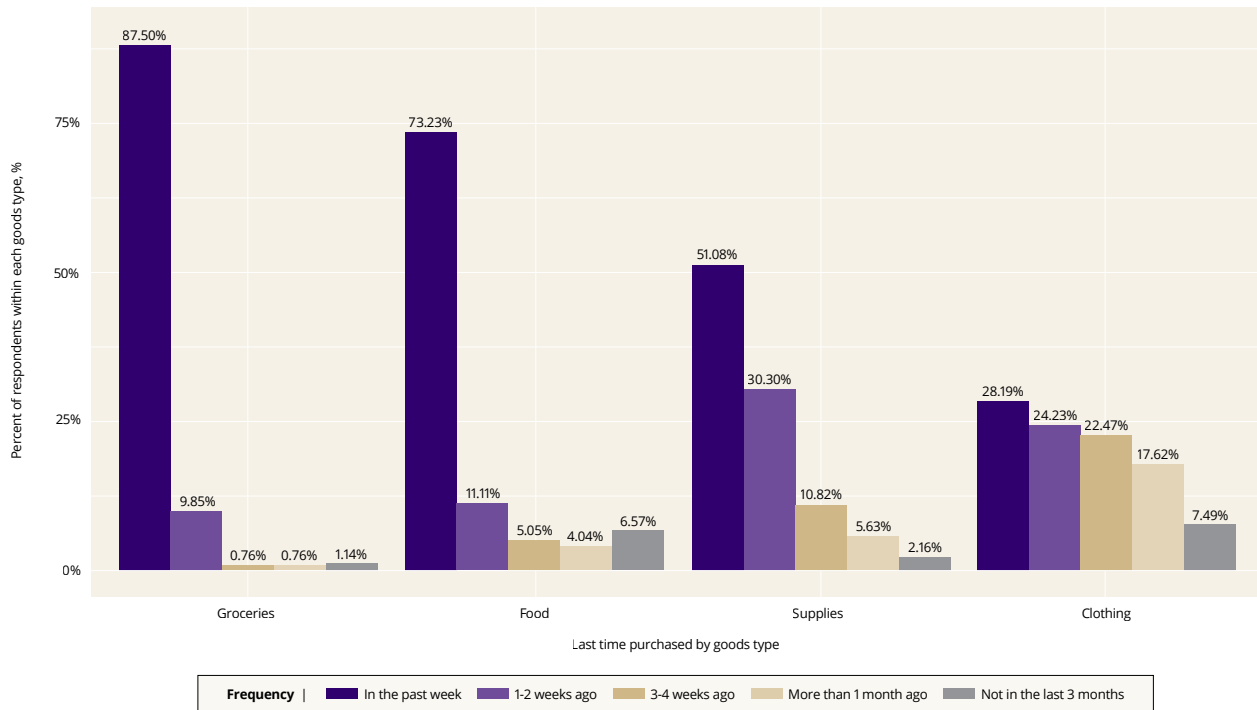
Table 4. Shopping Frequency by Goods Type

LAST TIME	TYPES OF GOODS				TOTAL
	GROCERIES	**HOUSEHOLD SUPPLIES**	**RESTAURANT FOOD**	**CLOTHES**	
In the past week	231 (87.5%)	118 (51.08%)	145 (72.23%)	64 (28.19%)	558 (60.7%)
1-2 weeks ago	26 (9.85%)	70 (30.30%)	22 (11.11%)	55 (24.23%)	173 (18.8%)
3-4 weeks ago	2 (0.76%)	25 (10.82%)	10 (5.05%)	51 (22.47%)	88 (9.6%)
5-9 weeks ago	2 (0.76%)	13 (5.63%)	7 (4.04%)	40 (17.62%)	63(6.8%)
> 3 months	3 (1.14%)	5 (2.16%)	13 (6.57%)	17 (7.49%)	38(4.1%)
TOTAL	264 (100%)	231 (100%)	197 (100%)	227 (100%)	919 (100%)

4.2 How often do consumers shop online vs. in person?

Across all goods categories, 61.3 percent of respondents chose to perform the last shopping activity in person, while the remaining 38.7 percent shopped online. Online shoppers have further chosen between traveling to pick up the foods purchased online or having them delivered. Of the sample that shopped online, about a third chose to pick up the goods in person, while two-thirds chose the goods to be delivered.

Figure 10 and Table 5 report the choice of online vs. in-person purchases for each category. In-person shopping is most common for groceries at 89.3%, followed by household supplies at 75.7%. Clothes and restaurant food are significantly lower with 35.2 and 33.7 percent of respondents having shopped in person, respectively. Unlike groceries and supplies, where one can expect equivalent if not identical products in multiple stores, clothes shopping may entail finding products from specific retailers that are less widely available. Food initially seems to have a similar distribution to clothes, however, shoppers for restaurant food have a slightly different choice set than those shopping for groceries, supplies, or clothes. The in-person version of shopping would be in-person dining, which is not the same as shopping as browsing a grocery store; it requires significantly more time as well as being a social event rather than purely shopping. When purchasing restaurant food, shopping for online pick-up (often referred to as curbside pickup or online take-out) is much more popular than online delivery: 76 percent of the respondents that purchased restaurant food online decided to travel to pick it up.

For the three other goods types, shopping for online pickup is a relatively new option, that has become more popular during the COVID-19 pandemic as a "no-contact" method of shopping that could support local stores and had no delivery fees. As a result, though shopping for online pickup is present in each goods type, it is less than 5% in everything else. Take-out restaurant food, however, has been well-established practice long before this, which can explain its divergent and dominant share.

The chi-square test statistic is $1.9*10^{-101} < 0.05$ with 6 degrees of freedom, confirming the significant difference for behaviors across goods types.

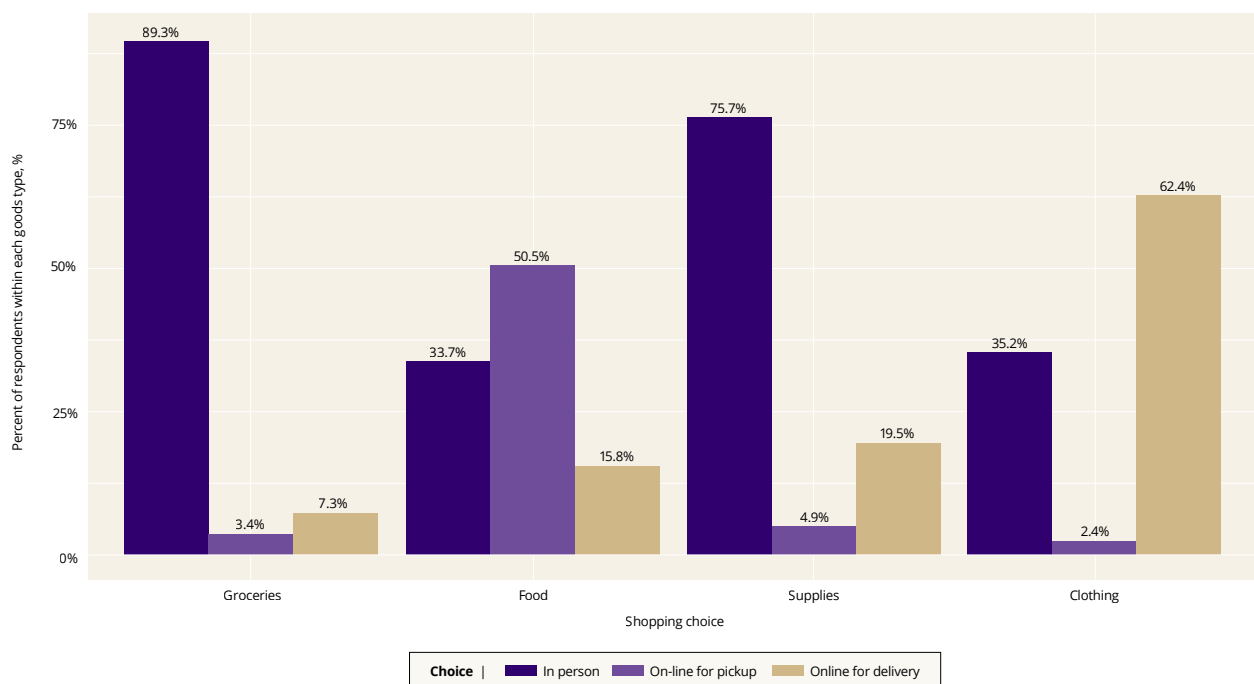**Figure 10.** Online vs. in-person shopping by goods type

