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Travel Behavior in E-commerce: Shopping, Purchasing, and Receiving

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Travel Behavior in E-commerce: Shopping, Purchasing, and Receiving

October 2022

A Research Report from the National Center for Sustainable Transportation

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16. Abstract
The growth of urban e-commerce has had enormous impacts on urban transportation and land use. Retailers are competing through free and 1- or 2-day delivery which has incentivized small-scale deliveries (small packages in small trucks) to personal residences. From an urban freight perspective, these trips are less efficient than large-scale deliveries to retail locations. However, there remain questions regarding the overall impact of online shopping on passenger travel and vehicle miles travelled (VMT). This project focuses on how delivery preferences affect individual travel behavior in California and the Greater Los Angeles Region. The research puts special emphasis on alternative delivery methods that cluster local deliveries, such as automated parcel lockers (APLs) offered by Amazon. Clustered local deliveries could reduce truck VMT while only marginally increasing passenger VMT. We conduct two separate but related surveys to explore the potential of APLs as an alternative for residence deliveries: The first survey examines e-shopping behavior in general; the second addresses the use of APLs. We find that that online shopping is ubiquitous. The pandemic increased e-shopping, expanding it to older age cohorts and more diverse products. The use of APLs is rare. Convenience is the dominant factor in delivery choice. The potential market for APLs could be increased if there were more locations available near home or workplace. Future research directions include modeling the impact of delivery methods on passenger VMT and incorporating product returns into our understanding of APL use.

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Disclaimer

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EXECUTIVE SUMMARY

The purpose of this research is to explore an important but understudied aspect of online shopping: how e-shoppers choose to have their purchases delivered. We use the term "e-shopping" to describe any purchase of retail goods transacted via the Internet. There are many questions regarding the overall impact of online shopping on passenger and truck vehicle miles traveled (VMT). It is argued that e-shopping decreases passenger travel and total VMT as delivering multiple packages via a single vehicle is more efficient than multiple shoppers making individual trips to shopping locations.

However, the net effect of e-shopping on passenger travel remains unknown, as shoppers may browse at stores before purchasing online or may use the time saved from online shopping to travel for other purposes. The net effect on truck travel is clear: small scale deliveries (small packages in small trucks) are less efficient than the large-scale deliveries made to retail establishments.

One possibility for reducing truck related VMT is the use of Automated Parcel Lockers (APLs), which allow for the clustering of deliveries within neighborhoods. The consumer performs the "last mile" by traveling a short distance to pick up the package. Reducing the number of local deliveries clearly would reduce truck travel, but the effect on passenger VMT depends on how the consumer travels to and from the APL. We conduct two separate but related surveys to explore the potential of APLs as an alternative for residence deliveries. The first survey elicits information on e-shopping behavior. The second survey targets APL users to understand how and why they are used.

Our research was affected by the COVID 19 pandemic. The research design was developed before the pandemic and was adjusted in response to the pandemic. Because shopping behavior changed dramatically over the course of the pandemic our findings may or may not be indicative of future trends.

Our findings are summarized as follows. First, e-shopping is frequent and widespread. Consistent with national statistics that show rapid growth in the online shopping market share, we find that over half of our respondents e-shop at least once per week, and 30% shop several times per week. While it is generally perceived that the younger generations show higher adoption rate of e-shopping, more than half of those who shop at least once per week are over the age of 44. In response to the pandemic, people are e-shopping more frequently and purchasing a greater variety of goods. The majority (60%) state that these patterns will continue after the pandemic.

Currently, APL use is a rare occurrence. Almost all deliveries (90%) are to home, while only 1 to 5% are to APLs. APL use is infrequent in part because of perceived inconvenience and in part by

lack of access to APLs or unawareness of their availability. Convenience is the motivating factor in e-shopping: people shop online because of convenience and have packages delivered to home for the same reason. When asked whether they would consider using APLs, respondents stated that if they were conveniently located and offered some type of benefit (e.g., discounts) they would be more likely to use them.

We conducted a second survey to understand the behavior of those who had used APLs at least once in the past four weeks. Use of APLs is associated with younger age, higher level of education, and residing in areas of higher population density. Again, the convenience theme was evident: APLs were used when they were the most convenient delivery option. Other reasons include security of the package, free shipping, or faster shipping. The question of VMT reduction depends on how APL users access the lockers. We asked questions about both usual behavior and the respondent's most recent pickup. The majority drove alone to or from home. There were differences in some of the responses. For example, a larger majority of respondents said they usually pick up packages on the way to or from other destinations, but less than half reported doing so on the most recent trip. Few respondents took transit or used non-motorized modes.

Our results suggest a larger potential market for APLs; if there were more APL locations available, they would be convenient to use for more people. If retailers offered incentives such as faster shipping or discounts more frequent use is likely. A competing trend in lower density areas may be curbside pickup. Next steps in the research include modeling potential impacts on passenger VMT and incorporating returns into e-shopping behavior and APL use.

Chapter 1: Introduction

1.1 Introduction

The purpose of this research is to explore an important but understudied aspect of online shopping: how e-shoppers choose to have their purchases delivered. We use the term "e-shopping" to describe any purchase of retail goods transacted via the Internet. There are many questions regarding the overall impact of online shopping on passenger and truck vehicle miles traveled (VMT). It is argued that e-shopping decreases passenger travel and total VMT as delivering multiple packages via a single vehicle is more efficient than multiple shoppers making individual trips to shopping locations. However, the net effect of e-shopping on passenger travel remains unknown, as shoppers may browse at stores before purchasing online or may use the time saved from online shopping to travel for other purposes. The net effect on truck travel is clear: small scale deliveries (small packages in small trucks) are less efficient than the large-scale deliveries made to retail establishments.

One way to reduce online shopping related truck travel is to cluster local deliveries at pickup points. In this case, packages are delivered to a central location, say a neighborhood store, and consumers make the final mile pickup. The delivery vehicle saves travel miles by eliminating many short trips to residences and avoiding delivery failures. If the consumer travels to the pickup point by transit or non-motorized mode, there would be a net savings in VMT. However, if consumers make a special trip to pick up the package there may not be any savings in VMT. Delivery and pickup choice behavior must be understood to determine whether pickup points can reduce net VMT and associated externalities.

This research examines package delivery choices and use of one type of pickup service, automated parcel lockers (APLs). We conduct two separate but related surveys to answer the following research questions:

1. What are the patterns of e-shopping with regard to frequency, goods purchased and other attributes, and how are these related to attributes of the shoppers?
2. How has the COVID-19 pandemic affected e-shopping behavior?
3. How do e-shoppers choose among delivery choices?
4. If an APL is chosen, how do e-shoppers travel to and from the pickup point?

The second question was added due to the COVID-19 pandemic, which commenced near the beginning of this project. The pandemic significantly delayed the research because the second survey was designed as a field survey. Details on how the effects of the pandemic were managed in the survey research are discussed in Chapter 3. The remainder of this chapter presents an overview on e-shopping trends, justification of the research, and a description of the following chapters.

1.2 Trends in e-commerce

The rise in e-commerce has been rapid. In the US, the market share of online shopping has increased from about 3.7% in 2008 to 9.5% in 2018 and 13.5% in 2021. The annual rate of

growth of online shopping sales has been around 11 to 13% since 2011, much greater than the rates for total retail sales of 3 to 4% (US Census, 2022). The global market share of online shopping among retail sales is estimated to be nearly 20% in 2021 with a value of nearly $5 trillion. China is by far the largest e-shopping market, accounting for about $2.8 trillion in purchases.[1]

The COVID-19 pandemic has accelerated the growth of online shopping. According to the most recent 2020 Annual Retail Trade Survey (ARTS) release, e-commerce sales increased by $244.2 billion or 43 percent in 2020, the first year of the pandemic, rising from $571.2 billion in 2019 to $815.4 billion in 2020 (U.S. Census, 2022). Consumers spent $792 billion online with U.S. retailers in 2020, up 32.4% from $598 billion the prior year, according to a Digital Commerce 360 analysis of U.S. Department of Commerce data. Online spending represented 19.6% of total retail sales last year, compared with 15.8% in 2019. Most forecasts expect continued growth in the US, as market share has not reached the levels of other countries. The lockdowns of the early pandemic served as a strong catalyst to shift to online purchases; with most retail stores closed online shopping was often the only choice. Those most vulnerable to severe illness could avoid exposure by shopping online. The question is whether the newfound convenience of online shopping results in continued growth or whether some consumers will revert to more in-store shopping.

E-commerce is changing as it grows. First, the variety of goods available continues to grow, and many new products have emerged. such as ingredients and instructions for home prepared meals (e.g., Blue Apron), or subscription services for frequently purchased items. An entirely new sector in the food industry has emerged: food preparation operations dedicated to delivery only service. These “ghost kitchens” are typically located in industrial districts close to the population, adding to the demand for urban industrial space.

Second, the price and convenience of product delivery continues to improve. Free delivery is widely available, creating incentives not only for more online shopping but smaller orders. Speed of delivery is also increasing. Led by Amazon, many firms now offer “instant deliveries” (within two hours), and one day delivery is now routine in many metropolitan areas. Short delivery times require products to be stored close to the population. This has resulted in the restructuring of retail supply chains and increased demand for in-city warehouse and distribution space. Brick and mortar retailers have responded with their own added convenience: curbside pickup. Of course, deliveries are not free. One effort to reduce delivery costs is the pickup point, where packages are delivered to a central neighborhood location and consumers perform the last mile of the journey.

Figure 1 shows how e-shopping has affected package delivery from 2004 to 2021. The bars show USPS mail volume; mail volume has declined consistently from 2007. The lines show parcel deliveries for UPS, USPS, FedEx, and Amazon. Total parcel deliveries have grown from 7.2

[1] Source: https://www.shopify.com/enterprise/global-ecommerce-statistics#:~:text=The%20global%20ecommerce%20market%20is,were%20made%20from%20online%20purchases

to about 28 billion, a four-fold increase. Clearly such shifts in consumer demand have significant impacts on both freight and passenger movements.

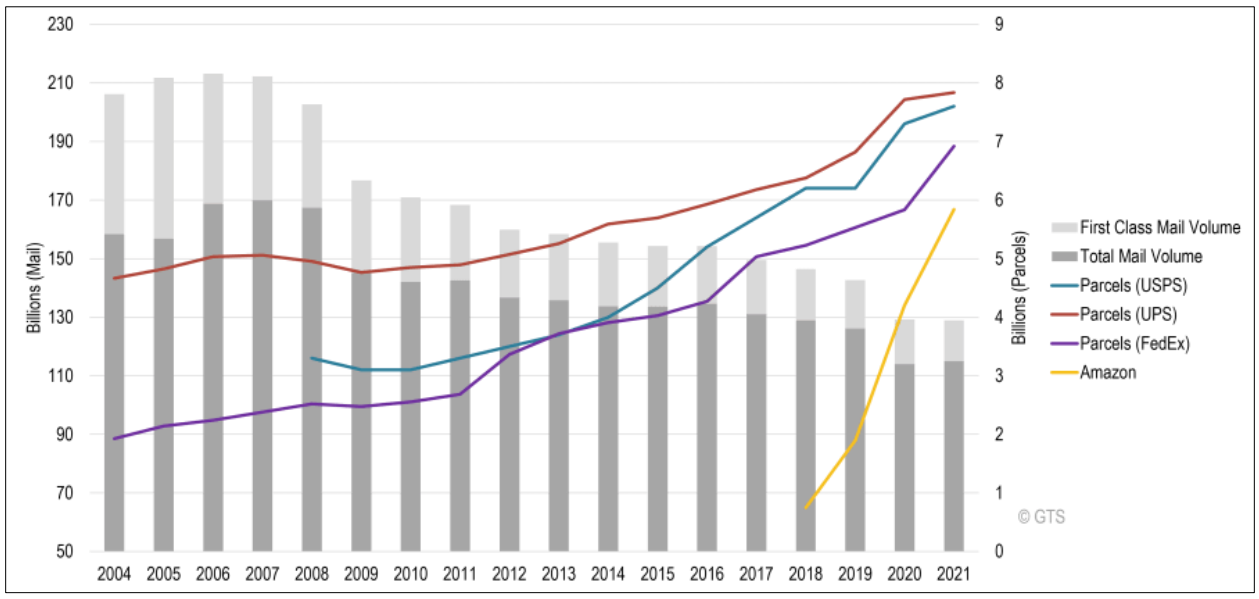


Figure 1. The Growth of E-commerce (Source: Rodrigue, J.P, 2021)

Third, the proliferation of products and services has led to fragmentation—smaller scale and more dispersed patterns of consumption and delivery. On the consumer side, free and convenient delivery, together with liberal return policies, incentivizes more frequent (and smaller) purchases. On the supply side, delivery companies have added specialized food and other delivery services (e.g., UberEats), and in dense city cores these deliveries may be made by bicycle, scooter, car, or small truck. Market forecasts predict continued expansion and diversification of instant deliveries. Taken together, these trends suggest continued fragmentation of the goods supply chain, as more consumption is individualized and delivered to home. Fragmentation in turn will generate more truck travel.

1.3 Justification of the research

The growth of e-commerce is having enormous impacts on the urban environment. Impacts are in two broad categories, land use and transportation. Land use impacts are difficult to underestimate and include the decline of shopping malls, the disappearance of flagship department store chains (e.g., Macy's, Sears), the growth of massive warehouse clusters at the periphery of large metropolitan areas, the growing demand for in-city warehouse facilities, and the emergence of new business models such as ghost kitchens. Land use impacts are beyond the scope of this research. Our focus is on transportation impacts.

The evolution of urban e-commerce as an instant market for any good produced anywhere in the world is resulting in significant transportation impacts. The most visible is the rise in truck traffic in cities. Increased local truck traffic is not simply a function of the rise of e-shopping, but rather of the rise together with the fragmentation discussed above.

E-shopping leads to a variety of inefficiencies in terms of the supply chain. First, e-shopping requires delivery to a residence or local common pickup point. Small scale deliveries (small packages in small trucks) are less efficient than the large-scale deliveries made to retail establishments. Although e-shopping eliminates at least some large-scale deliveries (due to loss of in-store business), these losses will be more than offset by the added truck travel generated by small scale deliveries.

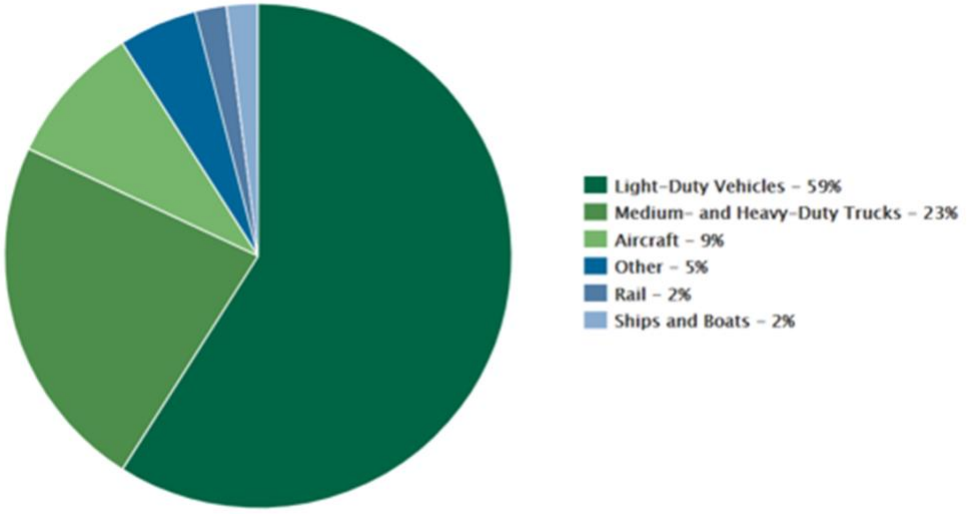
Second, efficiency of freight deliveries is further reduced by the rate of failed local deliveries and the higher rate of returns associated with online shopping. For example, free shipping and liberal return policies make it easy to purchase three pairs of shoes, try them on, and keep one while returning the other two (or returning all three). The higher return rate of online purchases is well documented. Data suggests that 20% of products purchased online are returned, compared to 9% of items purchased in-store.[2] According to the National Retail Federation, while overall returns have remained consistent year-over-year, online returns more than doubled in 2020 from 2019 (during the pandemic). In 2020, $102 billion worth of merchandise purchased online was returned. The outcome is increased truck VMT (Rotem-Mindali and Weltevreden, 2013). Finally, the trend of faster deliveries (1 or 2-day shipping, or "instant delivery" within two hours) intensifies freight inefficiencies by prioritizing speed over larger loads, all else equal.

1.3.1 Externalities

Truck deliveries are associated with several externalities. Air pollution is arguably the most critical due to its impacts on human health. Trucks account for a significant share of air toxics: about one-third of all nitrous oxides (NOX) and nearly 30% of all particulate matter of 10 microns or less (PM10) (EPA, National Emissions Inventory, 2020). The air toxins most damaging to human health are small particulates and ozone, a product of NOX and VOC. Small particulate matter (PM2.5) is a well-documented health hazard. Long-term health studies demonstrate that exposure to small particulates increases risk of both mortality and morbidity from asthma, other lung diseases, and cardio-vascular disease (e.g., Bose et al, 2015; Di et al, 2017; Madrigano et al, 2013). Diesel fuel combustion is a major source of fine particulate emissions.

Trucks also account for a significant share of greenhouse gas (GHG) emissions. The US transport sector accounts for 28% of all GHG emissions. Medium and heavy-duty trucks account for 27% of the transport share. See Figure 2.

[2] Source: https://www.shopify.com/enterprise/ecommerce-returns



Note: Totals may not add to 100% due to rounding. Transportation emissions do not include emissions from non-transportation mobile sources such as agriculture and construction equipment. "Other" sources include buses, motorcycles, pipelines and lubricants.

Figure 2. 2018 United States Transport Sector, GHG emissions by Source (Source: US EPA)

Trucks contribute to urban congestion. There is no data source that documents the contribution of trucks to congestion. However, the performance of trucks, including slower acceleration and deceleration, wider turning radius, and longer braking distance makes their impact disproportionately greater on the traffic stream. Additional externalities include safety and noise. Truck traffic can have significant impacts on vulnerable communities. For example, a crash analysis conducted in Southeast Los Angeles (SELA), a low-income, minority community, the analysis showed that the SELA area has a higher rate of heavy truck crashes on a per square mile basis than Los Angeles County (11.4 vs 2.0 per square mile), and a slightly higher share of fatalities (3.2 vs 2.9%) (Giuliano et al, 2022), Finally, trucks are a significant source of urban noise.

1.3.2 Research gaps

More research is necessary to better understand e-shopping behavior and address the inefficiencies of e-shopping deliveries. We focus on how e-shopping affects travel behavior. If shoppers simply substitute an online purchase for an in-store purchase, travel is reduced. However, shoppers may behave in many ways. Shoppers may inspect merchandise in stores and then purchase online, or the reverse. Shoppers may shop more overall because of the convenience of online purchases. And even if shoppers make fewer shopping trips, they may use the extra time to travel for other purposes. The mode of travel is also an important consideration. If the trip to the store is made by walking or biking, there is no environmental benefit even if it is fully replaced by online shopping. Currently there is insufficient evidence to draw any conclusions on travel behavior impacts (Cao, 2009).

A critical and under-researched aspect of e-shopping is consumer behavior on mode of delivery. Data on how e-shoppers receive packages is extremely limited, especially in the United States. This project examines e-shopping behavior, with the focus on deliveries. By collecting first-hand data on how people manage the receipt of goods purchased online we will develop a better understanding of the overall travel and environmental impacts of e-shopping. Furthermore, various innovative strategies have been introduced to reduce the negative impacts of home delivery, such as pick-up points or automated locker facilities. This project also investigates the uptake and effectiveness of those strategies. Discrete choice models are used to estimate how demographics, product characteristics and shipping options affect the choice to e-shop, as well as the choice of delivery method given the e-shopping purchase decision. Due to the disruption of COVID-19, the study also analyzes the pandemic's impact on people's e-shopping and travel behavior.

1.4 Organization of report

The remainder of this report is organized as follows. Chapter 2 presents a review of the literature on e-shopping behavior and its impacts. Chapter 3 presents our research approach and methodology. We introduce our conceptual framework and discuss our empirical approach. We describe the survey instruments and methodologies. Chapter 4 gives results on usual e-shopping behavior and responses to the pandemic. Chapter 5 gives results on delivery choice behavior. Chapter 6 presents conclusions and findings from our research.

Chapter 2: Literature Review

E-commerce is defined as any type of consumption that takes place via an online platform. This includes all types of consumption, from meal deliveries to cat litter to furniture. The most common type of e-commerce is online shopping: consumers order and pay online, and the goods are delivered to the consumer's residence. There are also variations: the consumer may order online and pick up at a retail or food/drink establishment, or at a designated pick-up point. The emergence of e-commerce has transformed where and how goods are produced, distributed, and sold, and how consumers make shopping as well as individual travel decisions (Mokhtarian, 2004).

This chapter provides a summary of key findings from a review of the literature on the relationships of online shopping and individual travel behavior, as well as on the environmental and social externalities associated with greater volumes of home delivery. The complete literature review is provided in Appendix A of this report.

2.1 Impact on Individual Travel Behavior

A number of studies have investigated the impacts of e-commerce on individual travel behavior. Overall, there are three main types of impacts (Mokhtarian, 2004; Weltevreden, 2007):

1. Substitution, replacing trips to a store with online shopping;
2. Complementary, generating additional trips to a store with online shopping; and
3. Neutral, or no significant impact.

The impact of e-commerce on travel behavior can be considered a dynamic balance between substitution and complementary effects based on different product types, trip purposes, and consumer characteristics. The empirical evidence shows a mix of both, partially due to the failure to distinguish clearly enough between impacts from browsing the internet versus those arising from purchasing online (Circella & Mokhtarian, 2017). It is also difficult for researchers to identify specific combinations of "bricks and clicks", such as the "showroomers" or "free riders" who use stores for testing products and obtaining advice but then purchase online from different retailers to get the cheapest possible price (Couclelis, 2004; Rapp et al, 2015). When it comes to travel mode, online shoppers tend to make more trips by travel modes other than car, including public transit bicycle or walking, especially when picking up goods purchased online. Part of the reason might be that these people are less likely to have a car (Hiselius et al., 2015).

Substitution is supported by some studies. A survey conducted in Tennessee shows that about 40% of the residents reported less driving with the use of the internet (Tonn & Hemrick, 2004). Data from the Netherlands suggests that 20 percent of online buyers made fewer trips to the city center stores (Weltevreden & Van Rietbergen, 2007). However, research focusing on trip frequency and distance reveals that online shopping has a limited or even no impact on the number of trips and total distance traveled for shopping (Golob & Regan, 2001; Sim & Koi, 2002; Rotem-Mindali & Weltevreden, 2013). Several studies even state that online shopping results in additional traveling because online browsing provides numerous products and

therefore stimulates people to make more shopping trips (Farag, Krizek, & Dijst, 2006; Choo, Lee, & Mokhtarian, 2007; Farag, Schwanen, Dijst, & Faber, 2007; Cao, 2012). Without online shopping, they may only go to one or two familiar stores. Other studies indicate that the time saved from online shopping will actually be spent on both additional shopping trips and trips for other purposes (Gould & Golob, 1997; Hiselius, Rosqvist, & Adell, 2015).

2.2 Other Impacts

The rise in home delivery and associated truck trips in residential areas also has social and environmental impacts on congestion, pedestrian safety, air pollution, and noise. As mentioned in Chapter 1, small scale deliveries (small packages in small trucks) are less efficient than the large-scale deliveries made to retail establishments. Although e-shopping eliminates at least some large-scale deliveries (due to loss of in-store business), these losses will be more than offset by the added truck travel generated by small scale deliveries. Efficiency of freight deliveries is further reduced by the rate of failed local deliveries and the higher rate of returns associated with online shopping. The outcome is increased truck VMT (Rotem-Mindali and Weltevreden, 2013).

Some studies measure environmental impacts by assessing the vehicle miles/kilometers traveled by freight transport. Allen et al (2018) examined impacts of light goods vehicles (LGVs, up to and including 3.5 tonnes gross weight) used by home delivery in London, England. Not only had the absolute volume of urban freight grown, but also the speed of response required, which indicated a further growth in LGV traffic. The existing urban infrastructure prioritizing cycling, walking and public transportation resulted in diminishing curbside unloading space and time, and then led to more VMT due to searching and detouring.

Consumer behavior also leads to more deliveries and VMT: when shopping online, consumers are more likely to purchase separate items from different websites, each requiring independent deliveries (Mangiaracina, Marchet, Perotti, & Tumino, 2015). The number of items per delivery is also an important factor. Carbon emissions, which are a function of VMT, increase as items per delivery decrease (van Loon, Deketele, Dewaele, McKinnon, & Rutherford, 2015).

A few studies have gone a step further and evaluated total energy consumption across the delivery chain. Taking factors like packaging, freight transport, and consumer travel into consideration, e-commerce in the bookselling industry was found to consume slightly more energy than traditional retailing, basically due to additional packaging (E. D. Williams, 2002). Follow-up research further revealed that in dense urban areas, each book traded via e-commerce consumed more energy because of additional packaging. The additional energy use could be canceled out in suburban and rural areas thanks to the replacement of home delivery with personal pickup (E. Williams & Tagami, 2008).

2.3 Innovative strategies to address impacts and inefficiencies

To address the high cost of home delivery and the above freight inefficiencies, carriers and online retailers have experimented with alternative strategies to replace home delivery

services. Two examples are pick-up point networks (PPs) and automated parcel locker systems (APLs):

- PPs typically operate through local shops such as dry cleaners, florists, gas stations, bars, etc. where consumers can receive and return parcels. This model provides more flexibility to both consumers and carriers. Consumers have more time and location options to pick up their goods, and carriers can also consolidate their deliveries saving money, energy and time. PPs often work as an additional source of foot traffic so are an attractive service for retailers to provide. PPs have already been very popular in European countries. For instance, in France, the PP networks have replaced 20% of the home deliveries and covered 90% of the French population within walking distance (Fang et al., 2019).
- APL systems or locker banks can be found in shopping centers, gas stations, train stations or on the streets. Packages are delivered to the lockers; the customer receives notification of the delivery and a code to open the locker. APLs are not as common as PPs yet, likely because the business model has not yet been worked out. Existing APLs tend to be located in higher density urban areas. APLs are becoming more common both in European and US cities, mainly driven by several big online retailers like Amazon and Walmart (Fang et al., 2019).

In addition, there is a third model, in-store pickup or curbside delivery: the customer orders online and picks up at the nearest store. One example is Target's "drive up". The customer shops via the Target app and is notified when the order is ready. Parking spaces are reserved for customer pickup. The customer alerts the store upon arrival and the items are brought out and placed in the customer's vehicle. During the pandemic curbside delivery was marketed as "contactless delivery". In-store pickup is common for smaller items such as books or prepared food.

PPs and APLs could provide a more efficient means of delivery, but their success relies on many key factors such as population density, people's acceptance, accessibility, and operational efficiency. More importantly, there is no solid evidence to show that PPs and APLs reduce the environmental impacts of last-mile home delivery. While these alternatives offer operating efficiencies to carriers, Morganti et al. (2014) estimated that in France about 90% of all consumers still request home deliveries (Morganti et al., 2014). UPS estimated that 74% of customers still prefer delivery to home (Singer and Ogg, 2015). Studies in European countries have revealed that immediate surroundings and proximity to home or work significantly affect the uptake of pick-up points (Weltevereden, 2008; Morganti et al, 2014; Iwan et al 2016).

Even if people become more willing to use pick-up points, their travel modes will affect energy consumption and GHG emissions associated with the e-shopping purchase. Pick-up points where most trips could be made on foot would reduce vehicle trips (Durand & Gonzalez-Feliu, 2012). However, most current studies reported that most trips were made by car or a mix of car, train and bus (Pålsson, Pettersson, & Hiselius, 2017), and the mode choices vary by demographics and region (Liu et al, 2017).

Chapter 3: Research Approach & Methodology

3.1 Research Approach

Our focus is how e-shoppers receive their purchases. E-shoppers have options: they can choose the speed of shipping (e.g., standard, 2-day, next day, instant), and how the shipment is received (e.g., residence, place of employment, pickup station or locker, retail establishment). We are interested in how e-shoppers choose their delivery method.

As discussed in the previous chapters, free shipping is widely available and the speed of receiving one's order continues to increase. While offering free shipping is an effective marketing tool for e-retailers, there is a cost to shipping that somehow must be absorbed. We discussed the inefficiencies associated with free shipping in Chapter 2. E-retailers clearly have an incentive to reduce shipping costs. Strategies include offering discounts or coupons when customers accept a longer delivery window, encouraging Amazon shoppers to accept deliveries on "Amazon delivery days", offering curbside pickup, and promoting the use of APLs. Are APLs an effective strategy for increasing delivery efficiency and reducing VMT along with the external costs they generate? The answer depends on the extent to which customers are willing to use APLs and how they travel to and from APLs.

The most common package destination is the home residence and for good reason. Simply having to pick up the package at one's doorstep is the ultimate in convenience for single family home dwellers. Apartment or condo buildings with reception and storage area make home deliveries safe and convenient. However, front porches and doorsteps may be subject to theft. Apartment complexes may not offer a secure place to leave a package. Those concerned about the security of their packages may choose the APL, when available. It is also possible that customers may find it convenient to pick up a package on the way to or from work. E-retailers may offer faster service for APL deliveries or may offer APLs for returns. It follows that use of APLs may be related to availability of an APL near the home or office or travel route, perceived security of delivery options, or services available with the APL. We also note that COVID 19 may affect locker use; customers may prefer home delivery to avoid exposure.

If the e-shopper chooses to use the APL, how it affects passenger VMT depends on the mode of travel. If the APL is accessed by non-motorized mode or transit, there will be a reduction in passenger vehicle VMT, all else equal. If the package is picked up by driving alone on a special trip, passenger VMT will increase. Then the question is whether reduced truck VMT offset the passenger VMT. Finally, the e-shopper may stop at the APL as part of another trip (e.g., to or from work), in which case the added VMT would be negligible.

This discussion suggests a sequential choice model: the choice to e-purchase, and given the choice of e-purchase, the choice of shipment speed and delivery location. To simplify the analysis, we do not model the choice to e-shop, but rather given the choice to e-shop, how delivery is chosen. The second stage is a joint choice, as shipment speed may depend on delivery location. For example, if you would like to receive your purchase within one day, you may have to pick it up at a particular APL instead of having it delivered to your home. There is

then a third choice: given the choice of using an APL, the choice of travel mode to pick up the package.

Figure 3 shows a conceptual model of the choice process. The first choice is whether to e-shop or not. We hypothesize that the choice is a function of product price and availability, shipping options, and attributes of the e-shopper. Once the choice to e-shop is made, the next choice is how to receive the package. Options include receiving at home or office, pick up at the store, or pick up at an APL. We hypothesize that this choice depends on product type and price, costs of other delivery options, shipping speed, and built environment characteristics (e.g., whether secure delivery option is available at place of residence, distance from home or work to nearest APL), as well as attributes of the e-shopper. The third choice is travel mode if the APL is chosen. This choice will be related to relative locations of home, work or other usual activity destinations and APLs, usual mode of travel, and product characteristics (e.g., small or bulky).

We estimate the following models based on the conceptual framework of Figure 3:

- Model 1, Usual shopping behavior: Model 1 examines the factors that explain the choice to shop online as a function of attributes of the individual and attributes of the alternatives, including product type, shipping costs and options.
- Model 2, Most recent online purchase: Similar to Model 1, but with the actual choice parameters.
- Model 3, Choice of delivery, given decision to online purchase: In this case the dependent variable is the combination of shipping speed and location choice. The independent variables here are prices and availability of the alternatives.
- Model 4, Travel mode choice, given pickup point choice delivery: The independent variables will contain three vectors: demographics, product characteristics and built environment near pick-up points.

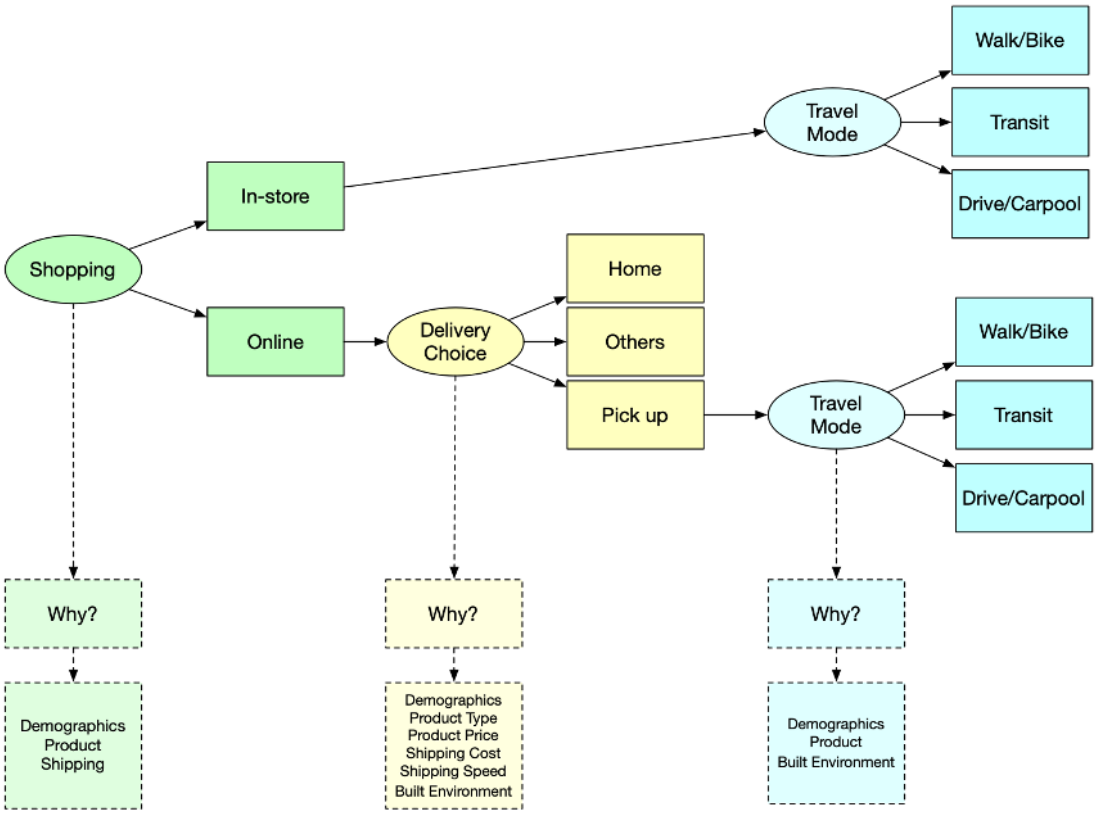


Figure 3. E-Purchase Delivery Choice

3.2 Methodology

Data on how e-shoppers receive packages is extremely limited, especially in the United States. There are estimates of annual package deliveries, and some case studies have been done. A study in New York City estimated that individual census tracts covering only a few blocks generated residential demands ranging from about 200-600 package deliveries per day (Chen, Conway & Cheng, 2017). Travel diary surveys increasingly include questions on e-shopping (usually frequency of online shopping), but not on choice of shipment speed or delivery location. Therefore, we chose to conduct a survey of e-shoppers to collect the necessary data to better understand e-shoppers' choice process. To our knowledge there is no data available on the use of APLs in the US.

Our methodology includes two surveys because use of APLs is a rare event. Conducting one random survey would require a very large number of surveys to achieve a suitable number of APL users for analysis. The first survey addresses e-shopping behavior in general; the second survey addresses use of APLs. Our initial survey design was to seek respondents via social media for survey 1 and conduct survey 2 as an intercept survey at APL locations. As will be further discussed below, these strategies were not sufficient to reach our target sample sizes. We supplemented both surveys with additional responses obtained via an online survey research company.

We selected Los Angeles County and its surrounding populated area as our case study area for the following reasons: the size and diversity of the population (Los Angeles County population is about 10 million), the diversity of the urban geography, and access for intercept surveys.

APLs are available in Los Angeles County but not ubiquitous. We decided to focus on Amazon Lockers because of Amazon's dominant position in US online sales (40.4% of US online sales in 2021) and the expansion of its APL network.[3] There are no pickup points in Los Angeles County for any other major online retailers. UPS has Access Points which are located at neighborhood retailers or UPS store locations, which we have categorized as pick-up points, or PPs. However, UPS itself is not an e-commerce retailer.

Using a Google Map API, we geo-located all Amazon Locker facilities in Los Angeles County; there are 442 Amazon Locker sites, with over 50% located at 7-Eleven convenience stores, and the remaining at gas stations, grocery stores, or colleges. Given the size and population of Los Angeles, this equates to 0.04 locker per 1,000 people. Thus, many e-shoppers do not have the option of choosing locker pickup, again reducing the potential number of APL users. Figure 4 shows the locations of Amazon APLs in the Los Angeles County area. Locations are spread throughout the area with just a few concentrations, notably in the Los Angeles downtown area, the westside, and Hollywood area. Most Amazon APLs are accessible 24 hours a day, often serving both deliveries and returns.

[3] Source: https://www.emarketer.com/content/amazon-dominates-us-ecommerce-though-its-market-share-varies-by-category.

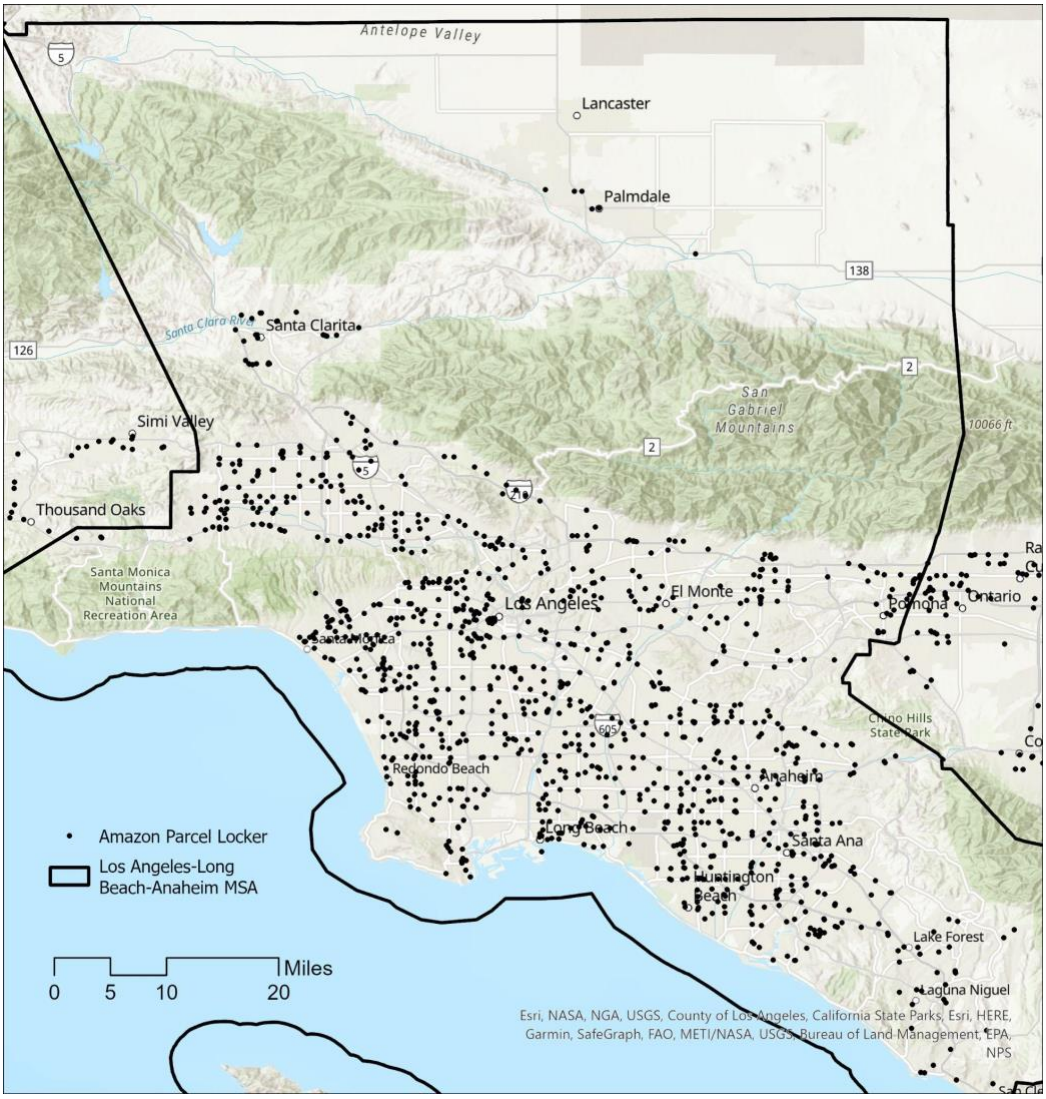


Figure 4. Map of Amazon APL Locations in Los Angeles County Area

3.2.1 E-Shopping Behavior Survey (Survey 1)

Survey 1 was designed to collect data on the usual behavior and experiences of the general population of e-shoppers. The survey included questions on the frequency of online purchases and most recent purchases, perceptions of e-shopping costs and convenience, and respondent demographics. Questions on the impact of COVID-19 are also included, asking about behavioral changes regarding online shopping and delivery choice. The full survey instrument is available in Appendix B of this report.