Table 5. Choice of online vs. in-person shopping by goods type

PURCHASE CHOICE	TYPES OF GOODS				TOTAL
	GROCERIES	RESTAURANT FOOD	HOUSEHOLD SUPPLIES	CLOTHES	
In-person	233 (89.3%)	62 (33.7%)	171 (75.7%)	74 (35.2%)	540 (61.3%)
Online • Pick-up • Delivery	28 (10.7%) 9 19	122 (66.3%) 93 29	55 (24.3%) 11 44	136 (64.8%) 5 131	341 (38.7%) 118 223
TOTAL	261 (100%)	184 (100%)	226 (100%)	210 (100%)	881 (100%)

4.3 How do consumers travel for in-person shopping?

To address the question of how consumers travel, in-person and online for pickup shoppers were grouped since they require personal travel to and from a store. Figure 11 and Table 6 report the distribution across in-person shopping travel modes, including:

- personal vehicle (either driving or as a passenger);
- walking (including the use of a mobility device like a wheelchair or mobility scooter);
- biking (including personal bike or shared micromobility devices);
- public transit (e.g. buses);
- rideshare (app-based or traditional taxis).

Overall, most of the respondents that shopped in person travelled by car (81.3 percent across all categories). Walking is a distant second preferred shopping travel mode, at 13.1 percent. Biking and public transit were rarely adopted as shopping travel modes. Though included as an option, no participants chose rideshare as a shopping travel mode.

A chi-square test is conducted over walking, driving, biking, and public transit, to test whether the shopping mode of travel changes across different goods categories. With 9 degrees of freedom, the chi-square test statistic is 0.422 > 0.05. Therefore, we fail to reject the null hypothesis that the choice of transportation is dependent on goods type.

The large share of use of a personal vehicle as a shopping mode among the respondents could be explained by the fact that 96% of survey participants reported having access to a personal vehicle that was owned by themselves or someone within their household. 9.8% of these vehicles were reported to be electric. However, while a large share of respondents also reported owning a bicycle (51.6 percent, with 15.5 percent reporting owning an electric bike) biking is not a common shopping mode of travel.

A similar mode share was observed for those respondents that chose to buy online but to travel to pick-up in person (most of these were for restaurant food pick-up): 84 percent drove a vehicle for online pick-up, and 14 percent walked.

Figure 11. Shopping travel mode by type of goods
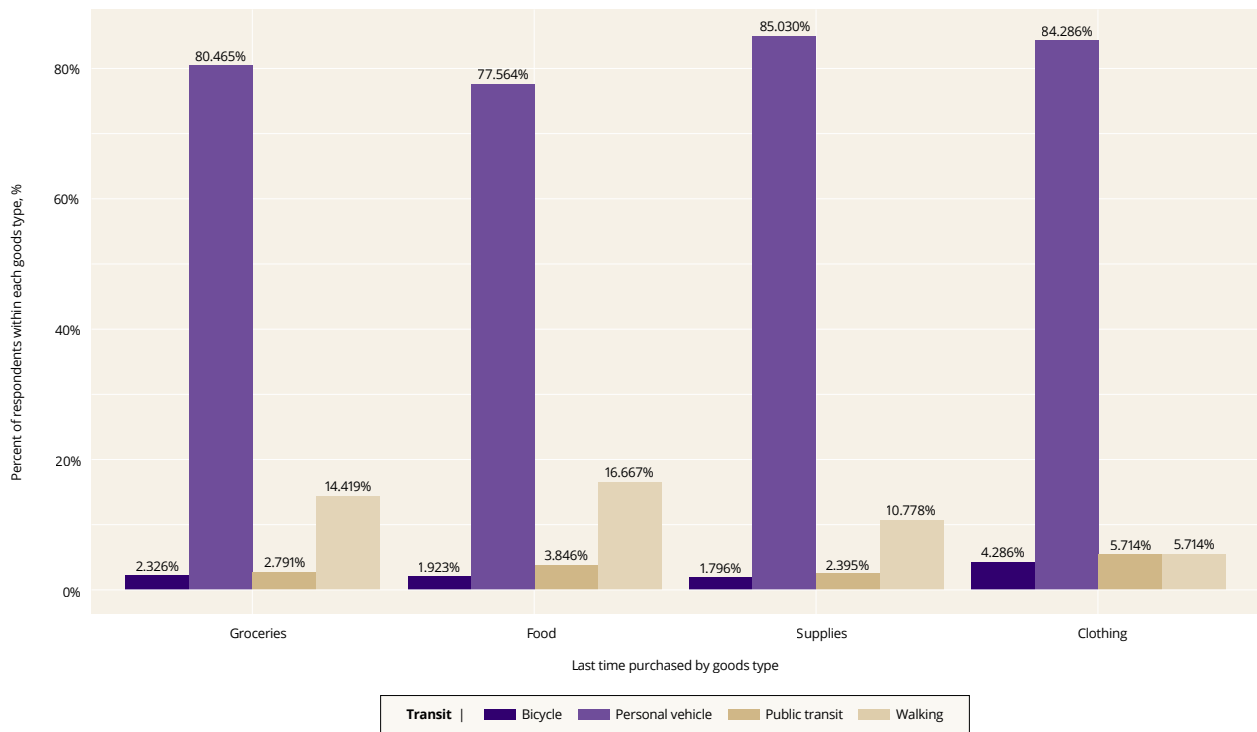
Table 6. In-person shopping travel mode

TRAVEL MODE	TYPES OF GOODS				TOTAL
	GROCERIES	**RESTAURANT FOOD**	**HOUSEHOLD SUPPLIES**	**CLOTHES**	
Bicycle	5 (2.3%)	3 (1.9%)	3 (1.8%)	3 (4.3%)	14 (2.3%)
Personal vehicle	173 (80.5%)	121 (77.7%)	142 (85%)	59 (84.3%)	495 (81.3%)
Public transit	6 (2.8%)	6 (3.8%)	4 (2.4%)	4 (5.7%)	20 (3.3%)
Walking	31 (14.4%)	26 (16.7%)	19 (10.8%)	4 (5.7%)	80 (13.1%)
Total	215 (100%)	156 (100%)	168 (100%)	70 (100%)	609 (100%)

4.4 How much time do consumers spend traveling for shopping?

Participants were asked to report their travel time on their most recent shopping trip. The summary statistics for the travel time for each travel mode and goods type are shown in Table 7. Figure 12 shows the empirical distribution of travel time by goods type and shopping travel mode (walking and driving to a store). Overall, travel times for walking and driving remain relatively consistent across the goods types. For walkers, the average walking time was within 10-12 minutes in each goods category. This is also the case for driving, where the average driving time is between 9-12 minutes for three of the goods categories: groceries, food, and

supplies. Also, for those respondents that chose to purchase online and pick up in person, driving travel time was 11 minutes on average.

However, driving travel time for the clothing category has a significantly different mean of 27.25 minutes per trip, showing a different travel behavior. This, paired with our previous results of a higher rate of online delivery being seen for clothing, indicates that consumers are willing to drive further and wait longer for clothing than for other goods types.

Travel by public transit always has the highest average travel time across each goods type, and bicycling has low travel times except for restaurant food. However, neither of these two categories have enough observations. As such, boxplots for travel times for walking and driving only are shown in Figure 12.

In Appendix C – Statistical tests of hypothesis: driving & walking time statistical tests of hypotheses are performed to test whether the distribution of walking and driving times are significantly different across different goods types. The tests confirm the hypotheses that walking time distribution is not affected by goods type and driving time distribution is only significantly different for clothing items and does not change across groceries, restaurant food, and household supplies.

Figure 12. Boxplots showing the empirical distribution of driving and walking travel times by type of goods
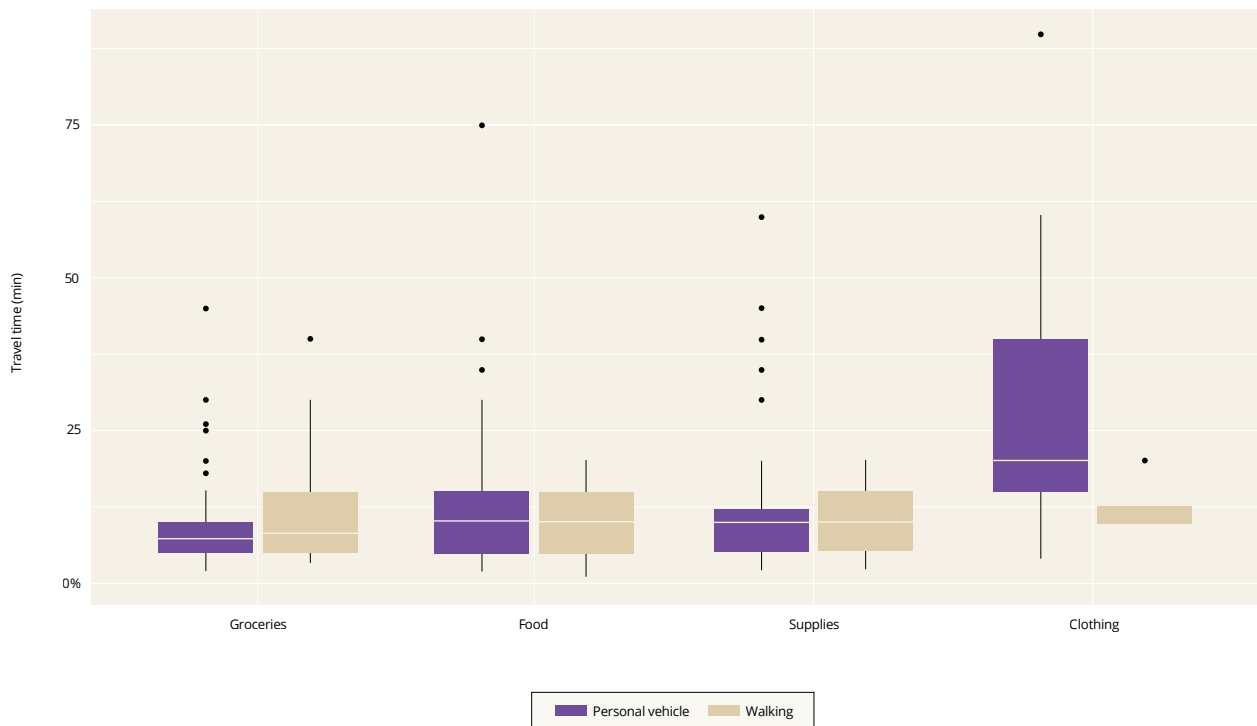
Table 7. Travel time (minutes) by mode of travel and type of goods

TRAVEL MODE		TRAVEL TIME (MINUTES)			
		GROCERIES	RESTAURANT FOOD	HOUSEHOLD SUPPLIES	CLOTHES
Bicycle	Mean	5	24.3	15	13.67
	[Min, max]	[3, 15]	[3, 65]	[10, 20]	[6, 20]
	SD [a]	4.7	35.2	5	7.1
Personal vehicle	Mean	9.2	11.75	11.5	27.24
	[Min, max]	[2, 45]	[2, 75]	[2, 60]	[4, 90]
	SD	6.5	9.5	9.2	17.0
Public transit	Mean	14.7	22.5	25	27.24
	[Min, max]	[5, 30]	[5, 50]	[20, 30]	[4, 90]
	SD	9.2	17.0	5.8	17.0
Walking	Mean	10.6	10	10.3	12.5
	[Min, max]	[3, 40]	[1, 20]	[2, 20]	[10, 20]
	SD	8.2	5.2	5.5	5.0

[a] SD = Standard Deviation

4.5 Does proximity to stores reduce driving?

In this section, we test whether living in proximity to stores is correlated to a higher likelihood of walking vs. driving for shopping or receiving home deliveries.

During the survey, participants were asked to record the closest intersection to their home address. Then, by querying the Google Maps Places API, the number of commercial establishments of the asked-about goods type within 0.5 miles, 1 mile, and 1.5 miles from the reported address were computed. Figure 13 shows the empirical distribution of the number of grocery stores within 0.5, 1, and 1.5 miles of each respondent's home address, by choice of shopping (walking or driving to the store or home delivery). For groceries specifically, respondents who walked to a store had significantly more groceries stores within a 0.5-mile radius than those who chose driving or delivery. This pattern is not shared as strongly with the other three goods types, reported in Appendix D – How does location affect shopping choice: additional plots. We note that as we expand the radius, the distribution of the number of grocery stores within 1 and 1.5 miles are similar across the choice of home delivery, driving, and walking to a store.