The survey was designed using the Qualtrics online survey hosting platform, with development and testing of the survey instrument taking place in Fall of 2021. The survey was opened for responses in November 2021 and closed in March 2022 with a target sample size of 500 complete responses, at minimum. We decided that an online, social media approach would be

the most cost-effective for distribution and would be most likely to generate an adequately large sample.

Distribution channels included:

- Social media channels under the METRANS Transportation Consortium: METRANS Facebook, Twitter and LinkedIn feeds
- METRANS Student News, METRANS News, and the METRANS general contact list
- USC Price School marketing, newsletters, events, Facebook, Twitter, and LinkedIn Feeds
- Caltrans Newsletter

While the primary geographic focus of the study is Los Angeles County, the survey was also distributed throughout California by the Caltrans team, to increase the sample size. We also supplemented our original samples with a third-party provider to meet our target sample goal of 500 responses.

3.2.2 Automated Parcel Locker Survey (Survey 2)

Survey 2 was designed to collect data on the behavior of e-shoppers who use or have used parcel lockers. The survey included questions on experiences with lockers, trip-related attributes (i.e., mode of transport, distance), potential incentives for further use, and respondent demographics. The survey was designed using the Qualtrics online survey hosting platform, with development and testing of the survey instrument taking place in Winter of 2022. Here, the survey questions were distributed to the online panels of the 3rd party company based on demographic factors to obtain a representative sample. Survey 2 included questions on frequency of APL use, reasons for using them, and means of travel to and from the APL location. The full survey instrument is available in Appendix C. Because APL use is rare, our sample target was modest: 200 responses.

The original Survey 2 was designed to be used as an intercept survey to be completed online. Given the infrequency of APL use our strategy was to identify the locker locations with high traffic and approach APL users directly. First, we used Yelp reviews as an indicator of use frequency; this effort yielded locations near the major universities as the most popular sites. We were later able to contact Amazon; they provided the top ten locations in Los Angeles based on use. Figure 5 shows the locations of the top 10 identified by Amazon as red dots. The most frequently visited lockers are located in some of the most densely populated neighborhood areas of Los Angeles - Koreatown, Pico Union, and MacArthur Park. The locker locations most frequently rated in Google maps are shown as blue dots. The most frequently ranked APLs are near USC, UCLA, and in Hollywood. Black dots are other APLs in the area.

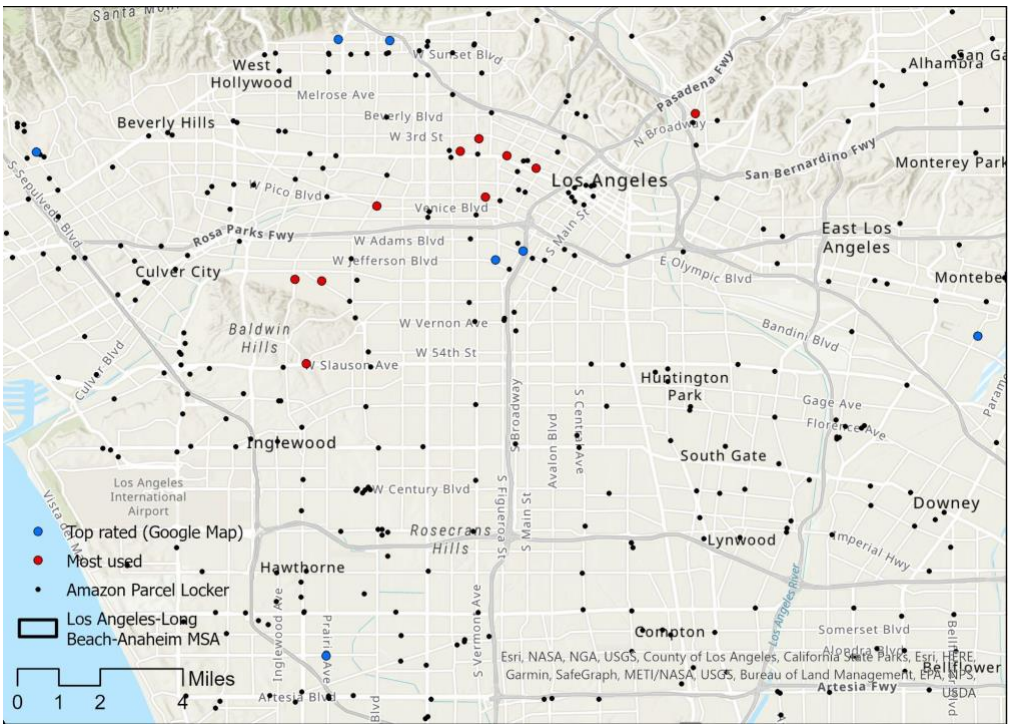


Figure 5. Map of Amazon APL Locations in Concentrated Areas of Los Angeles Region, Most Used and Top Rated by Google

We conducted field studies of each top ten location. See Figure 6 for some examples. We found that individuals using these lockers were time-restricted (preferring to pick up quickly and leave) and the location of Amazon lockers (inside small 7-Elevens and shopping centers) were not conducive to intercept surveys. COVID-19 pandemic restrictions also limited the feasibility of in-person contact and receptiveness of individuals to engage in contact with strangers.

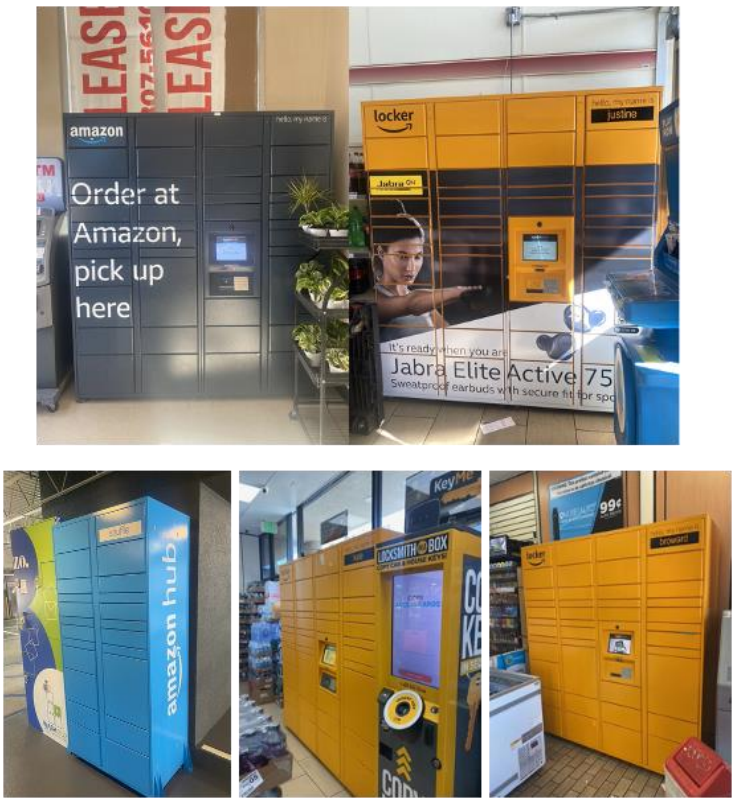


Figure 6. Amazon APL Locations and Lockers

As an alternative, the survey was distributed through a combination of in-person (using a contactless QR code) and digital survey techniques, with a filter to ensure individuals had experiences with parcel lockers. For in-person surveys, focus was placed on the UCLA and USC Amazon Hub Locker locations, which are two of the most highly trafficked amazon lockers in Los Angeles, and the location for Amazon free pick-ups and returns. Surveys were conducted from January through March of 2022.

Chapter 4: Descriptive Analysis

This chapter presents a descriptive analysis of the two surveys. We describe characteristics of the samples and present results on some of the key survey questions.

4.1 E-Shopping Behavior Survey (Survey 1) Results

Survey 1 examines the usual experience and behavior of e-shoppers, specifically attributes of most recent online purchase, perceptions of e-shopping costs and convenience, and respondent demographics and socioeconomics. Specifically, we wanted to understand how e-shoppers make their delivery choice—results that lead us into the second survey which specifically considered the usage of lockers for package delivery. All respondents have made a purchase online over the last several months, as noted by the first question in the survey.

We collected 127 responses to the survey through outreach across the METRANS Transportation Consortium and Caltrans social media feeds and newsletters. With the desire to collect a sample that was closer to being demographically and socioeconomically representative of the California population, we pursued additional responses through a third-party survey response provider. We collected 525 responses to the survey using the third-party vendor, resulting in a total of 652 responses. We filtered the data to eliminate responses from outside California and incomplete responses. This resulted in a total of 596 observations.

The socio-demographic status of the final data set and comparisons with California population characteristics are reported in Table D1. Respondents skew more educated but with lower incomes than the population of California: 53% report a bachelor's degree or higher while less than 34% of the population of California are within these categories of educational attainment. Respondents making more than $100,000 made up nearly 26% of the respondents, while nearly 40% of the population of California makes over $100,000. The geographic reach of the survey was within California and included responses within Southern California and the Bay Area, as shown in Figure 7 and Figure 8. The size of the dots in each zip code indicates the number of observations. Observations are concentrated in the central core of each of the major regions in California, and most substantially in Central Los Angeles likely due to the team's outreach and the density of the population in Los Angeles.

Our sample is not representative of the total population due to the challenges and costs of reaching this size of a sample within California. Since a significant portion of the adult population participates in e-shopping, theoretically it would be possible to eventually achieve a statistically representative sample.

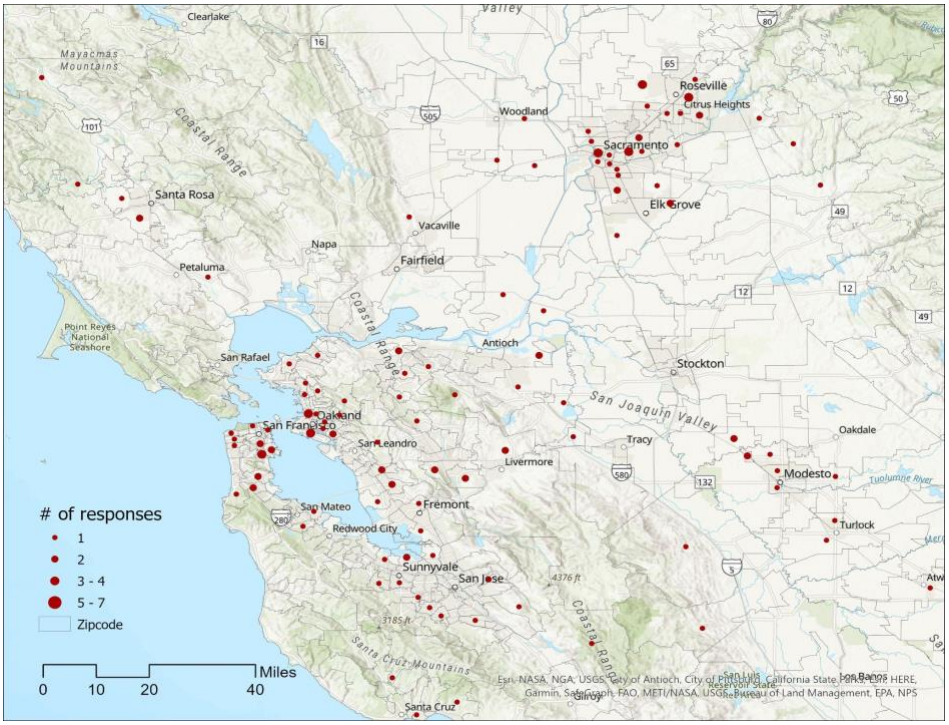


Figure 7. Location of Survey 1 Respondents, Greater San Francisco Bay Region

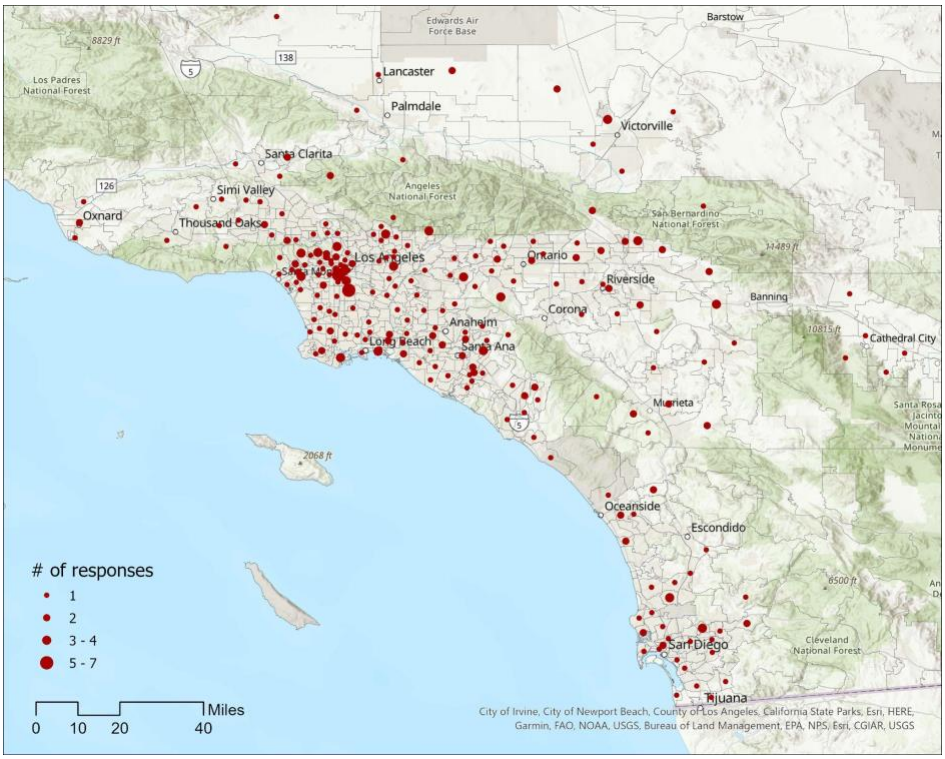


Figure 8. Location of Survey 1 respondents, Southern California (rural parts of San Bernardino County, Imperial County not shown)

4.1.1 E-Shopping Behaviors

The frequency of e-shopping is very high among respondents, which is reflective of both our survey approach (including only those who e-shop) and country-wide trends discussed in Chapter 1. Within a typical month, half of survey respondents shop online at least once a week, with over 30% ordering multiple times a week or almost every day. The modal response is more than once per month but less than once per week. See Figure 9. When asked about their most recent online purchase, 54% of survey respondents cited receiving their last package within the week, with 16% that very same day. The vast majority had received only one package (62%), free shipping (82%), and 42% had received their package within the 2 day "fast" delivery window.

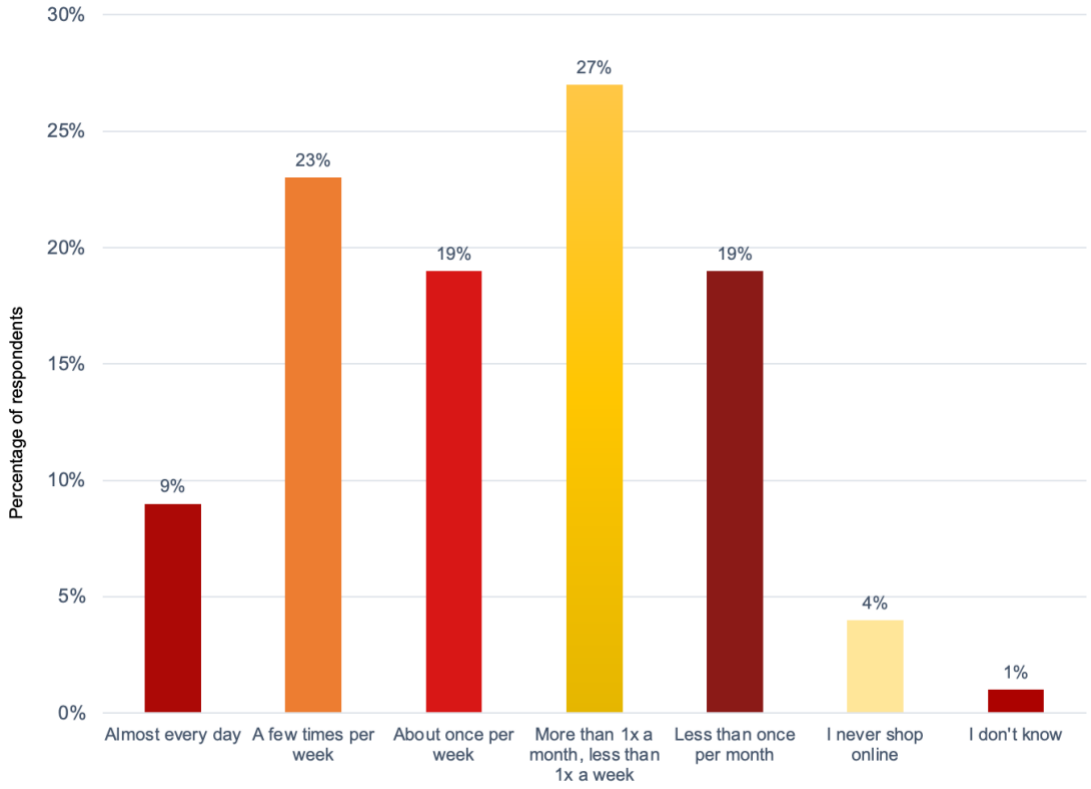


Figure 9. Thinking about a typical month, how often do you usually shop online?

The most reported items ordered online are:

1. Clothes and shoes
2. Food/drink[4]
3. Consumer electronics (phones, tablets, headphones, etc.)

In general, more and more consumers are relying on their mobile device to search, browse, and purchase online. Within the survey sample, individuals are most frequently using their

[4] The category of food/drink can include grocery delivery as well as restaurant mobile app delivery (i.e., UberEats)

smartphones to e-shop, with 47% using it as their primary device for online shopping, however laptop and desktop devices are still a close second (44%).

Respondents were asked to rank the importance of various factors influencing their decision to shop online versus in store on a scale of 1 to 10. Table 1 gives results. All factors listed were ranked at 5 or more. The highest ranked factors are ease of purchase and shipping costs, followed by availability of product online, price and shipping time. Interestingly, the variance in responses is quite consistent across all factors. Our surveys took place from late 2021 to early 2022, a period of the COVID-19 Omicron variant surge but no lockdowns. Choosing online shopping to avoid entering stores at that time was not highly ranked.

Table 1. Importance of Factors for Choosing Online vs In-Store Shopping

Factors important for choosing to buy online or in-store	Mean	Median	S.D.
Price	7.88	8	2.23
Availability of product in-store	6.89	7	2.70
Availability of product online	7.92	8	2.19
Variety of produce choices	7.71	8	2.17
Ease of purchase	8.14	9	2.11
Shipping costs	8.07	9	2.45
Shipping time	7.35	8	2.38
Concerns about security and protection of delivery (broken or stolen)	6.85	7	2.90
Avoid entering stores during pandemic	5.54	6	3.36
Saving time	7.33	8	2.60
Avoid making trip to store	6.60	7	3.03
Weight or bulkiness of product	5.09	5	3.11

COVID-19 Pandemic Effects

As mentioned in Chapter 1, the COVID-19 pandemic has accelerated the growth of online shopping. Our survey findings support this statement, with 59.9% of respondents citing an increase in their online shopping during the pandemic. Our survey suggests that this level of online shopping will continue: 60% of respondents said they will continue their COVID-19 shopping behaviors in the future. For nearly half of the sample the types of products purchased online also increased. See Table 2.