Figure 13. Distribution of the number of grocery stores within 0.5, 1, 1.5 miles from respondents' home addresses, by shopping choice (walking, driving to store, or delivery)
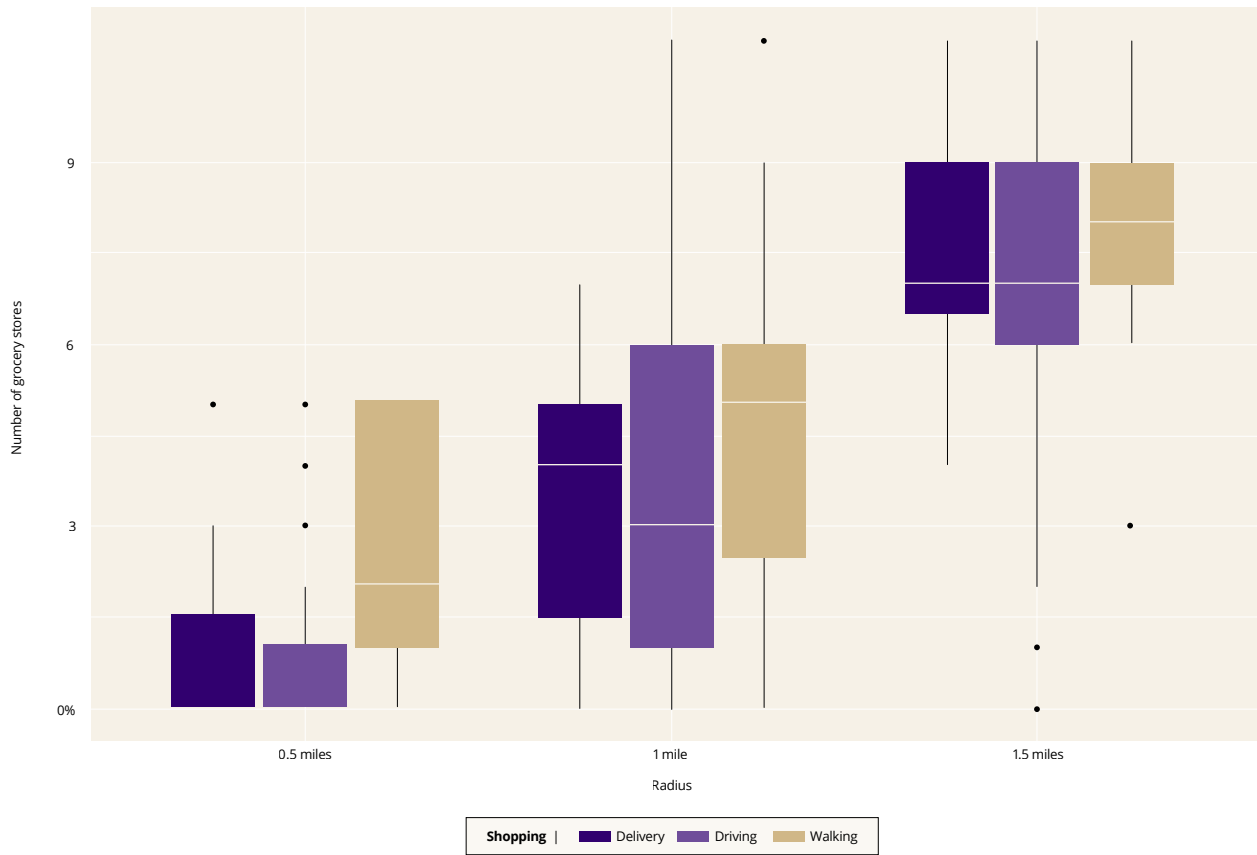
4.6 How do consumers receive online deliveries?

If a survey participant reported buying online, he/she was asked the type of delivery destination, among home delivery (doorstep, mailbox, garage), private parcel locker or building reception, public parcel locker (e.g. Amazon parcel locker in a store), or other destinations.

Since groceries and food delivery are perishable items and cannot feasibly be stored in a parcel locker for later pickup, we assumed that they are always received via home delivery. Instead, we will focus on household supplies and clothing items, both of which are typically non-perishable.

Table 8 reports the distribution of delivery locations for non-perishable goods (household supplies and clothing items) purchased online. The overwhelming majority (84%) of deliveries were dropped directly at the receivers' residences. 15 percent of participants reported using private or public parcel lockers.

Table 8. Number of respondents by online delivery locations

DELIVERY LOCATION	HOUSEHOLD SUPPLIES	CLOTHING ITEMS	TOTAL NON-PERISHABLES
Doorstep/mailbox/garage	33 (87%)	98 (83%)	131 (84%)
Private locker/reception	4 (11%)	14 (12%)	18 (12%)
Public locker	0	5 (4%)	5 (3%)
Alternative destination	1 (2%)	1 (1%)	2 (1%)
Total	38 (100%)	118 (100%)	156 (100%)

4.7 Have consumers experienced package theft?

Participants were asked whether they had ever experienced package theft; that is, whether they had ever ordered a package for delivery, but it was stolen after it had been delivered before they received it. 247 participants (27 percent) reported having experienced package theft in the past. Of the 639 participants who had not experienced package theft and had gone shopping for an asked-about good in the past 3 months, 400 (63 percent) shopped in-person, 83 (13 percent) used online pickup, and 156 (24 percent) used online delivery. Of the 240 participants who had experienced package theft and had gone shopping for an asked-about good in the past 3 months, 139 (58 percent) shopped in-person, 35 (15 percent) used online pickup, and 66 (27.5 percent) used online delivery. There does not seem to be a strong relationship between prior package theft experiences and the present choice of shopping option.

4.8 What factors influence shopping behavior?

A multinomial logit regression was used to model the choice of shopping type between

- Delivery: buying online and receiving a home delivery,
- Driving: driving to a store, and
- Walking: walking to a store.

We assume that shoppers decide between these three options simultaneously rather than necessarily first choosing in-person versus online. The reference level in the model was set to be walking, with all factors being evaluated for their significance in shifting the choice to driving or delivery. Table 9 describes the model inputs used.

Table 9. Model input variable description

DELIVERY LOCATION	HOUSEHOLD SUPPLIES	CLOTHING ITEMS
Socioeconomic variables	Age	Age of respondent
	Male	Binary variable = 1 if the respondent identifies as male
	Not employed	Binary variable = 1 if the respondent is not employed
	Disability	Binary variable = 1 if the respondent reports having a mobility impairment
	Children	Number of children in the household
	Vehicle	Binary variable = 1 if the respondent reports having access to a motorized vehicle
Goods-specific variables	Clothes	Binary variable = 1 if the good purchased is a clothing item
	Food	Binary variable = 1 if the good purchased is a meal from a restaurant
	Supplies	Binary variable = 1 if the goods purchased are household supplies
	Recent	Binary variable = 1 if the purchase took place less than 2 weeks from the time of the survey
Geospatial variables	Halfmile	Number of establishments within 05 miles radius of the nearest intersection to the respondent's home address
	1st Avenue Bridge	Euclidean distance from the nearest intersection to each respondent's home address and the 1st Avenue bridge
West Seattle variables	Local shopping	Binary variable = 1 if the respondent reported that the closure of the High Bridge made him/her more likely to purchase locally
	Online shopping	Binary variable = 1 if the respondent reported that the closure of the High Bridge made him/her more likely to purchase online

The variables identified to be significant and their coefficients are shown in Table 10, and the full model output can be found in Appendix D: MNL model .

First, we observe that as the number of establishments in the asked-about goods type within a 0.5-mile radius increases, the likelihood of shopping via delivery or driving both significantly decreases, with the driving likelihood decreasing at a higher rate than the delivery likelihood. This indicates that the survey participants are more interested and/or willing in walking as their shopping choice when there are more shopping options available within 0.5 miles.

We also observe that respondents identifying as male are more likely to report their shopping choice as walking over delivery or driving.

Vehicle access significantly increased chances of driving over walking. The choice set was restricted for participants who indicated that they did not have vehicle access; driving was not allowed to be an option for these participants. However, the vast majority of participants reported having a vehicle, and it was also previously observed that driving was more common than walking across all goods types and more common than online delivery in three of the goods types.

The goods type itself is significant as well. The default value is groceries; both restaurant food and household supplies significantly increase the likelihood of driving and online delivery over walking. For clothes, only the likelihood of delivery increases.

Finally, of the West Seattle Factors, only the preference for in-person versus online shopping was significant. In this survey question, participants were asked to rate how their preference for how in-person versus online shopping was affected by the West Seattle High Bridge closure on a Likert Scale, from a strong preference for online shopping to a strong preference for in-person shopping. In our model, we see a significant increase in the likelihood of shopping via delivery for those participants who indicated that their preference had s hifted toward online shopping. This is expected; however, it is notable that neither of the other two West Seattle factors were significant. These factors were a self-reporting of how the distance travelled for shopping trips had changed since the West Seattle Bridge closure, and the distance to the nearest open bridge, the 1st Avenue South bridge. Our expectation was an increased distance from the 1st Avenue Bridge (the closest bridge to the West Seattle High Bridge that was closed due to structural deterioration) or an increased distance travelled for shopping trips may result in participants preferring more local options via walking or preferring increased levels of deliveries so that they would not need to drive as far; however, the model results did not support this hypothesis.