Table 2. Responses to Pandemic-Related Questions

Has the pandemic affected the frequency of your online shopping?	
Response	Percentage of Respondents
I have increased my online shopping	59.9%
My online shopping has not changed	36.9%
I have reduced my online shopping	3.2%
Has the pandemic affected the types of products you purchased online?	
I purchase more types of products now	48.2%
I purchase the same products as before	46.8%
I purchase fewer types of products now	5%
Has the pandemic affected the way you have your purchases delivered?	
Yes, I use more methods of delivery than before the pandemic	26.8%
Yes, I use fewer methods of delivery than before the pandemic	3.1%
No, I use the same methods of delivery as before the pandemic	70%

4.1.2 Demographics of E-Shoppers

We found that those shopping with the highest frequency tend to be of higher income (see Figure 10), but that e-shopping is no longer an activity limited solely to millennials and Generation Z. Over 50% of respondents who e-shop at least once a week were over the age of 45 (see Figure 11), with 49% of shoppers between the ages of 18 and 44. Within our survey sample, those who shop most frequently also identify as white (but this may be due to the limitations of our survey sample).

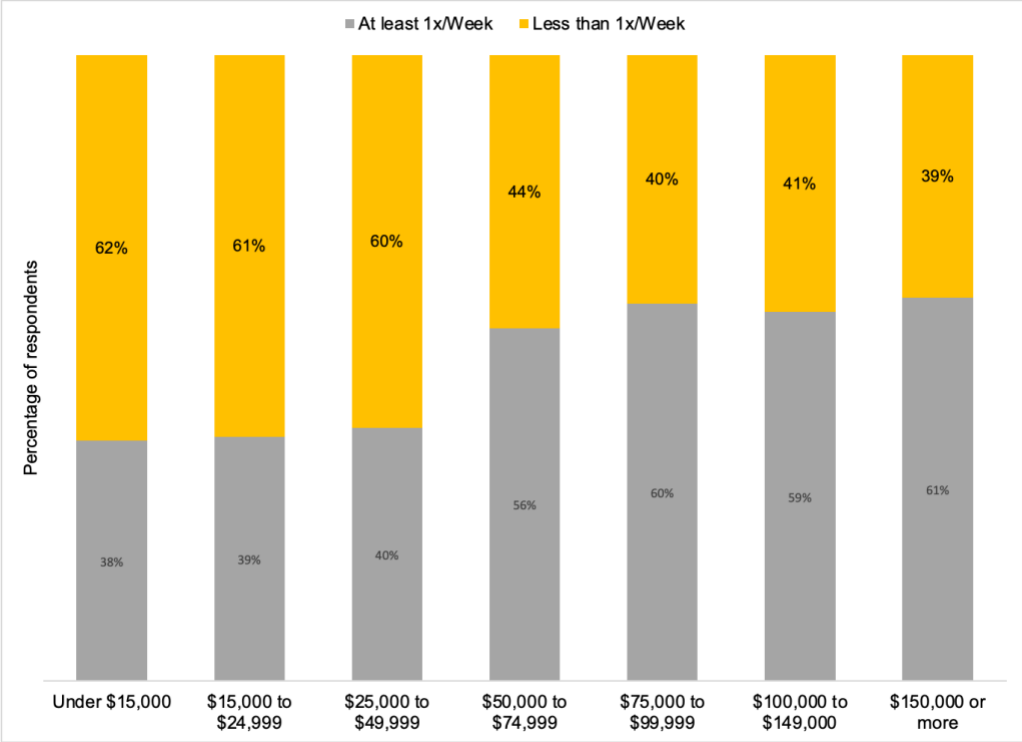


Figure 10. Those who e-shop at least 1x a week by household income category

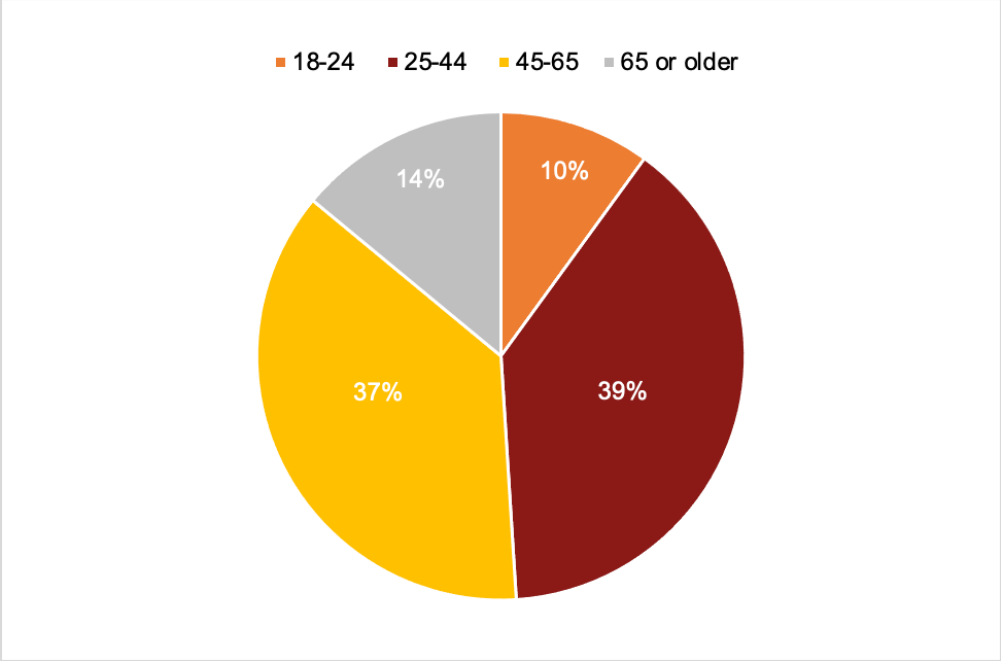


Figure 11. Those who e-shop at least 1x a week by age category

4.1.3 Delivery Preferences

With the most common package destination the personal residence, we would expect the characteristics of the residence to influence package receiving behavior, and possibly the likelihood of e-shopping. It could be hypothesized that apartment or condo buildings with reception and storage areas make home deliveries safe and convenient. Single family homes or small apartment buildings may pose the problem of theft or damage if there is no secure place to leave a package. Conversely, it could be hypothesized that those who live in apartment buildings live in more densely populated areas with higher likelihood of theft or lack of security (see Survey 2 modeling section for more information). However, analysis of the Survey 1 sample found similar demographic profiles for those who receive packages at home versus APL and other alternative methods (however numbers of alternative users were low for Survey 1; see Survey 2 results).

While e-shopping frequency may be high, the use of APL systems is very low. Respondents were asked two questions: how do you usually receive your package? and what ways have you received your packages over the past 6 months? The latter question asks respondents to mark all that apply. Figure 12 shows usual delivery (one choice) and Figure 13 shows all delivery methods used within the last 6 months (multiple choices). The primary location for delivery of online purchases is a person's private residence. Only 1% of respondents usually receive their online purchase using an APL, with 90% having it delivered to their home address. The shares are somewhat different for ways received over the past 6 months. In response to that question, 8.4% of respondents have received their online purchase using an APL, while 96.6% have had it delivered to their home address, 33.9% to a work address, and 8.4% have picked it up from the store. Regardless, APL use seems to be an option used only rarely by online shoppers. The large share of respondents receiving packages at work at a time when many workers were still working from home is unexpected and possibly related to a unique attribute of our sample.

Interestingly, a greater number of respondents choose to have their packages delivered to a PP or UPS Access Point, or to pick up the item physically at the store, than pick up at an APL. Many grocery chains and large retailers began offering curbside pickup in response to the pandemic. It will be interesting to see whether curbside pickup becomes a standard offering post-pandemic.

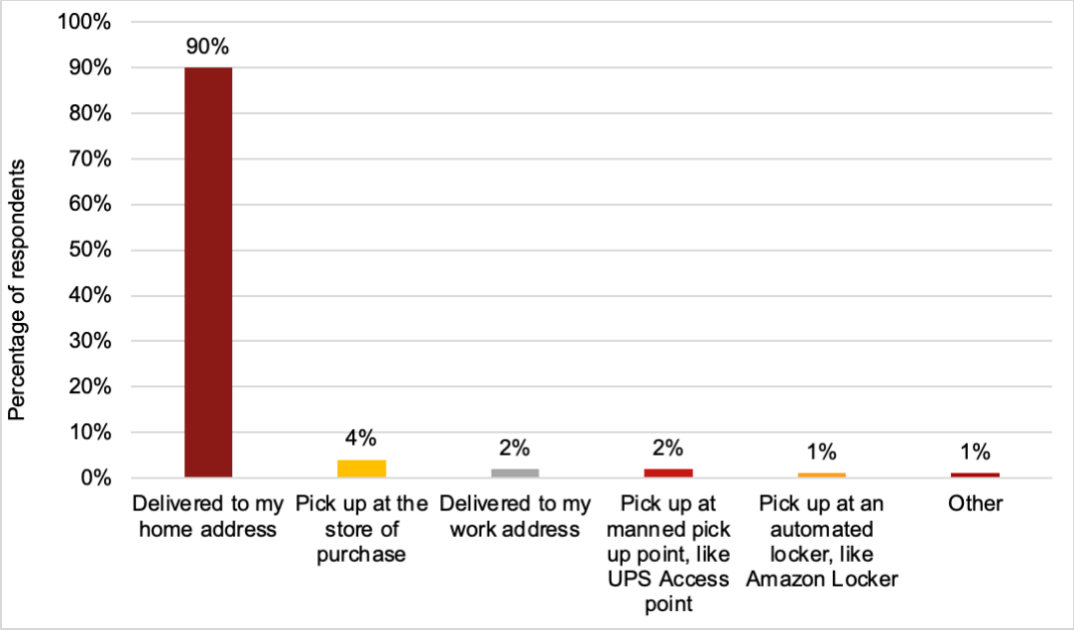


Figure 12. How do you usually receive your online purchase?

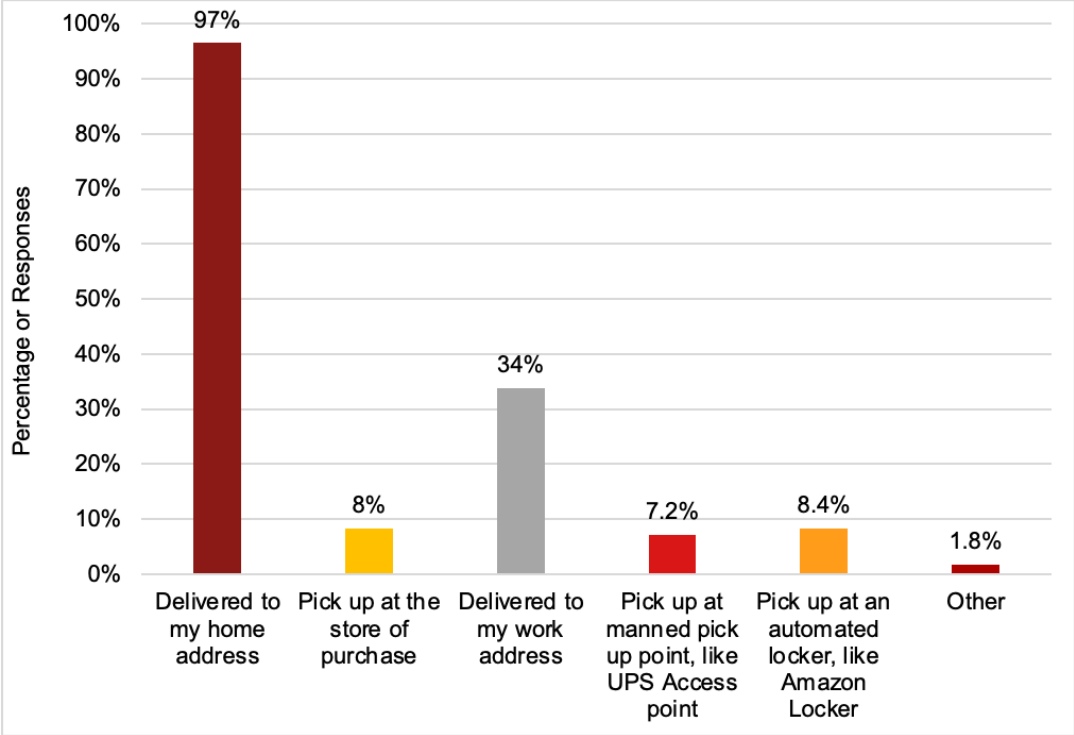


Figure 13. How have you received your packages over the past 6 months? (Multiple choice)

When asked about the reason for choosing certain delivery methods, Respondents could mark up to 3 reasons. Convenience is the top priority; 84% of responses cite convenience as the reason for having an online purchase delivered to their home. The most frequent reasons for

home delivery are convenience and speed, followed by security concerns either for the package or personal. Personal security refers to safety or low risk of personal harm. See Table 3. We also asked respondents who had not used APL or pick up points why they chose not to. See Table 4. The most frequently stated reason was also convenience, in this case the inconvenience of using a locker. In open text responses, respondents stated that they prefer the convenience of home delivery and that "picking up an order would defeat the conveniences of online delivery". The next most frequent responses were not having a locker location near home or work, or not knowing where a locker might be. These responses suggest a potential market if there were more locker locations and more information available. We note that a less frequent but still significant response was that APL locations are not safe. Our field visits suggest that this could be the case for some locations. Some of the most used locker sites are in neighborhoods with high crime rates.

Table 3. Reasons for Having Purchases Delivered to Home

Reasons for usually having online purchase delivered at home	N	(%)
Most convenient option for me	501	84.1
Package security concern	184	30.9
Personal security concern	156	26.2
Fastest option	272	45.6
Do not have other options for delivery	64	10.7
Pick-up locations are not located near my home	51	8.6
Pick-up locations are not convenient to use	42	7.0
Minimize travel and exposure due to the pandemic	127	21.3
Others	21	3.5

Table 4. Reasons for Not Using Pick Up Location or Lockers

Reasons why never used a pick-up location	N	(%)
Do not know about pick-up locations	155	26.0
Do not know where to find a pick-up location	207	34.7
No pick-up locations near home or work	232	38.9
It is not convenient	401	67.3
Not comfortable using apps on phone	82	13.8
Pick-up locations are not safe	122	20.5
Others	80	13.4

We also asked respondents to compare home delivery with APL delivery and identify factors that would influence their choice between them. The most frequently identified factor was time to travel to the locker (63.9%), followed by shipping time (54.7%), receiving a discount (53.4%), and bulk and weight of package (51.7%). Finally, we asked what would make APL use

more attractive. The most frequent responses were discounts on purchase (52.3%), location close to home or work (50%) , free shipping (48.7%), same day or one day delivery (33.7%), and faster shipping than home delivery (30.5%).

4.2 Automated Parcel Locker Survey (Survey 2) Results

Survey 2 examines use of lockers; all respondents have used a locker at least once in the last four weeks. We collected 84 responses from the volunteer survey, of which 56 were valid after removing missing values. We obtained 310 responses from our third-party survey provider. Among these responses, we removed seven responses that were from areas outside of the Los Angeles-Long Beach-Anaheim MSA region. After removing responses with missing values and unknown zip code numbers, we used 342 observations for the analysis.

The socio-demographic status of the collected samples and comparisons with California population characteristics are reported in Table D2. The geographic reach of the survey is the Los Angeles-Long Beach-Anaheim metropolitan area as shown in Figure 14. The size of the dots in each zip code indicates the number of observations. Observations are concentrated in the central core of the region both because of our method of conducting the intercept surveys and the location of lockers. Our sample is not representative of the total population as the survey focuses on individuals who have experience in online shopping and using the APL service for delivery. For instance, almost half of the respondents were between 25 to 44 years of age, and the samples had a higher educational attainment level compared to the general population.

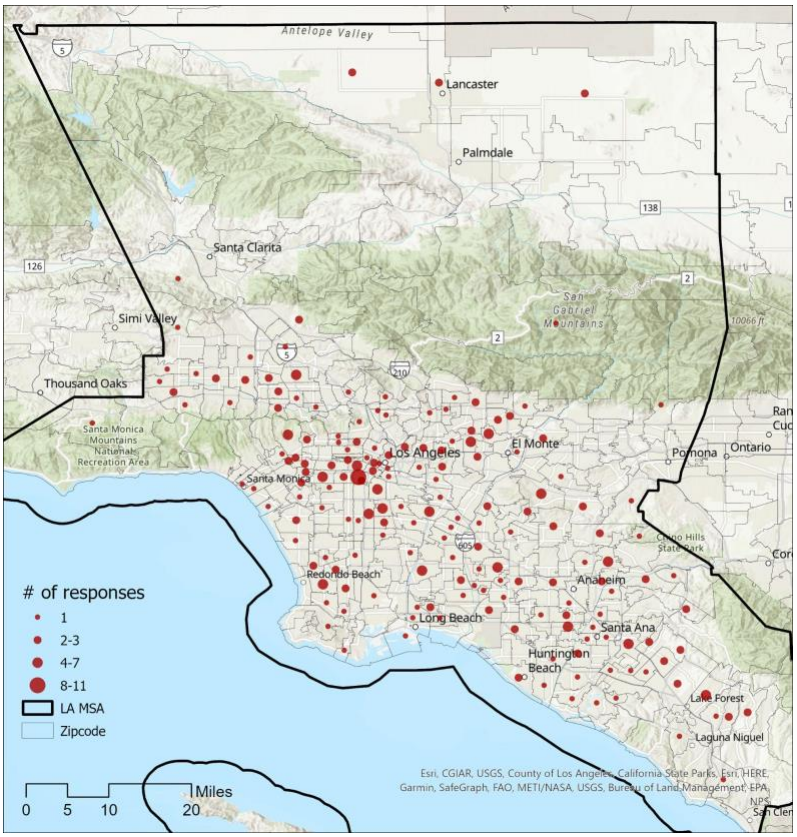


Figure 14. Geographic distribution of Survey 2 Respondents in Los Angeles-Long Beach-Anaheim area

4.2.1 Online shopping and APL use behavior

A summary of the characteristics of online shopping, APL use, and travel behavior of pick-up trips are shown in Figure 15, Figure 16, and Table 5. Figure 15 shows that 68.5% of the respondents reported that they shopped online at least once a week. Most individuals (47.4%) used the APL service for some of their online purchases, followed by 34.8% who rarely used the service. Only 17.8% reported using the APL service for all their purchases. Almost two-thirds of the respondents answered that they had experienced delivery failure, which implies that this may be why individuals use the APL service. Table 5 shows all the ways the respondent could receive a purchase. Although delivery to home is the most frequently reported option, 20.2% did not list home as an option.

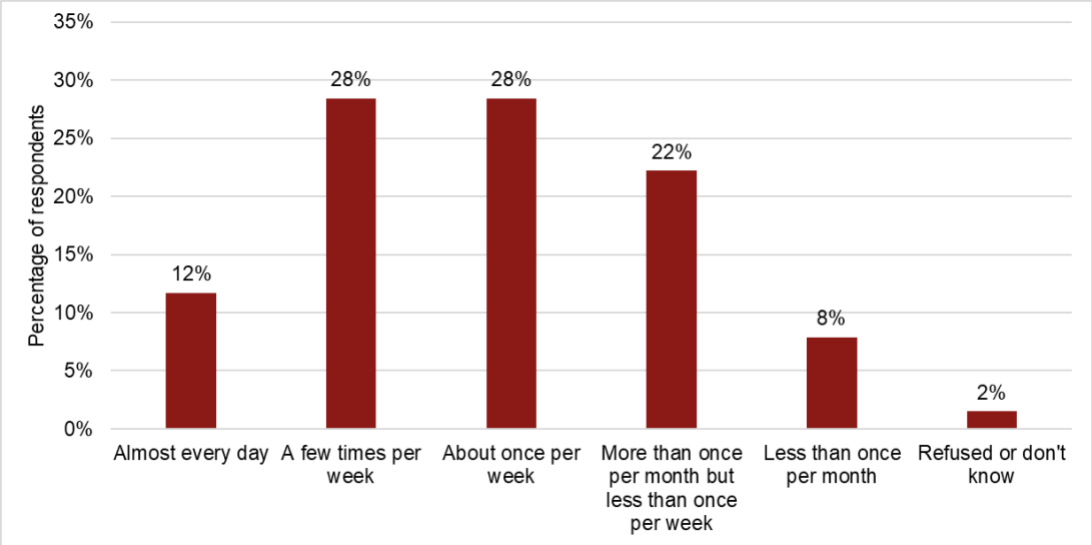


Figure 15. Frequency of Online Shopping, Survey 2 respondents

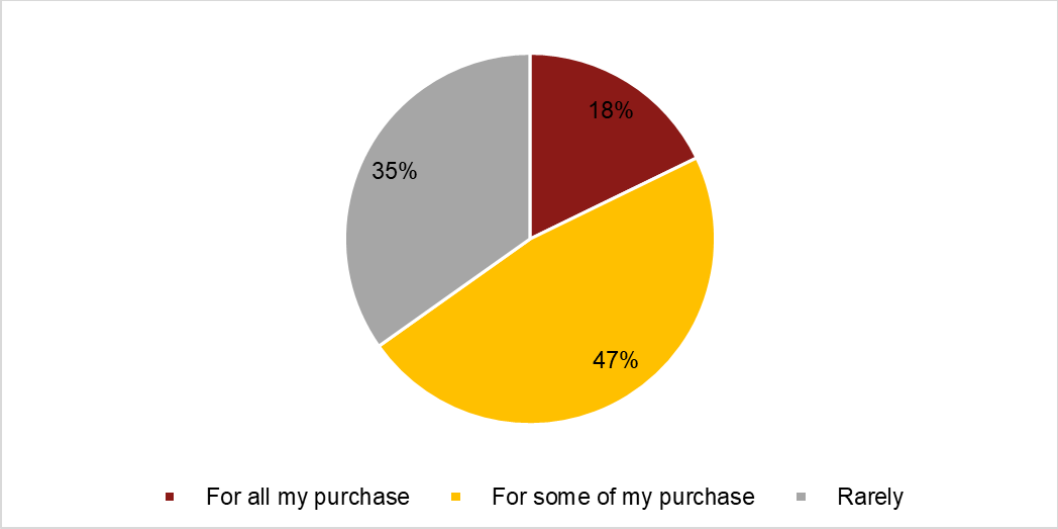


Figure 16. Frequency of APL service use

Table 5. Possible Ways to Receive Online Purchases

Possible ways to receive purchases from online	N	(%)
Delivery to my home address	273	(39.3)
Delivery to my work address	126	(18.2)
Pick up at the store of purchase	187	(26.9)
Pick up at a manned pickup point, like UPS Access Point	104	(15.0)
Others	4	(0.6)

* respondents were allowed to select multiple responses

4.2.2 Detailed APL use behavior

Figure 17 and Figure 18 show the reasons for choosing to use the APL service and the types of products they picked up from the APL during the latest experience. It should be noted that the respondents were allowed to choose multiple answers for the three questions. The top reason for choosing to use the APL service was package security (54.4%), followed by convenience (37.7%). Other main reasons included personal safety issues, fast delivery to APL, and free shipping options. Only 12% reported that they use the APL because of the discount on their purchase.

Products related to clothing, shoes, other personal items, and consumer electronics were the most common purchases picked up at APL services. Regarding selecting a specific APL location, 62.3% of the respondents chose proximity to home. Other primary factors included locker availability (40.1%), safety concerns (39.8%), and parking availability (28.7%). See Figure 19.

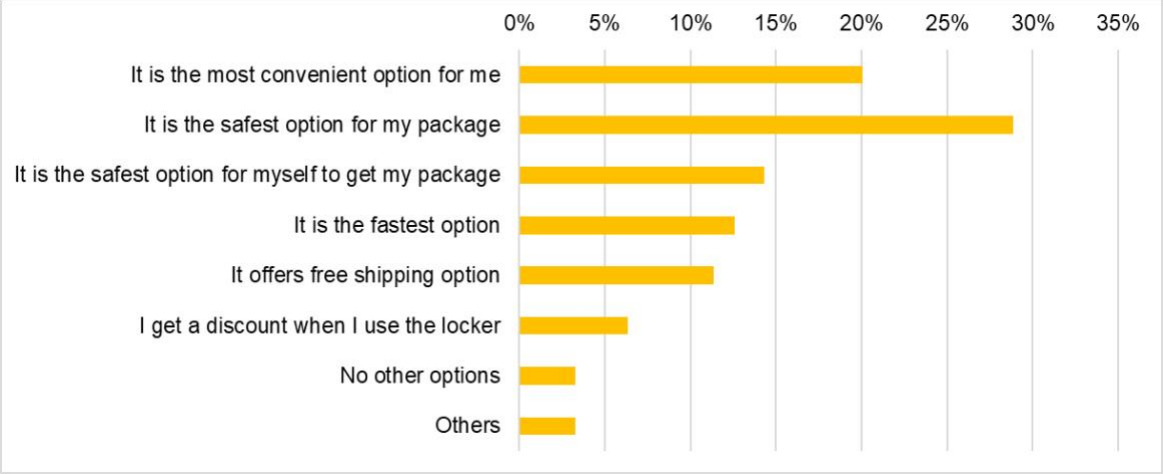


Figure 17. Reasons for Using the APL Service (multiple choice)

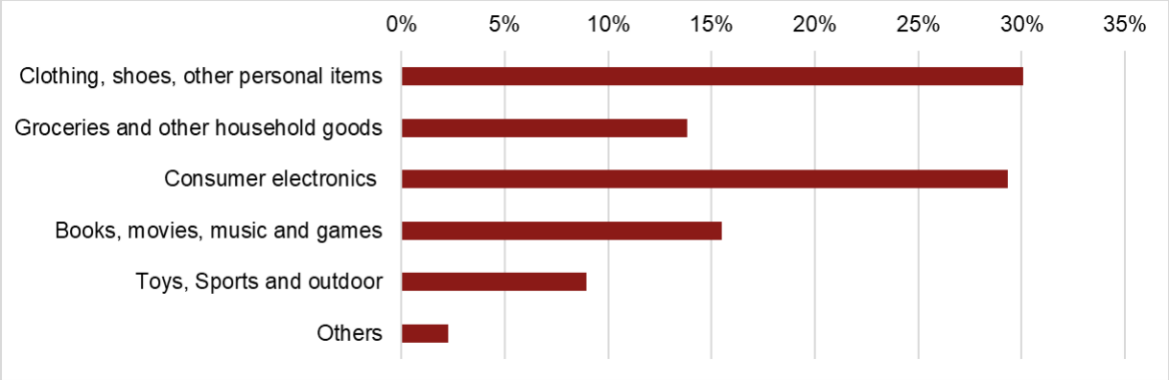


Figure 18. Type of Products Picked-Up from APL Locations (multiple choice)

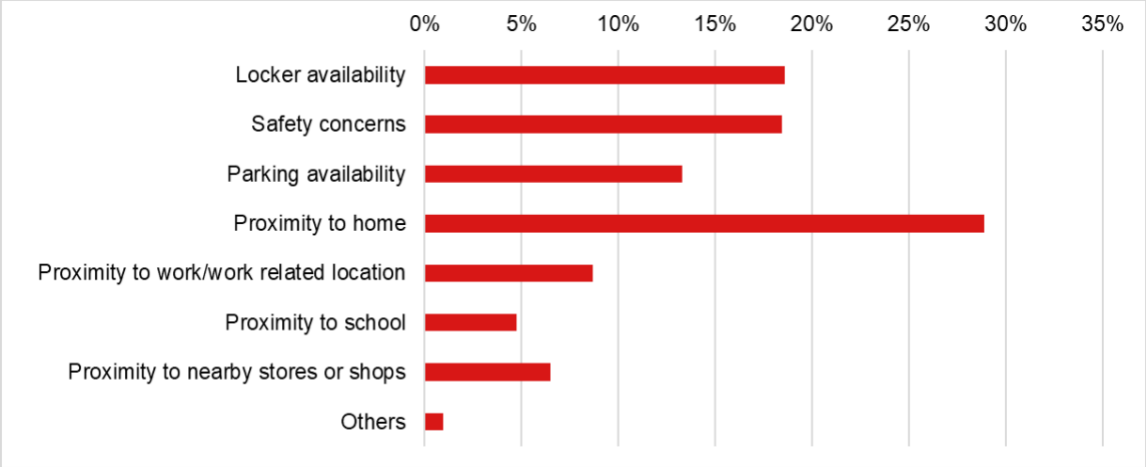


Figure 19. Reasons for Choosing APL Location (multiple choice)

4.2.3 Travel behavior of APL pick-up trips

Figure 20 shows the travel behavior attributes of pick-up trips to APL. Most of the respondents (67%) reported driving to the APL locations. On the other hand, 6.4 percent and 11.7 percent respectively responded that they either used transit or walked to the APL, respectively. The origin of pick-up trips and the destination after pick-up were primarily associated with home and work-related locations. Only around ten percent made their pick-up trips from nearby retail stores, while 17.6% went to nearby retail stores after picking up their delivery. Overall, 48.8% of respondents chained their pick-up trips with other travels. When we asked the respondents about their usual trip chaining behavior, 72.5% answered that they usually chain their pick-up trips.

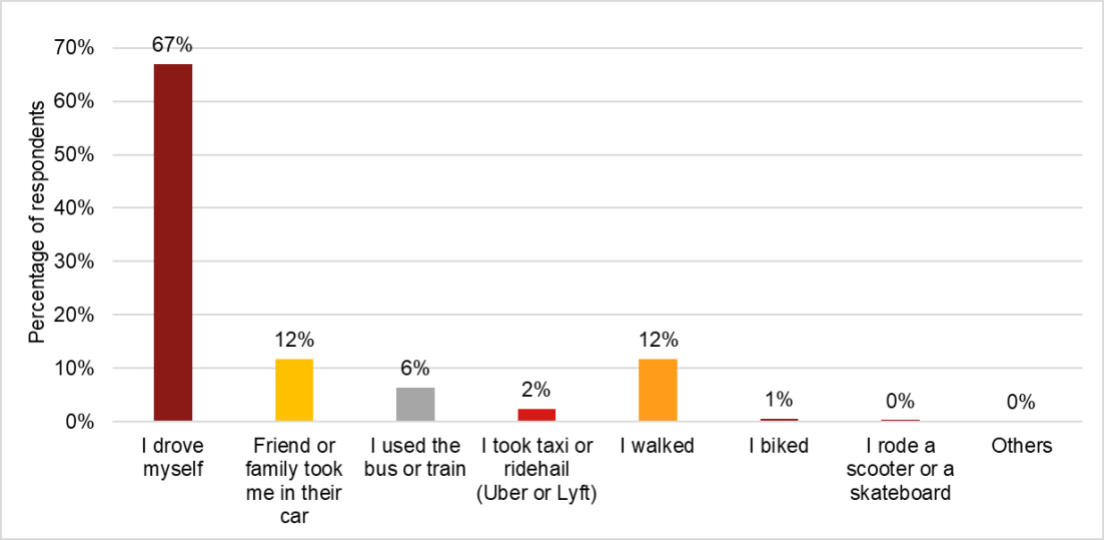


Figure 20. Mode Choice for Pick-Up Trips

Table 6. Origin and Destination of Pick-Up Trips

Origin and destination of pick-up trips	N	(%)
Origin		
Home	224	(65.5)
Work or work-related location	53	(15.5)
School	17	(5.0)
Nearby shops (to buy goods such as groceries, clothes, appliances, gas)	27	(7.9)
Nearby services (dry cleaners, banking, service for car, pet care)	6	(1.8)
Nearby restaurants or café (meal, snack, carry-out)	9	(2.6)
Nearby recreational activities (parks, movies, bars, museum)	3	(0.9)
Others	3	(0.9)
Destination after pick-up		
Home	226	(66.1)
Work or work-related location	41	(12.0)
School	13	(3.8)
Nearby shops (to buy goods such as groceries, clothes, appliances, gas)	39	(11.4)
Nearby services (dry cleaners, banking, service for car, pet care)	6	(1.8)
Nearby restaurants or café (meal, snack, carry-out)	13	(3.8)
Nearby recreational activities (parks, movies, bars, museum)	2	(0.6)
Others	2	(0.6)

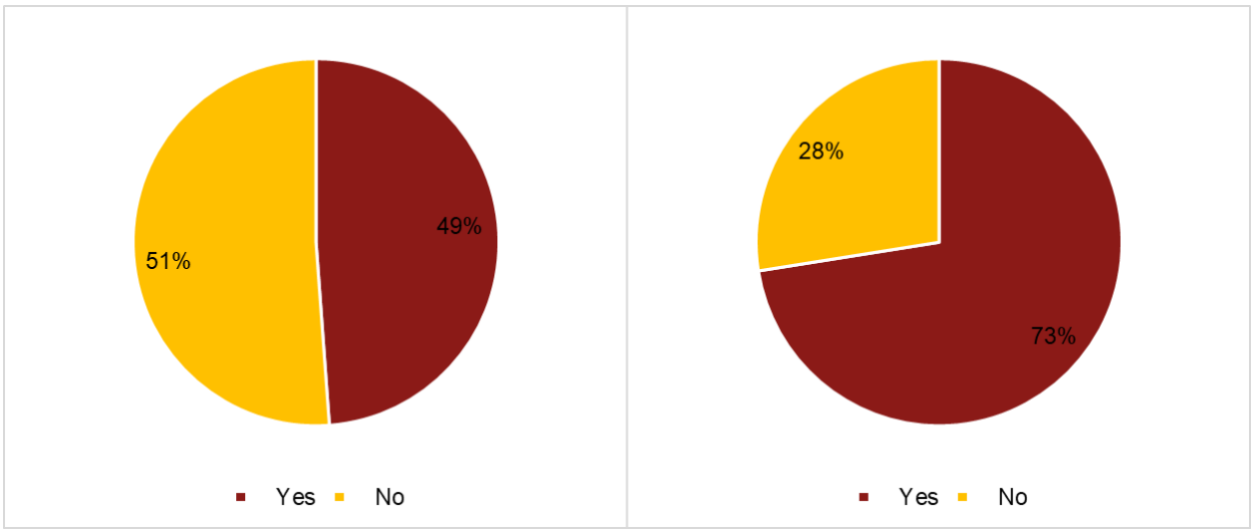


Figure 21. Trip-chain behavior (left: latest experience; right: usual behavior)

4.2.4 Online shopping and APL use behavior by APL use frequency

A cross tabulation of online shopping and APL use behavior by APL use frequency is shown in Table 7. Individuals who use the APL service for all their deliveries showed that they are more likely to frequently shop online. In detail, 78.7% of the respondents who always use the APL service responded that they shop online at least once a week. On the other hand, among those who use the APL service rarely, only 65.5% reported that they shop online at least once a week.

The reasons for using the APL service also varied according to the frequency of APL use. For instance, a larger percentage of respondents who rarely use the APL service reported that they use the APL service because of fast and free shipping, as well as discounts. This implies that providing fast and free shipping with discounts may encourage individuals to use the APL service for delivery. On the other hand, individuals who always use the APL service were more likely to use the service because they think that it is more convenient and reduces their personal security concerns.

Individuals who responded that they always use the APL service for delivery showed a larger percentage of trip-chaining behavior. For instance, among individuals who always use the APL service, 75.4% reported that they usually chain their pick-up trips; on the other hand, 68.1% of individuals who rarely use the APL service responded that they usually chain their pick-up trips.

Table 7. Cross Tabulation

Online shopping and APL use behavior	APL use frequency					
	Rarely		Sometime		Always	
	N	(%)	N	(%)	N	(%)
All respondents	119	(100.0)	162	(100.0)	61	(100.0)
Frequency of shopping online						
Almost every day	14	(11.8)	13	(8.0)	13	(21.3)
A few times per week	26	(21.8)	50	(30.9)	21	(34.4)
About once per week	38	(31.9)	45	(27.8)	14	(23.0)
More than once per month but less than once per week	27	(22.7)	39	(24.1)	10	(16.4)
Less than once per month	10	(8.4)	14	(8.6)	3	(4.9)
Refused or don't know	4	(3.4)	1	(0.6)	0	(0.0)
Reasons for choosing to use APL service *						
It is the most convenient option for me	22	(11.5)	69	(22.1)	38	(27.0)
Package security	50	(26.2)	96	(30.8)	40	(28.4)
Personal security	22	(11.5)	42	(13.5)	28	(19.9)
It is the fastest option	29	(15.2)	37	(11.9)	15	(10.6)
It offers free shipping option	30	(15.7)	36	(11.5)	7	(5.0)
I get a discount when I use the locker	17	(8.9)	17	(5.4)	7	(5.0)
I do not have any other delivery choice when I shop online	9	(4.7)	8	(2.6)	4	(2.8)
Others	12	(6.3)	7	(2.2)	2	(1.4)
Trip-chain behavior (latest APL use experience)						
Yes	47	(39.5)	84	(51.9)	36	(59.0)
No	72	(60.5)	78	(48.1)	25	(41.0)
Trip-chain behavior (usual APL use experience)						
Yes	81	(68.1)	121	(74.7)	46	(75.4)
No	38	(31.9)	41	(25.3)	15	(24.6)

* multiple answers were allowed

4.3 Summary

Based on the descriptive statistics of Survey 1 and 2, there are a couple key takeaways. First, individuals' attitudes towards using the APL service is important. In Survey 1, a large portion of respondents reported that they never tried using the APL service because they think that using the service is inconvenient and that the locations are unsafe. However, the top reasons for respondents always using the APL service for their delivery from Survey 2 were associated with

convenience and also security issues. Individuals' attitudes on whether using APL services are convenient and whether the locations are safe appear to be related to their experience using the service as well as the frequency of APL use.

Second, the results imply that respondents who never tried using the APL service are unaware of the service. These respondents were also less accessible to the APL service in terms of using new technology. A large number of respondents answered that they do not know about the APL locations and that they are not familiar with using apps on their cellphone. This result suggests that increasing the accessibility and awareness of the APL service is one way to encourage APL use.

Lastly, frequent APL users usually chained their pick-up trips, which implies that they are likely to lead to sustainable outcomes. It is possible that frequent APL users do not think that visiting an APL location along their travel is burdensome. It is also possible that the frequent APL users have adapted to using the APL locations for receiving their delivery. Another possible explanation is that the frequent APL users have APL locations close to their home or work which makes them convenient to use and easy to chain with other trips.

Chapter 5: Modeling and Analysis

This chapter presents details on the statistical modeling undertaken on data collected from Surveys 1 and 2. Using the sample collected from Survey 1, we are able to describe the factors associated with online shopping frequency, as well the chosen delivery method. With data from Survey 2, we explore the factors associated with the frequency of APL use, trip chaining behavior of pick-up trips, and the mode used for such trips.

5.1 Survey 1 Model Analysis

5.1.1 Online shopping frequency

We developed an ordered logit regression model to explore the factors associated with online shopping frequency. The dependent variable is an ordinal variable consisting of five levels: less than once per month, less than once per week, about once per week, a few times per week, and almost every day. We considered attributes related to socio-economic status and the neighborhood for the independent variables. We used 534 observations for the regression model after removing those with missing data on socio-demographic characteristics.

Table 8 shows that male and Hispanic respondents were negatively associated with online shopping frequency. On the other hand, younger adults and White were associated with more frequent online shopping. Regarding income, respondents from mid- and high-income households were more likely to shop online than those from low-income households. Similarly, individuals with either a full-time job or who owned their homes were more likely to shop online, possibly due to their restricted time for in-store shopping. Respondents who reside in areas with higher population density showed a positive association with online shopping frequency. These results are quite consistent with previous studies. It should be noted that the results do not necessarily indicate that those who shop online more shop less in-store.

Table 8. Ordered Logit Regression Result (DV: frequency of online shopping)

Variable	coef.	t
Socio-economic attributes		
Male	-0.354 **	-2.14
Age (under 45)	0.643 ***	3.74
Education (bachelor's or higher degree)	0.240	1.28
White	0.350 *	1.91
Hispanic	-0.447 *	-1.86
Mid-income HH (ref: low-income HH)	0.576 ***	2.67
High-income HH (ref: low-income HH)	0.429 *	1.68
Full time job	0.370 **	1.97
Home owner (ref: renter)	0.365 *	1.72
Housing type - Single family (ref: others)	0.848 **	2.22
Housing type - Apartment (ref: others)	0.707 *	1.71
Neighborhood attributes		
ln(pop. Density)	0.100 *	1.79
Intercepts		
Less than once per month | Less than once per week	1.060 *	1.75
Less than once per week | About once per week	2.438 ***	3.98
About once per week | A few times per week	3.371 ***	5.44
A few times per week | Almost every day	5.102 ***	7.96
Model Statistics		
N	534	
AIC	1558.474	

5.1.2 Experience using the APL service for delivery

Next, we examined the factors associated with the experience of using the APL service for delivery. A limited number of respondents usually used the APL for delivery, and thus we focus here on whether a respondent has experience in using the APL. As discussed in Chapter 4, APLs are not universally available, and many e-shoppers are unaware of the APL option. Thus, not having experienced using an APL can be due to factors beyond preferences. Table 9 gives results for a model that includes socio-demographics and neighborhood population density, a rough proxy for the likely availability of APLs. Results show male, White, Hispanic, and mid- and high-income levels are negatively associated with the likelihood to have experience using the APL service. On the other hand, younger age, bachelor's degree or higher, full-time employment, or residence in single-family housing are positively associated. Local neighborhood population density also has a positive relationship.