Table 10. Selected estimated parameters for the multinomial logit choice model of shopping online vs. driving or walking to a store

COEFFICIENT	UTILITY	ESTIMATE	STD. ERROR	Z-VALUE	PR(>|Z|)	SIGNIFICANCE
Male	Delivery	-0.650	0.284	-2.291	0.02194	*
Male	Drive	-0.568	0.228	-2.488	0.01284	*
VehicleYes	Drive	2.15	0.74	2.910	0.00360	**
HalfMile	Delivery	-0.131	0.339	-3.863	0.00011	***
HalfMile	Drive	-0.142	2.82E-2	-5.015	5.28E-7	***
Clothes	Delivery	3.28	0.439	7.463	8.42E-14	***
Restaurant food	Delivery	2.28	0.526	4.329	1.49E-5	***
Restaurant food	Drive	1.76	0.428	4.101	4.11E-5	***
Supplies	Delivery	1.69	0.391	4.316	1.59E-5	***
Supplies	Drive	0.705	0.289	2.441	0.01462	*
Pref since WS Bridge closure	Delivery	-0.352	0.118	-2.983	0.0028	**

Significance: *** p-value<0.001, ** p-value<0.01, * p-value<0.05

4.9 How did the West Seattle High bridge closure impact shopping behavior?

Survey participants were asked about the impacts of the West Seattle High Bridge closure on their shopping and travel habits.

First, participants were asked to report the effects of the bridge closure on their in-person shopping trips, and whether this had caused their in-person shopping trips to be closer to or farther from their homes. 44 percent of the respondents reported that the bridge closure made them more likely to shop locally, while 33 percent reported that the bridge closure did not impact their shopping travel behavior, and the remaining 23 percent reported longer shopping travels. We tested whether this behavior could be explained by the distance between respondents' home location and the 1st Avenue bridge, the closest bridge to leaving the peninsula, but the correlation was not significant.

Participants were also asked about their preferences for in-person versus online shopping because of the West Seattle High Bridge closure. 40.8 percent of participants reported buying more online, compared to before the bridge closure, and 33 percent reported buying more in-store.

5

Conclusion

⑤ CONCLUSION

This study involved surveying residents in West Seattle, a peninsula located southwest of Seattle downtown, Washington State, for their shopping behavior. The survey took place from May 2022 to August 2022, in the months leading up to the re-opening of the West Seattle High Bridge, one of the major bridges connecting the peninsula to the rest of the city, which was closed due to increased structural deterioration in March 2020. Over 900 valid responses to the survey were collected. The survey was structured in five parts: 1) household socioeconomic factors, 2) information about the dwelling, and usual transportation habits, 3) general information about home delivery behavior, 4) detailed information about the most recent shopping activity for a given goods category randomly sampled among groceries, household supplies, restaurant food, and clothing items, 5) the impacts of the West Seattle Bridge closure on shopping behavior.

The sample collected skewed towards high-income, well-educated, White, and female residents of West Seattle; however, we were able to collect a broad variety of shopping behaviors. We identified the effects of the West Seattle High Bridge closure on shopping habits. Though a plurality of participants identified that their shopping trips had become closer to home as a result of the bridge closure, this was not found to be related to their ease of leaving West Seattle, nor was it a significant factor in determining shopping choice.

The types of goods being shopped for has an impact on both how frequently shopping takes place, as well as the mode of shopping used. Groceries and Restaurant food, both perishable items, were both most recently purchased within the last week for the vast majority of shoppers (87.5%, 73.23%), while Household Supplies and clothes, both nonperishable, had a slightly wider distribution of most recent purchase (51.1%, 28.2% within the last week). Participants strongly preferred in-person shopping for Groceries and Household supplies (89.3%, 75.7%), while the online pickup was preferred for restaurant food (50.5), and delivery was preferred for Clothing (62.4%). Trips for in-person shopping and online pickup were dominated by travel by personal vehicle (>75% across all categories), even though over 50% of participants owned a bicycle. Driving times were mostly consistent near an average of 10 minutes, except for clothing at an average of 27 minutes, implying that clothes shopping involves farther travel. Walking was a distant second in preferred transit, and it was observed that across all goods types, walking times were consistent at around 10 minutes. A logit model identifying significant factors for shopping choice also identified that residents with a higher number of establishments within a half-mile radius from them had an increased likelihood to choose in-person shopping via walking. This supports the idea of the "10-minute city", where people would ideally have establishments with all the goods they need within a 10-minute walk as a strategy for reducing automobile travel.

The survey data collected provided the first insight into the shopping behavior of West Seattle residents, at a level of detail that, to the knowledge of the authors, has not been collected in the Seattle region before. The research team identified the following actions for a future extension of the research effort.

- Increase geographical reach. While the survey was focused on the West Seattle peninsula, the urban form in the study area was relatively uniform. In the next phase of the survey, the research team recommends enlarging the geographical scope of the survey to potentially be able to capture a wider range of shopping behaviors and how they are affected by a wider variety of urban form factors.

- Increase the representativeness of the sample. While it is always difficult to ensure representativeness, the research team can perform a focus in-person intercept survey to complement the online survey to collect data from a more diverse population. Moreover, the research team could offer the survey to be translated into different languages (only English was used).

- More in-depth analysis of the 10-minute city. Although the hypothesis of the existence of a 10-minute city was tested in the modeling effort, the research team could perform a more in-depth analysis of the concept, including in the modeling effort not only the number of stores within 10 minutes walking distance but also the quality and variety of stores.

- Expand survey scope. Some preliminary interesting results obtained through the present survey should be validated and tested at a larger scale. An expanded survey could include more questions related to the curbside pick-up behavior to better understand this behavior, as well as include information on the store destination and/or the carrier performing the delivery. An expanded analysis could also focus on the use of electric cars and bikes, and how these greener modes of driving affect shopping travel behaviors.

6 REFERENCES

1. U.S. Department of Commerce Census Bureau, "Quarterly retail e-commerce sales - 4th quarter 2012," U.S., 2012.

2. U.S. Department of Commerce Census Bureau, "Quarterly retail e-commerce sales - 3rd quarter 2022," U.S., 2022.

3. N. McGuckin and A. Fucci, "Summary of Travel Trends: 2017 National Household Travel Survey," US, 2018.

4. United Parcel Service UPS, "UPS Pulse of the online shopper study," 2018.

5. A. Goodchild, G. Dalla Chiara, N. Goulianou, and S. Gunes, "Understanding and Mitigating Freight-Related Impacts from the West Seattle Bridge Closure," Seattle, WA, U.S., 2021.

6. "Google Maps Geocode API," *Developer Guide*, 2022. [Online]. Available: https://developers.google.com/maps/documentation/geocoding/overview. [Accessed: 01-Jul-2022].

7. R Core Team, "R: A language and environment for statistical computing," *R Foundation for Statistical Computing*. Vienna, Austria, 2017.

8. "Google Maps Places API," Developer Guide, 2022. [Online]. Available: https://developers.google.com/maps/documentation/places/web-service/overview. [Accessed: 01-Jul-2022].

WEST SEATTLE PHASE II SURVEY

Instructions are written in italics

Section 1: Demographics

1.1 What is your Gender Identity?

☐ Male
☐ Female
☐ Gender(s) not listed here/None of these

1.2 What is your expected household income in 2022, before taxes?

☐ Less than $24,999
☐ $25,000 to $49,000
☐ $50,000 to $99,999
☐ $100,000 to $149,000
☐ $150,000 to $199,999
☐ $200,000 or more

1.3 What is your Age?

_____

1.4 Do you have a disability that limits physical activities? (Walking or use of mobility device, carrying, lifting, etc.)