Results suggest that APLs are still in the early stages of adoption. As e-shopping was in its earlier days, APLs are an option for younger generations and those who have a strong incentive to use them, whether it be convenient location or lack of package security at the residence.

Table 9. Logit Regression Result (DV: tried APL service for delivery)

Variable	coef.	t
Socio-economic attributes		
Male	-1.787 ***	-3.54
Age (under 45)	2.002 ***	3.78
Education (bachelor's or higher degree)	2.189 ***	3.46
White	-0.830 *	-1.86
Hispanic	-1.791 *	-1.93
Mid-income HH (ref: low-income HH)	-1.605 **	-2.44
High-income HH (ref: low-income HH)	-2.231 ***	-3.09
Full time job	1.282 **	2.30
Home owner (ref: renter)	0.934	1.54
Housing type - Single family (ref: others)	2.233 *	1.66
Housing type - Apartment (ref: others)	2.047	1.56
Neighborhood attributes		
ln(pop. Density)	0.548 **	2.50
Intercepts	-10.431 ***	-4.46
Model Statistics		
N	534	
AIC	184.68	

5.1.3 Summary

From the two models, we identified the factors associated with the frequency of online shopping and the experience of using APL service for delivery. The results indicate that young adults (under age 45), individuals with full-time jobs, and those who live in single family housings are positively associated with both dependent variables. It is possible to explain the results based on three components: attitude towards technology, limited time for in-store shopping, and security concerns. Younger adults are likely to have positive attitudes toward online shopping and the use of APL services. Individuals who have a full-time job or who live in single family housing could have time constraints that limit in-store shopping.

On the other hand, males were less likely to shop online frequently and use the APL service for delivery. This result is not surprising; men do less shopping overall than women. High-income individuals were associated with frequent online shopping but less experience of using the APL for delivery. There may be some degree of suburban residence effect. Higher income

households are more likely to live in single family residences in suburban locations where APLs are less available. Also, higher income suggests higher value of time and therefore less willingness to spend time picking up a package.

5.2 Survey 2 Model Analysis

5.2.1 Frequency of APL use

To examine the factors associated with the frequency of APL use, we developed an ordered logit model. The dependent variable is the frequency of APL use, represented in three levels: rarely, for some of my purchases, and for all my purchases. For the independent variables, we included factors related to socio-economic attributes, E-shopping and APL use, reasons for using the APL service, and neighborhood attributes measured at the zip code level. We used 291 observations after removing responses with missing data on key variables.

Males, younger adults, White, and individuals with full-time jobs were likely to use the APL service frequently. On the other hand, individuals with higher educational attainment (i.e., bachelor's or higher degree), Hispanic, and high-income individuals were less likely to use the APL service frequently. Regarding e-shopping and APL use related factors, individuals who shop online frequently (i.e., at least once a week) were associated with frequent use of the APL service. In contrast, individuals who have used a limited number of APL locations were less likely to use the APL service frequently.

Individuals who perceive APL services as their most convenient option for delivery showed that they are frequent APL users. Individuals who have concerns about either their package or personal security were also likely frequent users of the APL service. Fast shipping is another positive factor, supporting the idea that shoppers are willing to use APLs to receive the order sooner. Free shipping has a negative coefficient, possibly because most respondents receive free shipping whether or not they use a locker.

Population density and the number of APL locations per 1,000 population showed a positive association with frequent use of APL. APL use could be easier to use in areas with high density due to better accessibility, which further implies that frequent use of APL services may differ by the attributes of regions. The results also suggest that providing more APLs may increase the share of APL use.

Table 10. Ordered Logit Regression Result (DV: frequency of APL use)

Variable	coef.	t
Socio-economic attributes		
Male	0.524 *	1.84
Age (under 45)	0.672 **	2.11
Education (bachelor's or higher degree)	-0.868 ***	-2.78
White	0.693 **	2.48
Hispanic	-0.700 **	-2.08
Mid-income HH (ref: low-income HH)	-0.555	-1.57
High-income HH (ref: low-income HH)	-1.269 ***	-3.09
Full time job	0.844 ***	2.70
E-shopping and PL use related attributes		
E-shop at least once a week	0.516 *	1.74
Experienced delivery failure	-0.456	-1.58
Have used only one PL location	-1.844 ***	-5.82
Reason for using PL service		
Most convenient option	1.415 ***	4.64
Package security concerns	1.328 ***	4.41
Personal security concerns	0.845 ***	2.65
Fast shipping	0.710 **	2.10
Free shipping	-0.749 **	-2.16
Discount	0.806 *	1.89
Neighborhood attributes (zipcode level)		
ln(pop. Density)	0.272 *	1.65
# PL per 1,000 pop.	4.349 **	2.50
Intercepts		
Rarely | For some of my purchase	2.682 *	1.81
For some of my purchase | For all my purchases	6.135 ***	4.00
Model Statistics		
N	291	
AIC	440.5	

5.2.2 Trip chaining behavior of pick-up trips

An important aspect of APL use is how people make the pick-up trip. If the pick-up is linked with another trip, VMT and emissions will be reduced, all else equal. Our survey included questions on both usual behavior and behavior on the most recent pick-up trip. We expect usual and

actual behavior to be similar, but our findings revealed significant inconsistencies: 38% stated trip chaining as usual behavior and reported trip chaining on the most recent trip; 19% reported no trip chaining as usual behavior and most recent trip. Thus, the total reporting consistent behavior is 57%. The remainder—43%—had different behaviors, with most (37% of the total sample) stating they usually trip chain but did not on the most recent trip. We further examined the data and found that inconsistent responses are associated with demographics: those with higher education level or higher household income level are more likely to report trip chaining as usual behavior but not trip chain on the most recent trip. In addition, those who reported using APLs for free shipping were more likely to be in this group. Explanation for these inconsistencies is unclear. One possibility is that more educated respondents may give more favorable responses as a way of demonstrating compliance with shared norms.

We estimated logit regressions to examine the relationship between trip chaining, demographics, and perceptions of APLs. Table 11 gives models for both usual behavior and most recent pick-up. Starting with usual behavior, we find that being male, While, and in the middle income category is negatively related to trip chaining. Younger age, higher education status, and Hispanic race are positively associated. Trip chaining as usual behavior is positively related to APL use frequency, identifying APLs as most convenient delivery option, having package security concerns, and being offered free shipping. Personal security concerns reduce the likelihood of trip chaining.

The third column of Table 11 gives results for the most recent pickup. Within the demographic variables the educational status variable coefficient changes sign and is not significant while the high income coefficient becomes negative and significant. These results are explained by the inconsistencies in behavior described above. There are other differences as well: trip chaining is more likely among those who use APLs more frequently and who are more frequent e-shoppers. Why results differ on these models is unclear and merits additional research. On reasons for using APLs coefficient signs are positive for personal security and negative for free shipping. The changed sign on personal security for actual behavior makes sense: one would not use a locker if one did not feel personally safe when doing so. The free shipping result is explained by the inconsistencies discussed earlier.

Local geography also seems to play a role in trip chaining. Population density has a negative association with trip chaining behavior. Walking and biking are more frequent as density increases, hence there are fewer car trips overall. The availability of APLs is marginally positively related to trip chaining for usual behavior but not for actual behavior.

Finally, we were able to ask about the type of product picked up at the APL on the most recent trip. We note that adding the product variables does not materially affect results for the other independent variables (results not shown). Toys and sports equipment, as well as groceries and household goods are associated with trip chaining, while personal item and consumer electronics are less likely to be associated with trip chaining. Trip chaining is a car mode and it makes sense that heavy or bulky items would more likely be picked up via car.

Table 11. Logit regression result (DV: trip chaining behavior)

	Usual behavior		Actual behavior	
Variable	**coef.**	**z**	**coef.**	**z**
Socio-economic attributes				
Male	-0.863 **	-2.15	-0.801 **	-2.26
Age (under 45)	0.942 **	2.17	0.728 *	1.81
Education (bachelor's or higher degree)	0.983 **	2.27	-0.617	-1.64
White	-1.075 **	-2.51	-1.108 ***	-3.00
Hispanic	1.131 **	2.25	0.707	1.64
Mid-income HH (ref: low-income HH)	-0.834 *	-1.72	-1.423 ***	-3.09
High-income HH (ref: low-income HH)	0.830	1.36	-1.028 **	-2.10
Full time job	0.668	1.55	0.759 *	1.92
E-shopping and PL use related attributes				
Use PL for some purchases (ref: rarely)	-0.812	-1.63	0.951 **	2.27
Use PL for all purchases (ref: rarely)	1.543 **	2.09	0.951 *	1.65
E-shop at least once a week	-0.788 *	-1.84	1.189 ***	2.91
Have used only one PL location	-1.218 ***	-2.61	-0.620	-1.61
Reason for using PL service				
Most convenient option	1.123 **	2.45	-0.558	-1.47
Package security concerns	0.781 *	1.84	1.019 ***	2.67
Personal security concerns	-0.930 **	-1.97	0.908 **	2.08
Fast shipping	0.688	1.35	0.867 **	2.08
Free shipping	1.202 **	2.32	-0.922 **	-2.07
Discount	-0.946	-1.63	1.204 **	2.33
Types of product picked up from APL				
Clothing, shoes, other personal items			-0.853 **	-2.25
Groceries and other household goods			0.846 *	1.96
Consumer electronics			-1.235 ***	-3.16
Books, movies, music, and games			0.609	1.57
Toys, Sports and outdoor			1.032 **	2.16
Neighborhood attributes (zipcode level)				
ln(pop. Density)	-0.525 *	-1.96	-0.460 **	-2.13
# PL per 1,000 pop.	8.274 **	2.49	0.555	0.95
Intercepts	4.556 *	1.92	2.998	1.59
Model Statistics				
N	291		291	
AIC	350.74		290.84	

5.2.3 Mode choice of pick-up trips

Table 12 shows the logit regression result for mode choice of pick-up trips. As shown in the descriptive statistics, 67% drove to the APL locations, while 12.3% of the respondents walked or biked. Since we are interested in individuals who made trips conducive to mitigating transport emissions, we focus on the individuals who used active modes of transportation for their pick-up trips.

Males, younger adults, individuals with higher education, White, and individuals who have full-time jobs were more likely to either walk or bike for their pick-up trips. On the other hand, Hispanic and medium and high-income individuals were associated with modes other than walking or biking. Among e-shopping and APL use related attributes, individuals who frequently use the service and those who e-shop at least once a week were also less likely to walk or bike to APL locations. Reasons for using the APL service and the type of products picked up at the APL location were also associated with mode choice. Also, individuals who value APL as their most convenient option for delivery and those who have package security concerns are also less likely to walk or bike. Among the type of products, individuals who purchased groceries and other household goods were associated with nonactive transportation modes. This is expected: heavy or bulky items are more difficult to transport via non-motorized modes.

Population density and the number of APL locations per 1,000 population were positively associated with active mode use. Considering the regression model for trip chaining behavior, individuals in areas with high density are less likely to chain their pick-up trips but more likely to use active modes.

Table 12. Logit regression result (DV: walked or biked)

Variable	coef.	t
Socio-economic attributes		
Male	2.400 **	2.44
Age (under 45)	7.422 ***	3.42
Education (bachelor's or higher degree)	2.131 **	2.05
White	6.305 ***	3.45
Hispanic	-3.205 **	-2.33
Mid-income HH (ref: low-income HH)	-2.774 **	-2.40
High-income HH (ref: low-income HH)	-4.568 ***	-2.75
Full time job	2.012 **	2.00
E-shopping and PL use related attributes		
Use PL for some purchases (ref: rarely)	1.813 *	1.70
Use PL for all purchases (ref: rarely)	-3.130 **	-1.98
E-shop at least once a week	-3.028 ***	-2.88
Have used only one PL location	6.706 ***	3.75
Reason for using PL service		
Most convenient option	-3.791 ***	-2.94
Package security concerns	-2.901 ***	-2.70
Personal security concerns	-1.403	-1.29
Fast shipping	-3.005 **	-2.47
Free shipping	-1.753 *	-1.76
Discount	3.502 ***	2.67
Types of product picked up from APL		
Clothing, shoes, other personal items	4.260 ***	3.08
Groceries and other household goods	-3.524 **	-2.16
Consumer electronics	2.586 **	2.57
Books, movies, music, and games	2.410 **	2.43
Toys, Sports and outdoor	-1.666	-1.62
Neighborhood attributes (zipcode level)		
ln(pop. Density)	1.585 **	2.28
# PL per 1,000 pop.	2.137 *	1.83
Intercepts	-28.964 ***	-3.43
Model Statistics		
N	291	
AIC	120.0	

5.2.4 Summary

Our results indicate that young adults (under age 45) and individuals from low-income households are likely to use the APL frequently and chain their pick-up trips while using active modes such as walking or biking. Individuals with full-time jobs were also associated with frequent APL use and active mode use for pick-up trips, while they did not show a significant relationship with trip-chaining behavior. Similarly, males were associated with frequency of APL use and active mode use. Overall, the three models provide implications for understanding the factors that are associated with the potential of reducing emissions that occur during the last-mile delivery.

Regarding neighborhood attributes, the number of APL locations showed association with the frequency of APL use, trip-chaining behavior, and active mode use. This result suggests that providing additional APL locations will possibly lead individuals to select alternative delivery methods and conduct sustainable travel behavior. While population density also showed positive relationship with frequent APL use and active mode use, it showed a negative relationship with trip-chaining behavior. Here, we suspect that APL users living in areas with high density are unlikely to chain their trips as they can easily access APL locations.

Chapter 6: Findings & Conclusions

Our research examined package delivery choices and the use of an alternative pickup method to home delivery: the automated parcel locker (APL). We conducted two separate but related surveys to answer the following research questions:

1. What are the patterns of e-shopping regarding frequency, goods purchased and other attributes, and how are these related to attributes of the shoppers?
2. How has the COVID-19 pandemic affected e-shopping behavior?
3. How do e-shoppers choose among delivery choices?
4. If an APL is chosen, how do e-shoppers travel to and from the pickup point?

Below is a summary of our findings for each research question, as well as a discussion on how these findings contribute to our understanding of the impacts of e-shopping on travel behavior.

6.1 Findings

6.1.1 What are the patterns of e-shopping regarding frequency, goods purchased and other attributes, and how are these related to attributes of the shoppers?

Survey 1 shows a high frequency of e-shopping overall; over half of respondents e-shop at least once per week and 30% shop several times per week. These findings are consistent with national statistics that show rapid growth in online market share.

Several factors are incentivizing the high frequency of online shopping, including the use of the smartphone and 1-click shopping, free shipping (85% of respondents received free shipping on their last order), and fast deliveries to a person's front door. The most common package destination is the home residence, and the majority of deliveries are of single packages. All these elements support the "Amazon Effect", whereby an increase in online shopping and the promise of fast delivery means more one-package-per-stop trips to consumers.

Recent studies show that while the shift to online shopping has been almost universal across all categories, high-income earners and millennials are leading the way.[5] We found that those shopping with the highest frequency tend to be of higher income, but that e-shopping is no longer an activity limited solely to millennials and Generation Z. These changing demographics may also lead to higher levels of online shopping and package delivery.

6.1.2 How has the COVID-19 pandemic affected e-shopping behavior?

Studies have shown that the COVID-19 pandemic has changed the e-shopping ecosystem and driven more store and regular purchases (e.g., groceries, cosmetics) online. We document an increase in e-shopping behavior and frequency as well as an increase in the type of goods purchased online. These trends are likely to continue into the near future. Both studies and our

[5] Source: https://www.mckinsey.com/business-functions/growth-marketing-and-sales/our-insights/the-great-consumer-shift-ten-charts-that-show-how-us-shopping-behavior-is-changing

survey research show an increase in shopping during the pandemic, and a likelihood to continue similar behaviors at least into the near-term. Since it is unclear when and if the COVID-19 pandemic will cease completely, it is difficult to ascertain whether this will be a long-term or permanent shift in behavior.

6.1.3 How do e-shoppers choose among delivery choices?

The primary location for delivery of online purchases is a person's private residence, with APL use being a rare occurrence. We found that an APL is used typically by 1 to 5% of e-shoppers, while 90% have online deliveries sent to their home. Convenience is cited as the most important factor when having an online purchase delivered to a home address. Cost of shipping and price of product are also important elements that influence choice of delivery method.

Data from our survey of APL users found that individuals are more likely to use APLs when package security is a concern; or when delivery to home is not an option: 20.2% of respondents answered that they could not have their purchase delivered to their home address. Almost two-thirds of the respondents answered that they had experienced delivery failure, which could be a rationale for using the APL service. More frequent APL users tend to be individuals with the sentiment that APL services are their most convenient option for delivery. Faster shipping and free shipping were other reasons that lead to frequent use of APL services.

Population density and the number of APL locations per 1,000 population shows a positive association with frequent use of APL, showing that APL use could be easier and more frequent in areas with high density due to better accessibility. This implies that there could be a greater market for APL usage if there were a greater number of locations accessible to shoppers. When asked whether they would consider using APLs, respondents stated that if they were conveniently located and offered some type of benefit (e.g., discounts) they would be more likely to use them.

6.1.4 If an APL is chosen, how do e-shoppers travel to and from the pickup point?

If an APL is chosen, we found that the majority of e-shoppers (67%) reported driving to the APL location. On the other hand, 6.4% and 11.7% respectively responded that they either used transit or walked to the APL. The origin of pick-up trips and the destination after picking up were largely associated with home, work, and school related locations. Around 10% of the respondents made their pickup trips from nearby retail stores, while 17.6% of the respondents went to nearby retail stores after picking up their delivery.

The association with trip chaining behavior was mixed between individuals' usual and actual behavior. When we asked the respondents about their usual trip chaining behavior, 72.5% answered that they usually chain their pickup trips. However, when asked about their most recent behavior (or actual behavior), only 48.8% of respondents had chained their pickup trips with other travels. Considering their usual behavior, individuals who value APL as their most convenient option were likely to chain their pick-up trips. Also, individuals who have package security concerns or use the APL service because of free shipping benefits were associated with

trip-chaining behavior. Those with personal security concerns were more likely to make a trip solely for their delivery pick up.

The products picked up at APL locations were also associated with individuals' trip chaining behavior. While those who purchased groceries or other household goods or toys, sports, and outdoor-related items were likely to chain their pick-up trips, those who bought personal items or electronics were less likely to show trip-chaining behavior. We suspect that the monetary value of items purchased online or whether the items are perishable affects individuals' trip chaining behavior.

There is a conflicting result for the relationship between online shopping frequency and trip chaining behavior; the sign for this variable was negative based on individuals' usual behavior but positive for their actual behavior. While we do not have a clear explanation for this result, we suggest that individuals who frequently e-shop may be unable to chain their pick-up trips for all their delivery.

6.2 Conclusions

6.2.1 Impact of e-shopping on travel behavior and externalities

As noted earlier in the report, if an e-shopper chooses to use an APL, how it affects passenger VMT depends on the mode of travel. If the APL is accessed by non-motorized mode or transit, there will be a reduction in passenger vehicle VMT, all else equal. If the package is picked up by driving alone on a special trip, passenger VMT will increase. Most of Survey 2 respondents (67%) reported driving to the APL locations, while 6.4% and 11.7% responded that they either used transit or walked to the APL, respectively. However, we also find that consumers generally combine pickup trips to an APL with other trips, called trip chaining, which suggests that there is potential for VMT savings even when a car is used for pick-up.

The decision to trip-chain has the potential to minimize the impacts of a car trip to an APL. However, it remains to be discovered if this minimization of impact is more or less than the impact of reduction in truck VMT, or additional trips to and from work, home, and other establishments.