☐ Yes   ☐ No

1.5 What is your Race and/or Ethnicity?

☐ American Indian or Alaska Native
☐ Asian or Asian American
☐ Black or African American
☐ Hispanic or Latino/a/x
☐ Middle Eastern or North African
☐ Native Hawaiian or Pacific
☐ Islander
☐ Race or ethnicity not listed here
    (please tell us more) _____
☐ White

1.6 What is your Employment status?

☐ Employed part or full-time
☐ Full-time Student
☐ Unemployed & looking
☐ Unemployed & not looking
☐ Retired

1.7 What is the highest level of education you have completed?

☐ Primary School or lower
☐ High School Diploma/GED
☐ Community college/Associates degree/post-secondary certificate
☐ Bachelor's degree
☐ Graduate degree

1.8 How many children (below 18 years old) live in your household?

_____

1.9 How many people in total (including children) live in your household?

_____

1.10 Do you own a smartphone?

☐ Yes   ☐ No

2.1 Do you have a driver's license? *Please answer NO if your license is expired or otherwise invalid*

☐ Yes ☐ No

2.2 Do you/does someone in your household own a vehicle for personal use?

☐ Yes ☐ No **[Skip to 2.5]**

2.3 Is this an electric vehicle?

☐ Yes ☐ No

2.4 What type of vehicle do you use most often?
Select all that apply

☐ Sedan/coupe/hatchback/compact car
☐ Pickup Truck
☐ SUV
☐ Minivan
☐ Station Wagon
☐ Other *(please specify):* _____

2.5 Do you own a...
Select all that apply

☐ Bicycle (including bike share)
☐ Electric Bicycle (including bike share)
☐ Cargo Bicycle (including bike share)
☐ Electric Cargo Bicycle (including bike share)
☐ Electric Scooter (including scooter share)
☐ Electric Unicycle/Personal Transporter
☐ Other *(please specify):* _____

2.6 What is your home address OR the nearest intersection to your home? *(Example: "15th Ave and 50th St". If you'd prefer, you can also enter a nearby bus stop or landmark we will use this to calculate distances to various stores)*

_____

Section 3: Package delivery questions

The following questions ask about packages that are too large to fit in a mailbox.

3.1 Does your residence have a package locker or other way for carriers to securely deliver packages?

☐ Yes, a locker
☐ Yes, a reception area/building manager
☐ No

3.2 How do you usually receive packages?
Select all that apply

☐ I receive it on my doorstep
☐ I receive them from a reception area/lobby
☐ I receive them from a package locker in my building
☐ I pick them up from a store/ nearby package locker
☐ I meet the driver outside my building
☐ I ship it somewhere else (like my office)

3.3 Have you ever experienced package theft?
This is when a package is stolen after being delivered to the doorstep

☐ Yes ☐ No

3.4 How worried are you about theft if a package is left outside your building unattended?

☐ 5 (Very worried)
☐ 4
☐ 3 (Neutral)
☐ 2
☐ 1 (Not at all worried)

3.5 How often per month do you receive packages for delivery? (Including subscription services like Dollar Shave Club, Hello Fresh, etc.)

_____

The following questions ask about groceries bought from a grocery store, for example, fresh produce, milk, eggs, etc. bought from Safeway. Food items bought from a convenience store, for example, snacks from 7-11 are not included in the term "groceries"

4.1   In the past 3 months, how often have you bought groceries (either in-store or online)? *Please only answer for yourself rather than for your household. If someone else in your household other than you always buys groceries, please answer "I did not buy groceries in the last 3 months".*

☐   More than 2 times per week
☐   1-2 times per week
☐   1-2 times per month
☐   Less than once per month
☐   I did not buy groceries in the last 3 months **[Skip to Section 5]**

The following questions will ask about the most recent time you bought groceries.

4.2   When was the most recent time you bought groceries? *Please only answer for yourself rather than or your household*

☐   In the past week
☐   1-2 weeks ago
☐   3-4 weeks ago
☐   More than 1 month ago

4.3   How much/many groceries did you buy?

☐   A few items
☐   About 1 full grocery bag
☐   About 2 full grocery bags
☐   About 3-5 full grocery bags
☐   More than 5 full grocery bags

4.4   Did you buy groceries in-person or online?

☐   In-person
☐   Online for pickup
☐   Online for delivery **[Skip to 4.8]**

4.5   What form of transportation did you take to and from the store?

☐   Personal Vehicle (driven by yourself or others)
☐   Public Transit (e.g. King County Metro bus)
☐   Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐   Ridehail (e.g. Uber/Lyft) or taxi
☐   Bicycle (including bike share)
☐   Scooter (including scooter share)
☐   Other: _____

4.6   How many minutes did it take you to reach the store?

_____

4.7   Did you buy items from other stores as part of the same trip?

☐   Yes   ☐   No

4.8   If you did order for delivery, where were your groceries delivered?

☐   On my doorstep
☐   To a reception area/building manager
☐   To a package locker in my building
☐   To a store/nearby package locker
☐   Met the driver outside my building
☐   Other: _____

The following questions ask about household supplies: cleaning products, trash bags, laundry detergent, toothpaste, etc.

5.1   In the past 3 months, how often have you bought household supplies?
Please only answer for yourself rather than for your household. If someone else in your household other than you always buys household supplies, please answer "I did not buy household supplies in the last 3 months".

☐   More than 2 times per week
☐   1-2 times per week
☐   1-2 times per month
☐   Less than once per month
☐   I did not buy household supplies in the last 3 months *(Skip to Section 6)*

The following questions will ask about the most recent time you bought household supplies.

5.2   When was the most recent time you bought household supplies? *Please only answer for yourself rather than for your household.*

☐   In the past week
☐   1-2 weeks ago
☐   3-4 weeks ago
☐   More than 1 month ago

5.3   How much/many household supplies did you buy?

☐   A few items
☐   About full grocery bag
☐   About 2 full grocery bags
☐   About 3-5 full grocery bags
☐   More than 2 full grocery bags

5.4   Did you buy household supplies in person or online?

☐   In-person
☐   Online for pickup
☐   Online for delivery **[Skip to 5.8]**

5.5   What form of transportation did you take to and from the store?

☐   Personal Vehicle (driven by yourself or others)
☐   Public Transit (e.g. King County Metro bus)
☐   Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐   Ridehail (e.g. Uber/Lyft) or taxi
☐   Bicycle (including bike share)
☐   Scooter (including scooter share)
☐   Other: _____

5.6   How many minutes did it take you to reach the store?

_____

5.7   Did you buy items from other stores as part of the same trip?

☐   Yes   ☐   No

5.8   If you did order for delivery, where was your package delivered?

☐   On my doorstep
☐   To a reception area/building manager
☐   To a package locker in my building
☐   To a store/nearby package locker
☐   Met the driver outside my building
☐   Other: _____

The following questions ask about restaurant food. This includes any meal prepared by someone in food service/ from a food establishment that you travelled to from home or ordered for delivery to your home. Please do not include restaurant food that you ordered/travelled to from work or any location other than home.

6.1   In the past 3 months, how often have you bought restaurant food? *Please only answer for yourself rather than for your household. If someone else in your household other than you always buys restaurant food, please answer "I did not buy restaurant food in the last 3 months".*

☐   More than 2 times per week
☐   1-2 times per week
☐   1-2 times per month
☐   Less than once per month
☐   I did not buy prepared food in the last 3 months **[Skip to Section 7]**

The following questions will ask about the most recent time you bought food from a restaurant

6.2   When was the most recent time you bought restaurant food? *Please only answer for yourself rather than for your household*

☐   In the past week
☐   1-2 weeks ago
☐   3-4 weeks ago
☐   More than 1 month ago

6.3   Did you order for in-person dining, take-out, or delivery? (If delivery, skip to 6.6)

☐   In-person dining
☐   Take-out
☐   Delivery **[Skip to 6.6]**

6.4   What form of transportation did you take to and from the restaurant?

☐   Personal Vehicle (driven by yourself or others)
☐   Public Transit (e.g. King County Metro bus)
☐   Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐   Ridehail (e.g. Uber/Lyft) or taxi
☐   Bicycle (including bike share)
☐   Scooter (including scooter share)
☐   Other: _____

6.5   How many minutes did it take you to reach the store?

_____

6.6   Where was your food delivered?

☐   On my doorstep
☐   To a reception area/building manager
☐   To a package locker in my building
☐   To a store/nearby package locker
☐   Met the driver outside my building
☐   Other: _____

The following questions ask about clothing items. This includes any clothing, footwear, outerwear, underwear, etc.

7.1 In the past 3 months, how often have you bought clothing items for yourself/for yourself or someone in your household? *Please only answer for yourself rather than for your household. If someone else in your household other than you always buys clothing items, please answer "I did not buy clothing items in the last 3 months".*

☐ More than 2 times per week
☐ 1-2 times per week
☐ 1-2 times per month
☐ Less than once per month
☐ I did not buy clothes in the last 3 months **[Skip to Section 8]**

The following questions will ask about the most recent time you bought clothing items.

7.2 When was the most recent time you bought clothing items? *Please only answer for yourself rather than for your household.*

☐ In the past week
☐ 1-2 weeks ago
☐ 3-4 weeks ago
☐ More than 1 month ago

7.3 How much clothing did you buy?

☐ 1-2 items
☐ 3-5 items
☐ 6-10 items
☐ More than 10 items

7.4 Did you buy clothing items in-person or online?

☐ In-person
☐ Online for pickup
☐ Online for delivery **[Skip to 7.8]**

7.5 What form of transportation did you take to and from the store?

☐ Personal Vehicle (driven by yourself or others)
☐ Public Transit (e.g. King County Metro bus)
☐ Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐ Ridehail (e.g. Uber/Lyft) or taxi
☐ Bicycle (including bike share)
☐ Scooter (including scooter share)
☐ Other: _____

7.6 How many minutes did it take you to reach the store?

_____

7.7 Did you buy items from other stores as part of the same trip?

☐ Yes   ☐ No

7.8 If you did order for delivery, where was your package delivered?

☐ On my doorstep
☐ To a reception area/building manager
☐ To a package locker in my building
☐ To a store/nearby package locker
☐ Met the driver outside my building
☐ Other: _____

The following questions will ask about the impact of the construction of the West Seattle bridge on your shopping habits.

8.1 How has the closure of the West Seattle High Bridge affected your preference for in-person vs. online shopping?

☐ Strongly prefer online shopping
☐ Somewhat prefer online shopping
☐ Neutral
☐ Somewhat prefer in-person shopping
☐ Strongly prefer in-person shopping

8.2 Since the closure of the West Seattle High Bridge, are your in-person shopping trips closer or farther away from your home?

☐ Much closer to home
☐ Somewhat closer to home
☐ Neutral
☐ Somewhat farther from home
☐ Much farther from home

8.3 What mode of transportation do you use most often in West Seattle?

☐ Personal Vehicle (driven by yourself or others)
☐ Public Transit (e.g. King County Metro bus)
☐ Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐ Ridehail (e.g. Uber/Lyft) or taxi
☐ Bicycle (including bike share)
☐ Scooter (including scooter share)
☐ Other: _____

8.4 Which modes of transportation have you used more often since the West Seattle High Bridge Closure?

☐ Personal Vehicle (driven by yourself or others)
☐ Public Transit (e.g. King County Metro bus)
☐ Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐ Ridehail (e.g. Uber/Lyft) or taxi
☐ Bicycle (including bike share)
☐ Scooter (including scooter share)
☐ Other: _____

8.5 Which modes of transportation have you used less often since the West Seattle High Bridge Closure?

☐ Personal Vehicle (driven by yourself or others)
☐ Public Transit (e.g. King County Metro bus)
☐ Walking or use of mobility device (e.g. wheelchair, mobility Scooter (including scooter share))
☐ Ridehail (e.g. Uber/Lyft) or taxi
☐ Bicycle (including bike share)
☐ Scooter (including scooter share)
☐ Other: _____

8.6 Has the West Seattle High Bridge closure affected your shopping behaviors in any other ways? Please elaborate below

_____

VARIABLE NAME	POSSIBLE VALUES	DESCRIPTION
Gender	Male Female	The gender identity of the participant. "Gender not listed" was not included in the MNL model due to few entries
Income	Less than $24,999 $25,000 to $49,000 $50,000 to $99,999 $100,000 to $149,000 $150,000 to $199,999 $200,000 or more	Expected household income of participants, selected from possible income ranges
Age	18+	Age of participant
Disability	Yes No	Whether the participant has a disability affecting mobility
Employed	Employed Not employed	The employment status of the participant was consolidated from the original 5 options into 2
Children	0+	Number of children living in the participant's household
Vehicle	Yes No	Whether the participant has access to a vehicle
Shopping category	Groceries Household supplies Restaurant food Clothing items	Randomly choose which shopping category/goods type
Recent	Less than 2 weeks ago More than 2 weeks ago	In most recent times participants bought goods, consolidated into 2 ranges
Option	Walking Driving Delivery	Method of purchasing goods, the dependent variable in the MNL model
HalfMile	0+	Number of establishments in the shopping category within a half-mile radius of the participant's approximate location
Distance to Bridge	0+	Distance to the 1st Avenue South bridge
Close	1-5	The extent to which participant believes their shopping trips are closer to or farther from home since the bridge closure
Pref	1-5	The extent to which participant prefers in-person versus online shopping since the bridge closure

DRIVING & WALKING TIME

From Table 7, it appears that personal vehicle travel time may be different across the goods types, specifically concerning clothing items. It can also be seen that the standard deviations for personal vehicle travel time are unequal across goods types. Similar to personal vehicles, the standard deviations for walking travel time are also not equal.

We used a Welch One-Way ANOVA used to compare means of travel times across goods types. The results of this test are reported in Table 11. From Table 7 we can see that there is no significant difference in walking travel times between the goods types since the p-value is greater than 0.05. In conjunction with our earlier chi-squared test, this indicates that the type of goods being shopped for does not affect the mode choice if walking is the chosen mode. It appears that the amount of time spent walking is consistent across all goods categories at around 10 minutes.

Significant differences were found between the goods types in personal vehicles, however, justifying a test between each pair of goods. Since the categories have unequal variances, the Games-Howell nonparametric comparison is used at the 95% confidence level, the results of which are shown in Table 12.

There are 3 significant differences between groups that are indicated by the Games-Howell test: Groceries-Clothing, Food-Clothing, and Supplies-Clothing. This indicates that there is a significant difference in travel times between Clothing and each of the other 3 goods types. No significant differences are observed between groceries, food, and clothing (though groceries-food gets very close). We can conclude as a result that driving travel time is consistent across these three goods types at between 9-12 minutes.