Truck VMT can be reduced by increasing usage of APLs. Our research found several influencing factors that could potentially encourage greater APL usage in California. Increasing the number of locations would increase locker accessibility and hence ease of using lockers. Financial incentives, be it on price of product or delivery (if not free), could also potentially incentivize greater APL usage. However, in terms of convenience, price, and speed of delivery, no alternative delivery option currently dominates free home delivery, so these factors would have to be offset with greater costs for home delivery or slower shipping times to incentivize a shift in consumer behavior. The elasticity of demand with respect to shipping price or speed would need to be examined to determine how to significantly increase APL use.

Although the potential for truck VMT savings is clear, the potential for passenger VMT savings is uncertain. From the passenger perspective, home delivery minimizes passenger VMT, all else

equal. Using active modes or transit to use APLs would not add to passenger VMT. Driving as part of a trip chain would add a small amount of VMT and driving on a special trip would significantly add to passenger VMT. How driving to APLs would net out relative to truck VMT savings remains to be explored.

6.2.2 Limitations of study & future research

Studies of APLs and personal travel behavior are inherently limited due to the lack of data, but also because there are multiple factors that must be considered and are lacking even from our study. One contribution of our research is to understand the gaps in the research and data collection processes.

The first limitation of our research is the lack of travel data for shoppers or shippers. Given the number of e-retailers (e.g., Amazon, Target, virtual stores) and delivery providers (e.g., Amazon fleet, UPS, FedEx, ShipIt, Instacart), it is a challenge to quantify the volume of home deliveries to a single residence or neighborhood. As such, it is difficult to understand the exact impact of these deliveries on VMT, congestion, and GHG emissions. Our research presents a first step for understanding how e-shoppers make delivery choices. A logical next step is to estimate potential VMT savings, most likely via simulation given the near impossibility of obtaining routing data from the major delivery service providers. There is also no data source for travel associated with e-shopping delivery choice beyond what we have collected in this study.

A second limitation is not considering product return behavior. Most studies, including our own, do not consider the VMT from returns, whereby individuals may travel to pick up points or an APL to drop off a return or to the store itself after having the online purchase delivered to the personal residence. It is important to note that after commencing data collection for this project, Amazon changed its return process to include free drop off at parcel locker hubs, UPS access points, and other locations (e.g., Whole Foods, Kohl's). These return processes incentivize consolidated drop offs as they often do not require the printing of a return label, but rather the use of a QR code. In addition, Amazon included a survey on return preferences and questions on the incentives that would work to increase returns at centralized drop off locations.

Thus, an area ripe for further research is the returns process of e-shopping, its impact on VMT (both freight and individual travel behavior), and the impact of potential alternative methods already introduced by Amazon. More research is needed on overall volume of deliveries on roads given frequency of packages and at home delivery.

E-shopping trends are all upward. The e-shopping market share is expected to continue to increase. The major retailers are competing with Amazon via free and instant deliveries as well as new delivery modes (e.g., curbside and in-store) that will generate additional passenger miles of travel. Achieving sustainability and urban livability goals will require better management of the e-shopping process. This research is a first step in understanding e-shopping delivery choice behavior, an increasingly critical element in online shopping.

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Data Summary

Products of Research

The results are mainly derived from two survey datasets. First, we collected 596 responses on e-shopping behavior and related socio-economic attributes by using the Qualtrics survey platform and a third-party survey provider. Second, we collected 342 responses on using automated parcel locker and related socio-economic attributes by conducting an in-person volunteer survey and using the third-party survey provider. We used the Google Maps Places API to identify the location of Amazon Parcel Lockers in the Los Angeles-Long Beach-Anaheim metropolitan statistical area (MSA). We obtained population data from the U.S. Census to estimate population density at the Zip Code Tabulation Area (ZCTA) level.

Data Format and Content

The data on the survey results are provided in .csv format. The questionnaires used for the two surveys are provided in the appendix. The authors compiled and cleaned the data by removing incomplete responses and responses collected outside of our geographical scope. We also provide the data on the location of Amazon Parcel Lockers in the Los Angeles-Long Beach-Anaheim MSA. This file is provided in .csv format.

Data Access and Sharing

Individuals will be able to access the data through Dataverse and should contact the principal investigator (Dr. Genevieve Giuliano) prior to accessing the data. The data should not be hosted in other locations and should only use the Dataverse repository. Users of the data should reference the system providers, and the data repository in Dataverse.

Reuse and Redistribution

Dr. Genevieve Giuliano and the other co-authors of the work hold the intellectual property rights to the data collected in this research. Data will not be able to be transferred to other data archives besides the ones approved by the PI. The data can be used by anyone with proper referencing to the authors, and cited as follows:

> Giuliano, Genevieve; Binder, Robert; Ha, Jaehyun; Holmes, Andrea, 2022, “Raw data for survey 1”, https://doi.org/10.7910/DVN/G1DASJ, Harvard Dataverse, V1
>
> Giuliano, Genevieve; Binder, Robert; Ha, Jaehyun; Holmes, Andrea, 2022, “Raw data for survey 2”, https://doi.org/10.7910/DVN/NDKAXS, Harvard Dataverse, V1

Appendix A: Reducing the Last-mile Environmental Impacts of Home Delivery: A Literature Review

Introduction

The rise of e-commerce has imposed increasing pressures on urban freight distribution systems with significant demand for dedicated delivery services to the end consumer. Last-mile delivery, which usually happens in residential areas conducted by small vans or trucks with low speeds, raises concerns for environmental and safety issues. One of the strategies to address these problems is to set up Pick-up Point networks (PPs) and Automated Parcel systems (APs).

Pick-up Points (PPs) typically operate through local shops such as dry cleaners, florists, gas stations, bars, etc. where consumers can receive and return deliveries. This model provides more flexibility to both consumers and carriers. Consumers have more time and location options to pick up their goods, and carriers can also consolidate their deliveries saving money, energy and time. PPs have already been very popular in European countries. For instance, in France, the PP networks have replaced 20 percent of the home deliveries and covered 90 percent of the French population within walking distance. Another alternative is Automated Parcel systems (APs), or locker banks, which can be found in shopping centers, gas stations, train stations or on the streets. APs are not as common as PPs due to technical issues, with few pilots in dense urban areas. Recently however, APs are becoming more popular both in European and US cities, mainly driven by several big online retailers like Amazon and Walmart. In London, grocery retailers and locker bank providers offer online shopping collection services in transportation stations and parking lots (Nolmark, Browne, Giuliano, & Holguin-Veras, 2016).

PPs and APs could provide clean and efficient means of delivery, but their success relies on many key factors like population density, people's acceptance, accessibility, and operational efficiency. More importantly, there is no solid evidence to show whether PPs and APs can really reduce the environmental impacts of last-mile home delivery. Therefore, this paper will review and summarize the existing academic research concerning the environmental impacts of home deliveries, with a special focus on the potential benefits of PPs and APs networks.

Literature review

The environmental impacts of last-mile delivery

Assessing VMT/VKT as an indicator for environmental impacts

Some studies indicate the environmental impacts by assessing the vehicle miles/kilometers travelled by freight transport. One research showed the increasing impacts of light goods vehicles (LGVs – up to and including 3.5 tonnes gross weight) used by home delivery in London. The researchers revealed that in London, not only had the absolute volume of urban freight grown (the flow of goods and services that require transportation), but also the speed of response required, which indicated a further growth in LGV traffic. Worse, the existing urban infrastructure prioritizing cycling, walking and public transportation resulted in diminishing curbside unloading space and time, and then led to more VMT used for detouring (Allen et al.,

2018). Compared to a conventional shopping trip that might be made to purchase multiple goods, consumers are more likely to purchase separate items from different websites, each requiring independent deliveries and then resulting in additional VMT (Mangiaracina, Marchet, Perotti, & Tumino, 2015). Similar findings were found in another comparative study of carbon emissions from online retailing of fast moving consumer goods. The researchers have concluded that the number of items per delivery could greatly affect the environmental impacts. They also indicated ways to make e-commerce more environmentally sustainable -- encouraging consumers to reduce complementary shopping trips and maximise the number of items per delivery (van Loon, Deketele, Dewaele, McKinnon, & Rutherford, 2015). In a study focusing on several cities in Finland, researchers reported a reduction in distance driven per order of 54-93 percent when e-commerce groceries replaced passenger travel by car (Punakivi & Saranen, 2001). Browne, Allen, & Rizet (2006) compared the energy consumptions in jeans and yogurt industry and demonstrated that the energy used by consumers transporting goods to their homes by car can be as great as total freight transport energy used in the supply chain from farm/field to retail outlet. Similar outcomes appeared in a research on flash drive (Weber et al., 2009). The researchers confirmed that e-commerce delivery used 30 percent lower energy consumption and CO2 emissions compared to traditional retail using calculated mean values. Tehrani, Karbassi, Ghoddoosi, Monavvari, & Mirbagheri (2009) conducted a survey in Tehran, and the results revealed that among total habitants (320,800) of the study area, 55 percent of the respondents considered e-shopping as crucial in reducing different kinds of pollution. They also concluded that e-shopping could reduce 39 percent of the air pollution and 71 percent of the energy consumption, thanks to the substitution of delivery vans with personal trips for groceries.

The impacts of failed and returned deliveries

In addition to the impacts of growing volume of home delivery, failed and returned deliveries can also add to the freight traffic and environmental pressures. According to Ghezzi, Mangiaracina, & Perego (2012), the returned items could take up to 30 percent of overall online sales. The additional traffic flows incurred by returns could offset the environmental advantages of e-commerce and make conventional shopping more sustainable (Wiese, Toporowski, & Zielke, 2012). A report from University of California Transportation Center also raised the pressure of reverse and unattended deliveries imposed on logistics management and freight traffic (Park & Regan, 2004). McLeod and colleagues assessed the overall travel impacts of failed deliveries, in terms of additional time and distance incurred by carriers' delivering and customers' collecting goods using local collection/delivery points (CDPs), based on two separate case studies in Winchester and West Sussex, United Kingdom. The analysis in their research demonstrated the scenarios in which using CDPs was better than home delivery methods. The parameter values of the key factors affecting the benefits of CDPs could vary locally. Customers would benefit the most in traveling cost while the carriers would save processing costs associated with failed delivery (McLeod, Cherrett, & Song, 2006; Song, Cherrett, McLeod, & Guan, 2009). A follow-up research by this team in 2013 quantified the GHG emissions of CDP related trips combining two datasets of households from across Winchester and West Sussex, as well as responses from nine major carriers. The outcomes revealed that a CDP network would reduce GHG emissions most effectively when a 30 percent or more of households

experienced failed deliveries (Song, Guan, Cherrett, & Li, 2013). Punakivi and colleagues examined the efficiency of different solutions to unattended deliveries -- reception box, delivery box and designed delivery time window. The results implied that reception box concept was more effective while the delivery box concept required less investment (Punakivi & Saranen, 2001; Punakivi, Yrjölä, & Holmström, 2001).

Energy consumption and greenhouse gas (GHG) emissions

With respect to energy consumption, two related studies focusing on the energy impacts of delivery systems in the book industries showed that when the return rate was 35 percent, the e-commerce method was found to be more costly and energy efficient, especially if private cars were used for shopping (H. Scott Matthews, Scott Matthews, Williams, Tagami, & Hendrickson, 2002; H. S. Matthews, Hendrickson, & Soh, 2001; E. Williams & Tagami, 2008). However, if taking factors like packaging, freight transport, and consumer travel into consideration, the total energy use indicated that e-commerce consumes slightly more than traditional retailing, basically due to additional packaging (E. D. Williams, 2002). A follow-up research further revealed that in dense urban areas, each book traded via e-commerce consumed more energy because of additional packaging. The additional energy use could be canceled out slightly in suburban and rural areas thanks to the replacement of home delivery with personal pickup (E. Williams & Tagami, 2008).

Some studies examined the greenhouse gas (GHG) emissions of last-mile delivery. Most studies focused on the comparison between conventional shopping trips and online shopping deliveries. Some researchers argued that since there was very little difference between the two alternatives if considering only transportation activities, the last-mile delivery became the most important part (Weber, Koomey, & Scott Matthews, 2010; Wiese et al., 2012). One study compared the level of carbon emissions from conventional shopping passenger trips with online delivery trips, based on the published UK government statistics and primary data from one of the UK's largest home delivery companies. The results indicated that some forms of conventional shopping behaviour emitted less CO2 than home delivery operations, but in the case of non-food purchases, the home delivery operation was likely to generate less CO2 (Edwards, McKinnon, & Cullinane, 2010). This study shared the similar results with Reichling & Otto (2002) that if bus transportation was considered as a means of conventional stores, neither home delivery nor conventional shopping by car proved to have any environmental advantages. Another study based in Finland observed that the GHG emission reduction of online grocery shopping was about 18 to 87 percent compared to conventional shopping, depending on the home delivery model used (i.e., at home, reception box, or in-store pick-up) (Siikavirta, Punakivi, Kärkkäinen, & Linnanen, 2008). Looking at a larger area in Europe including the UK, France and Belgium, Rizet, Cornélis, Browne, & Léonardi (2010) collected consumer travel behavior data through an online survey. They found that the GHG emissions emitted by shopping trips took up a major part of the total supply chain transportation emissions. Similarly, Borggren, Moberg, & Finnveden (2011) observed that online paper book purchase with home delivery or picking-up could be more environmentally friendly than buying a paper book in store. Weltevreden & Rotem-Mindali (2009) identified a "net mobility effect" where the reduction on personal travel due to online shopping was not fully compensated by the increase

in freight transportation, based on a nationwide sample of 3000 Dutch e-shoppers. The authors also emphasized that this mobility reduction was only fully attributed to B2C e-commerce since C2C e-commerce could lead to an increase in both personal travel and freight transportation.

The innovative strategies addressing last-mile issues

Increasing delivery efficiency

Increasing the overall route efficiency is one of the strategies to reduce VMT and GHG emissions. One study examined the effects of two factors -- customer density and delivery window length -- on the overall efficiency. The results provided a tool to balance the customer desire and operational efficiency, suggesting that offering a 3-hour delivery window is 30 to 45 percent more expensive and less efficient than offering unattended (9-hour delivery window) delivery (Boyer, Prud'homme, & Chung, 2009). Another study focused on the effects of different delivery time windows on freight VKT. The simulation indicated that the larger the time interval, the more the flexibility of the retailer in organizing the vehicle routing, and the better the environmental sustainability of the fast delivery service would be (Manerba, Mansini, & Zanotti, 2018).

Replacing home deliveries with self pick-up facilities

Another way to reduce the environmental impacts of last-mile deliveries is to replace direct door-side deliveries with consolidation centers, which provides more flexibility and higher efficiency in terms of timing and routing. There are two kinds of consolidation -- "pick-up points" and "click & collect" (Visser, Nemoto, & Browne, 2014). Pick-up points are locations for picking up goods that are ordered by mail or by internet. Two different types of pick-up points can be distinguished: (1) manned pick-up points, which can be found at supermarkets and stores; (2) unmanned pick-up points, installed with lockers. Observations in European countries indicated that manned pick-up points were more common in Germany, France, and Netherlands. Augereau & Dablanc (2008) compared these two types based on Kiala relay points in France and Packstation locaker banks in Germany, and argued that the two models were complementary to one another.

As for the environmental benefits of pick-up points, Eiichi Taniguchi & Kakimoto (2003) evaluated the environmental impacts of e-commerce using a vehicle routing and scheduling. The results showed that introducing e-commerce (B2C) may lead to more traffic in urban areas and make negative impacts on the environment, but strategies like designating time windows and pick-up points could effectively reduce the total cost, time and NOx emissions. A case study in Thailand used an analytic hierarchy process (AHP) and a criteria framework to determine the location of last mile delivery center (LMDC) to optimize the delivery efficiency. The outcomes showed that LMDC could improve last mile delivery efficiency to final destination amids conditions of GHG emissions, traffic congestion, and pollution problems (Amchang, Graduate School of Logistics, Incheon National University, & Song, 2018). Durand & Gonzalez-Feliu (2012) compared the vehicle trips incurred by three picking up methods -- (1) warehouse picking (2) store picking and (3) depot picking -- using simulations. They revealed that store-picking, though more popular, actually generated more trips because the use of freight vehicles had not

been optimized. Proximity picking-up points, where most trips could be made on foot, would significantly reduce vehicle trips. Meanwhile, Mommens et al. (2021) showed that the pick-up points located in urban areas can significantly contribute to sustainability compared to the pick-up points in rural or urbanized areas. In detail, they used an agent based model (TRABAM) to evaluate the transport-related external cost during the last mile delivery process. What should be noted here is that the passenger transport mode for store purchase or pick-up points will greatly affect the energy consumption. If the trip to the store substituted by e-commerce was made by bike, foot or public transport, the effects on energy consumption would be minor. However, most current studies reported that most trips were made by car or a mix of car, train and bus (Pålsson, Pettersson, & Hiselius, 2017). In addition, a recent study showed that small changes in the calibration process of the model can lead to different results regarding the impact of pick-up facilites on emission outcomes (Schnieder et al., 2021).

Following this track, the key to tap the environmental potential of pick-up point network is to increase its efficiency and accessibility with good design. Weltevreden (2008) used 2006 data from an online survey and the major collection-ad-delivery points (CDPs) in Netherlands to study the uptake of CDPs. The outcomes showed that in 2006, the uptake of CDPs was only mainly for returning orders. The author also argued that both shoppers and pick-up points benefit from vicinity -- online shoppers would be more willing to use CDPs when they have many CDPs near their home, and CDPs with many consumers in their immediate surroundings could also perform efficiently. Morganti, Dablanc, & Fortin (2014) assessed the relevance of population density and proximity to public transportation modes when designing a Pick-up Point network based on the cases in France. Iwan, Kijewska, & Lemke (2016) examined the usability and efficiency of the pick-up point system operated by Polish InPost Company. The results of pilot survey realized in Szczecin revealed that the most important factor of efficiency is the proper location of the machines used for deliveries. Users reported that the most significant expectations should be “close location from home”, “on the way to work” and “availability of parking spaces”. A follow-up research conducted by this research team mentioned the environmental benefits of InPost parcel lockers that the courier serving InPost parcel lockers was able to deliver 600 parcels in just one day, with travel distance of about 70 kilometers in comparison to respectively 60 parcels and 150 kilometers in traditional delivery system. It results with GHG emissions of 1516 tons per year in comparison to 32500 tons in traditional courier service (Lemke, Iwan, & Korczak, 2016). Deutsch & Golany (2017) took one step further trying to optimize the design of parcel locker networks using a simulation model that included factors of locker facilities and customer benefits. More recently, Lachapelle, Burke, Brotherton, & Leung (2018) explored the development, site and location characteristics of parcel lockers in five South East Queensland (SEQ) car-oriented cities, Australia. The findings suggested that though site locations were constrained by commercial decisions, proximity to highways, to public transport, population density, a balance of jobs and population, and higher rates of households Internet access was associated with the distribution of parcel locker network.

Recent studies have further conducted accessibility and equity analysis of pick-up points. Schaefer & Figliozzi (2021) examined the location of 176 Amazon lockers in the Portland, OR

metropolitan area to understand the population coverage of the facilities. The authors showed that a large percentage of the population have access to locker facilities since they are mostly distributed in small retail stores, close to arterial roads, and in areas with higher density. However, most people were able to access lockers by driving, while only a small share of population were able to access lockers by walking. When considering the sociodemographic attributes of population, the paper suggested that the accessibility to lockers is low for Hispanics as well as people with lower educational attainment levels and limited English language abilities. Related to the location of pick-up points, Keeling et al. (2021) suggested to locate the lockers in transit facilities to enhance the population coverage including the disadvantaged population. Furthermore, a recent study suggested to locate pick-up points in small retail stores (e.g., 24/7 minimarkets) to reduce the walking time for pick-up trips by 20-47 %.