Table 11. Welch One-way Anova over personal vehicles and walking

	F	NUMERATOR DF	DENOMINATOR DF	P-VALUE
Personal vehicle	22.42	3.0	183.53	2.06e-12*
Walking	0.37	3.0	14.4	.77

GROUP 1	GROUP 2	ESTIMATE	CONFIDENCE INTERVAL (95%)	P-VALUE (ADJUSTED)
Groceries	Food	2.57	[-0.015,5.15]	0.052
Groceries	Supplies	2.30	[-0.075,4.68]	0.062
Groceries	Clothing	18.1	[12.1,24.0]	2.42e-12*
Food	Supplies	-0.263	[-3.27,2.75]	0.996
Food	Clothing	15.5	[9.24,21.7]	4.2e-8*
Supplies	Clothing	15.7	[9.58,21.3]	2.14e-8*

ADDITIONAL PLOTS

Figure 14: Supply store accessibility
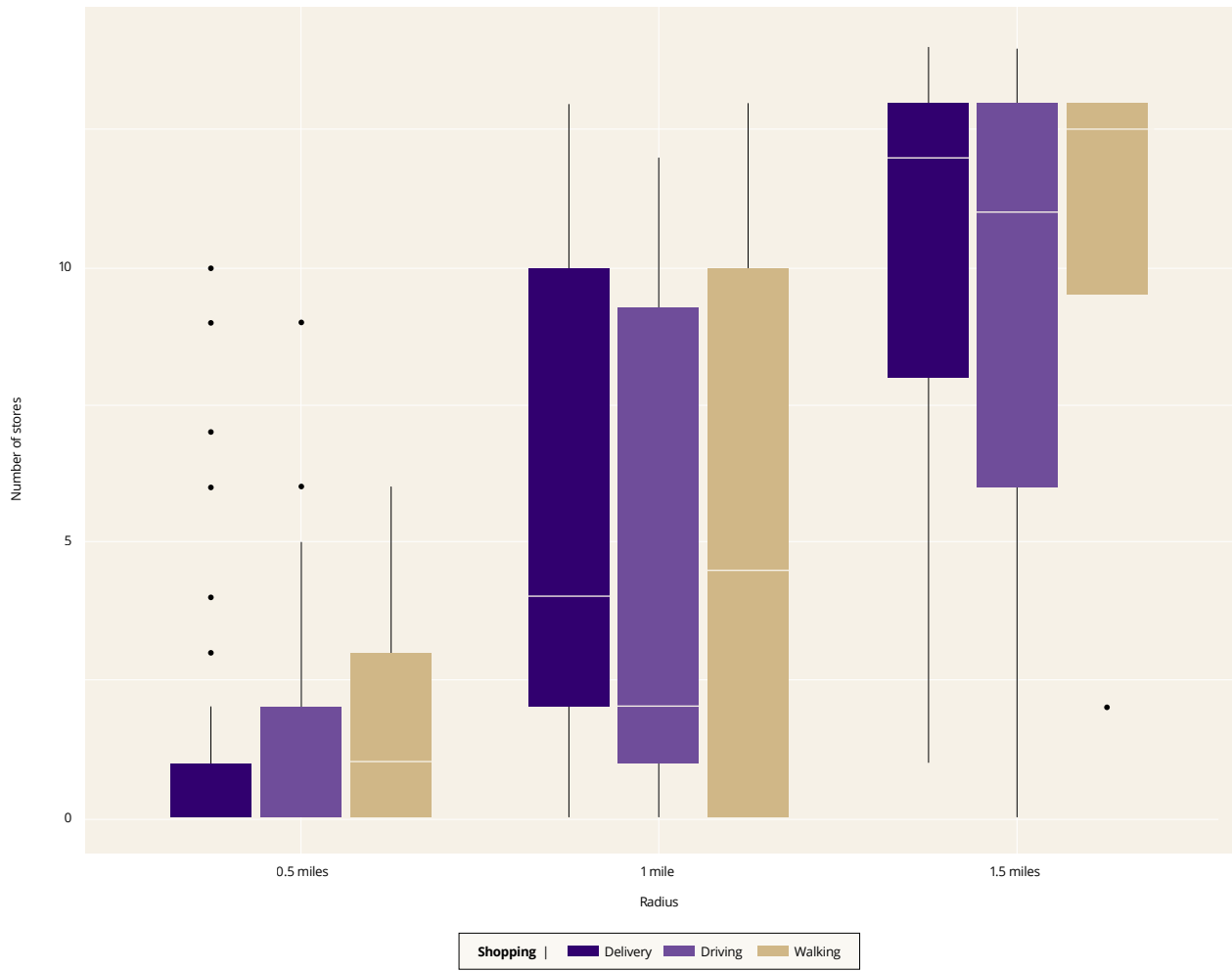
MNL MODEL ESTIMATION RESULTS

Table 13: Frequency of mode of

WALK	DELIVERY	DRIVE
0.15222	0.2647	0.5931

Table 14: Estimation results for MNL model parameters

COEFFICIENT	UTILITY	ESTIMATE	STD. ERROR	Z-VALUE	PR(>|Z|)	SIGNIFICANCE
(Intercept)	Delivery	0.567	0.924	0.614	0.53907	
(Intercept)	Drive	-0.863	0.920	-0.937	0.34840	
Age	Delivery	3.14E-3	1.16E-2	0.271	0.7861	
Age	Drive	9.78E-3	9.84E-3	0.993	0.3205	
Male	Delivery	-0.650	0.284	-2.291	0.02194	*
Male	Drive	-0.568	0.228	-2.488	0.01284	*
Not employed	Delivery	-0.412	0.349	-1.181	0.23757	
Not employed	Drive	-2.62E-4	0.289	-0.000	0.99927	
Disability	Delivery	0.630	0.519	1.214	0.22452	
Disability	Drive	0.392	0.457	0.859	0.3902	
Children	Delivery	0.149	0.177	0.845	0.39799	
Children	Drive	0.212	0.153	1.388	0.16492	
Vehicle	Delivery	0.325	0.630	0.515	0.60631	
Vehicle	Drive	2.15	0.74	2.910	0.00360	**
Recent > 2 weeks	Delivery	0.408	0.409	0.996	0.31891	
Recent < 2 weeks	Drive	0.398	0.392	1.015	0.31001	
HalfMile	Delivery	-0.131	0.339	-3.863	0.00011	***
HalfMile	Drive	-0.142	2.82E-2	-5.015	5.28E-7	***
Clothes	Delivery	3.28	0.439	7.463	8.42E-14	***

COEFFICIENT	UTILITY	ESTIMATE	STD. ERROR	Z-VALUE	PR(>|Z|)	SIGNIFICANCE
Clothes	Drive	0.299	0.389	0.76	0.44188	
Food	Delivery	2.28	0.526	4.329	1.49E-5	***
Food	Drive	1.76	0.428	4.101	4.11E-5	***
Supplies	Delivery	1.69	0.391	4.316	1.59E-5	***
Supplies	Drive	0.705	0.289	2.441	0.01462	*
Dist to 1st Ave Bridge	Delivery	-1.78E-4	9.91E-5	-1.79	0.07253	
Dist to 1st Ave Bridge	Drive	-9.72E-5	8.16E-5	-1.192	0.23322	
Close since WS Bridge closure	Delivery	5.20E-3	0.108	0.04	0.96170	
Close since WS Bridge closure	Drive	7.25E-2	9.21E-2	0.787	0.43092	
Pref since WS Bridge closure	Delivery	-0.352	0.118	-2.983	0.0028	**
Pref since WS Bridge closure	Drive	-5.54E-2	9.97E-2	-0.555	0.5788	

Significance codes: *** 0.001, ** 0.01, *0.05
Log-Likelihood: -608.52
McFadden R^2: 0.18333
Likelihood ratio test : chisq = 273.21 (p.value = < 2.22e-16)