People's attitudes and behaviors are also important to the success of pick-up point networks. Moroz & Polkowski (2016) explored the relationship between environmental attitudes and behaviors of Generation Y and their propensity to use parcel machines to collect their online purchases. Unfortunately, the results showed that Generation Y respondents in Poland did not perceive parcel machines as an environmentally friendly method. However, they would be willing to pay a bit more for environment-saving measures. Oliveira et al. (2017) analyzed the potential demand of automated delivery stations (lockers) in the city of Belo Horizonte, Brazil and found that though home delivery was the preferred option, automatic delivery stations scored high potential demand for online shoppers. Vakulenko, Hellström, & Hjort (2018) followed a focus group design and built on grounded theory to provide insights into customer value in relation to parcel lockers. Liu, Wang, & Susilo (2017) stepped further and used a panel cross-nested logit model to explore how people's travel behaviors (mode choice and trip chaining decisions) might change with the use of CDPs, based on the "picking up/leaving goods" trips selected from the Swedish National Travel Survey. Compared to previous research with general conclusions for average population, this research revealed some heterogeneities among populations -- young adults living with partners/spouses or children were more likely to use cars in CDP trips. A calibrated model in this research also indicated that the VKT of CDP trips would reduce 22.5 percent if relocating CDPs from urban area to suburban and rural areas. More recently, Rai et al. (2020) reported that the majority of consumers are likely to use pick-up points after experiencing a delivery failure during their home-delivery process.

A further step making full use of pick-up points is to create a sustainable networked delivery (SND) system, which combines e-commerce and centralized pick-up points together (Kim, Xu, Kahhat, Allenby, & Williams, 2008, 2009). Kim and his research team compared the GHG emissions and energy consumptions of the "sustainable networked delivery" (SND) system, "traditional networked delivery"(TND) system, and "e-commerce networked delivery"(END) system in delivering books to customers. The outcomes showed that both energy consumption and GHG emissions of the TND and END systems were over 5 times more than those of the SND system. The SND system has a lot of possibilities to save local transportation energy consumption and reduce environmental emissions in delivery system. Xue and colleagues found similar outcomes after exploring the dynamics of e-commerce market and the associated

environmental impacts using an agent-based model simulation for book market in the US (Xu, Allenby, Kim, & Kahhat, 2009; Xu, Kim, Kahhat, & Allenby, 2008). The results showed that the the book retail market would reach to an equilibrium state where the market shares of conventional bookstore, e-commerce and self pick-up system were about 50 percent, 10 percent and 40 percent respectively. Correspondingly, the energy consumption and GHG emissions would decrease dramatically by the rapid growth of the e-commerce and self pick-up system. The concept of SND/END system has also been used by Chinese scholars who presented a comparative study of the energy consumption and GHG emissions of books from the END and SND systems. In their research, the SND system had less environmental impacts than the END system thanks to the reduced round trips by couriers in the SND system (Zhang & Zhang, 2013).

The "click & collect" method is mostly used by traditional retailers who also have a web shops. They combine online shopping with picking up goods at their stores -- click and collect. This method benefits both consumers and retailers. Consumers have a wider choice of products to choose from and have the certainty that the products are available when they pick them up, which means that they would not waste any travels to stores. Retailers can compete with other web shops and keep their market share (Visser et al., 2014). However, since this method still requires a visit to a shop which might not locate near consumers, it may generate more environmental impacts than pick-up points.

Using clean energy vehicles

The use of clean energy vehicles can be another effective way to reduce the environmental impacts of home delivery. Cairns (2005) emphasized that the use of new fuels, hybrid vehicles, cleaner petrol or diesel, better filtration of emissions and quieter vehicles could reduce the negative impacts of freight transport. He also highlighted the potential of mixed fleets including bicycle carriers. Fulton & Lee (2013) examined the sustainable methods used by apparel companies to reduce carbon footprints, based on the responses from 156 apparel websites. They reported that alternative fuels were used by 3 percent of companies and consisted of items such as biodiesel, bike programs, and bus passes. Zhang & Zhang (2013) used mathematical models to examine the energy consumption and carbon dioxide emissions in book retail industry. They revealed that the wide use of electric bicycles greatly contributed to the reduction of environmental impacts per book. Visser et al. (2014) proposed strategies of using alternative energy carriers like biofuels, hybrid and electric vehicles. They also emphasized that electric trucks would be more feasible in light trucks than heavy trucks. Bicycles and carts had great advantages in downtown areas considering the lack of parking and street space allocated for freight loading.

Conclusion

Policy implications

The summary above indicates the rising concerns of environmental impacts of home delivery as well as the fast development of Sustainable Delivery Network equipped with Pick-up Point systems and Automated Parcel systems. Although there was no consensus in whether online

shopping increase or decrease environmental impacts in terms of energy consumption and GHG emissions, Pick-up Point systems and Automated Parcel systems have been proved to environmentally friendly by most scholars. Furthermore, the usability and accessibility of PP/AP systems are very important considering users' mode choice for picking up trips. Vicinity from home or work is required to encourage walking rather than driving trips. This indicates that PP/AP systems should be first applied in dense areas and then spread out to less dense areas. In addition, given the inevitable trend that online shopping and home delivery grows at a fast rate, freight traffic would still increase significantly even with PP/AP systems. Therefore, the use of clean energy freight vehicles should be promoted together with the installation of PP/AP systems.

Gaps and critiques

The lack of real-world data

The most significant issue concerning the studies on environmental impacts of last-mile home delivery is the lack of consensus. The reviewed studies reached conflicting findings. Some showed that e‐commerce had a more positive impact on the environment due to the lower energy consumption and GHG emissions, while others found the opposite. The controversy indicates both the lack of real "before and after" data as well as the lack of a standard analytical framework. Current studies calculate environmental impacts through simulation models, but not real energy consumption or GHG emission data. The formula and parameters used in their simulation models are different and sometimes even based on assumptions. Some studies estimated GHG emission reductions according to survey or interviews with consumers and carriers, the data from which might be invalid due to people's memory and cognitive bias. Since the environmental impacts of last-mile delivery (either picking-up or doorside delivery) are basically from freight trucks or passenger vehicles, future research should have daily or weekly real-time tracking data on consumers' travel behavior and carriers' delivery trajectories. Considering the difficulty of tracking consumers' travel behavior, one possible way to collect travel data from consumers is to combine a quick survey with PP/AP system, asking about their mode choice and travel time for the pick-up trips. The data collected in this way would be more reliable than asking people to recall their picking-up trips happening in the past.

The lack of studies in developing countries

Currently, most studies were based in western countries, especially in European countries. Despite the fast development of online shopping and innovative ways to address last-mile delivery issues in Asian countries like Japan and China, there is not much research examining the environmental impacts. There are some studies focusing on book retail sectors, but online shopping in those countries have already expanded to all kinds of goods including groceries, electronics and home essentials. Book retail sector, however, has experiencing a decline since electronic books are becoming more popular. In fact, the research framework used in European cities would fit better in Asian cities with higher density and walkability than car-oriented US cities. Based on my own experience in China, the last-mile deliveries are mainly completed via motorcycle or bicycles with relatively low GHG emissions. The conflicts between motorcycles

and pedestrians would be a bigger issue. In the US cities, PP/AP systems have been experiencing a fast development in recent year, driven by Amazon, Walmart and UPS. But there is no research examining the network design, the usability and the potential environmental benefits of the emerging PP/AP systems. The newly developed PP/AP networks in the US actually provide a good natural event to examine the “before and after” differences in environmental footprints of last-mile delivery trips. Future studies should make full use of this opportunity to explore the real environmental potentials of those so-called sustainable alternatives.

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Appendix B: Survey 1

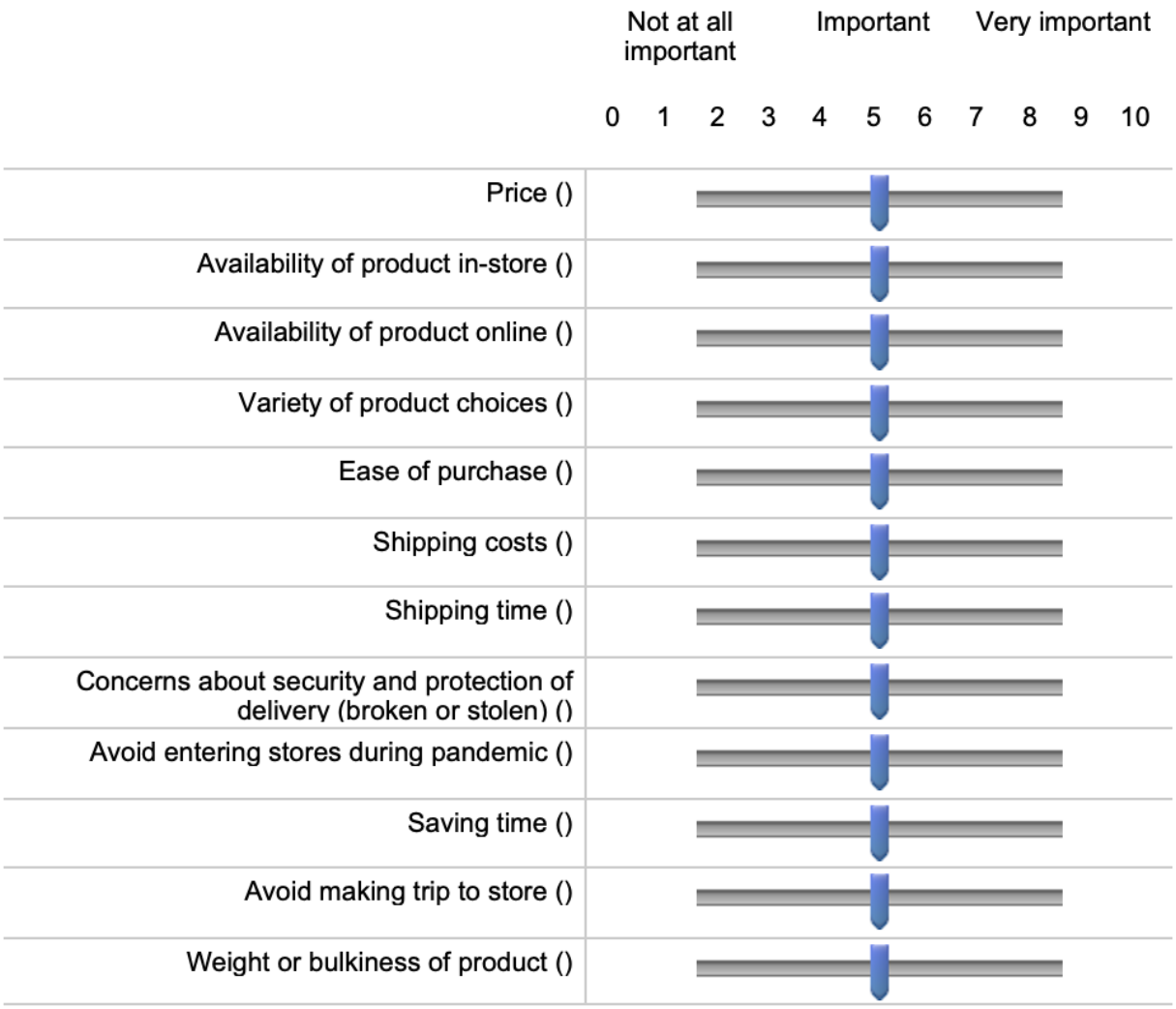
Survey Questions

Introduction

- **[1]** You are invited to participate in a research study. Your participation is voluntary. This page explains information about this study. You should ask questions about anything that is unclear to you. The purpose of this study is to investigate people's online shopping behaviors. We hope to learn more about how people make choices to shop online, how frequently they purchase online, and how they have their purchases delivered. You are invited as a possible participant no matter if you have shopped online or not. The research will help us to anticipate package delivery demand and develop more sustainable ways to meet this demand. All you need to do is to fill out an online survey which may take you about 15 minutes. Please read the question carefully before you answer. Some questions look identical but there will be some nuances. The members of the research team, The METRANS Transportation Center and the University of Southern California Institutional Review Board (IRB) may access the data. The IRB reviews and monitors research studies to protect the rights and welfare of research subjects. We are not collecting any identifiable information in this survey. The survey data will be archived by METRANS Transportation Center in Dryad, whose policies are conformant to the requirements enumerated by the US DOT Public Access Policy. If you have any questions about this study, please contact Dr. Genevieve Giuliano at (213)740-3956 or email giuliano@usc.edu. If you have any questions about your rights as a research participant, please contact the University of Southern California Institutional Review Board at (323) 442-0114 or email irb@usc.edu.

Usual Online Shopping

- This section asks about your **usual** online shopping behavior. Think about your shopping behavior over the **past several months** and answer the following questions.
- **[2]** Thinking about a typical month, how often do you **usually** shop online?
    - Almost every day
    - A few times per week
    - About once per week
    - More than once per month but less than once per week
    - Less than once per month
    - I never shop online
    - Refused or don't know
- **[3]** Thinking about your choice of buying online or in-store, how important are the following to your choice?



- **[4]** What types of products do you **most frequently** purchase online? ***(choose up to five)***
  - Clothing and shoes
  - Consumer electronics (phones, tablets, headphones, etc.)
  - Books, movies, music and games (excluding digital downloads)
  - Cosmetics and body care
  - Bags and accessories
  - Food and drink (non-perishable)
  - Food and drink (perishable)
  - Household appliances
  - Household furnishings
  - Sports and outdoor
  - Toys and baby products
  - Stationery and hobby supplies

    - DIY, garden and pets
    - Medications
    - Prepared food from restaurants, coffee shops, cafes, etc.
    - Other, please specify _____
- **[5]** What other products have you ever purchased online? ***(choose all that apply)***
    - Clothing and shoes
    - Consumer electronics (phones, tablets, headphones, etc.)
    - Books, movies, music and games (excluding digital downloads)
    - Cosmetics and body care
    - Bags and accessories
    - Food and drink (non-perishable)
    - Food and drink (perishable)
    - Household appliances
    - Household furnishings
    - Sports and outdoor
    - Toys and baby products
    - Stationery and hobby supplies
    - DIY, garden and pets
    - Medications
    - Prepared food from restaurants, coffee shops, cafes, etc.
    - Other, please specify _____
- **[6]** What device do you use **most frequently** for online shopping? ***(choose one)***
    - Smart phone
    - Laptop or desktop
    - Tablet
    - Alexa, Google or Siri devices
    - Other, please specify _____
- **[7]** Mark all the ways you have received your online purchases in the ***past 6 months***
    - Delivered to my home address
    - Delivered to my work address
    - Pick up at the store of purchase
    - Pick up at a manned pickup point, like UPS Access Point
    - Pick up at an automated locker, like Amazon Locker
    - Other, please specify _____

- **[8]** How do you **usually** receive your online purchase?
    - Delivered to my home address
    - Delivered to my work address
    - Pick up at the store of purchase
    - Pick up at a manned pickup point, like UPS Access Point
    - Pick up at an automated locker, like Amazon Locker
    - Other, please specify _____

Check Question

- **[9]** Check To show that you are paying attention, please select "none of the above" option as your answer.
    - Strong
    - Indifferent
    - Weak
    - Hostile
    - None of the above

Rank Home Delivery

- **[10]** Please mark the ***three*** most important reasons for usually having your online purchase delivered to your home address:
    - It is the most convenient option for me
    - It is the safest option for my package (not be stolen or broken) - package security
    - It is the safest option for myself to get my package - personal security
    - It is the fastest option
    - I do not have any other delivery choice when I shop online
    - Pick-up locations such as Amazon Lockers are not located near my home
    - Pick-up locations such as Amazon Lockers are not convenient to use
    - I am minimizing my travel and exposure to other people due to the pandemic
    - Other, please specify _____
- **[11]** Considering the times you have used pickup locations. Please mark the ***three*** most important reasons for usually using a pickup location to receive your purchase:
    - It was the most convenient option for me
    - It is the safest option for my package (not be stolen or broken) - package security
    - It is the safest option for myself to get my package - personal security
    - It was the fastest option
    - The pickup location was close to my home or work
    - Using a pickup location gave me free shipping

- I received a discount or coupon for using a pickup location
- Other, please specify_____

Rank Work Delivery

- **[12]** Please mark the ***three*** most important reasons for usually having your online purchase delivered to your workplace:
  - It is the most convenient option for me
  - It is the safest option for my package (not be stolen or broken) - package security
  - It is the fastest option
  - I do not have any other delivery choice when I shop online
  - Pick-up locations such as Amazon Lockers are not located near my home or workplace
  - Pick-up locations such as Amazon Lockers are not convenient to use
  - I am minimizing my travel and exposure to other people due to the pandemic
  - It is the safest option for myself to get my package - personal security
  - Other, please specify_____
- **[13]** Considering the times you have used pickup locations. Please mark the ***three*** most important reasons for usually using a pickup location to receive your purchase:
  - It is the most convenient option for me
  - It is the safest option for my package (not be stolen or broken) - package security
  - It is the fastest option
  - I do not have any other delivery choice when I shop online
  - Pick-up locations such as Amazon Lockers are not located near my home or workplace
  - Pick-up locations such as Amazon Lockers are not convenient to use
  - I am minimizing my travel/exposure to other people due to the pandemic
  - It is the safest option for myself to get my package - personal security
  - Other, please specify_____

Never Pickup Location

- **[14]** Please mark the ***three*** most important reasons you have **NEVER** used a pickup location:
  - I do not know about pickup locations
  - I do not know where to find a pickup location
  - There are no pickup locations near my home or work
  - It is not convenient to use a pickup location
  - I am not comfortable using apps on my phone
  - Pickup locations are not safe

- Other, please specify_____

Rank Instore Pickup

- **[15]** Please mark the ***three*** most important reasons for usually picking up your online purchase at the store:
  - It is the most convenient option for me
  - It is the safest option for my package (not be stolen or broken) - package security
  - It is the fastest option
  - If I didn't pick up at store, I would have to pay for delivery
  - Since the pandemic, I have avoided going into stores
  - It is the safest option for myself to get my package - personal security
  - Other, please specify_____

Rank Pickup Locations

- **[16]** Please mark the ***three*** most important reasons for usually using a pickup location to receive your purchase:
  - It is the most convenient option for me
  - It is the safest option for my package (not be stolen or broken) - package security
  - It is the fastest option
  - The pickup location is close to my home or work
  - Using a pickup location gives me free shipping
  - I receive a discount or coupon for using a pickup location
  - It is the safest option for myself to get my package - personal security
  - Other, please specify_____
- **[17]** How do you usually travel to and from the pickup location?
  - I drive myself (including car, vans, trucks, motorcycles)
  - Friend or family takes me in their car
  - I use the bus or train
  - I take taxi or ridehail (Uber or Lyft)
  - I walk
  - I bike
  - I ride a scooter or a skateboard
  - Other, please specify_____
- **[18]** Do you usually combine other trips with your pick-up trip?
  - Yes
  - No

- **[19]** Approximately how far is the pickup location you usually use from your home? (in miles)
    - _____
- **[20]** Approximately how long does it take to travel to the pickup location you usually use? (in minutes)
    - _____

Factors to Use More Pickup Locations

- **[21]** Choose the ***three*** most important factors that would make using pickup locations more attractive to you:
    - Pickup locations close to my home, work, or nearby stores and shops
    - Discounts on my purchase
    - Same day delivery or one-day delivery
    - Faster delivery than home-delivery
    - Free shipping
    - Easy way to use pickup locations
    - One or two days of grace period for pick-up (no hasty pickup)
    - Easier way to make returns
    - Nothing, it is too inconvenient to make a trip to pick up my package
    - Other, please specify_____
- **[22]** Now think about choosing whether to have your package delivered to home or use a pickup location. What factors would influence your choice***? (choose all that apply)***
    - The bulk and weight of the package
    - The time it would take to travel to the pickup location
    - The discount I would receive for using a pickup point
    - The shipping time for the package
    - The level of safety around my home or pickup location
    - The grace period for pick-up allowed by lockers
    - Other, please specify_____

Pandemic Influences

- **[23]** Has the pandemic affected the frequency of your online shopping? ***(choose one)***
    - I have increased my online shopping
    - My online shopping has not changed
    - I have reduced my online shopping

- **[24]** Has the pandemic affected the types of products you purchased online? ***(choose one)***
    - I purchased more types of products now
    - I purchased the same products as before
    - I purchased fewer types of products now
- [**25]** What types of products did you **START** to purchase online after the pandemic? ***(choose up to three)***
    - Clothing and shoes
    - Consumer electronics (phones, tablets, headphones, etc.)
    - Books, movies, music and games (excluding digital downloads)
    - Cosmetics and body care
    - Bags and accessories
    - Food and drink (non-perishable)
    - Food and drink (perishable)
    - Household appliances
    - Household furnishings
    - Sports and outdoor
    - Toys and baby products
    - Stationery and hobby supplies
    - DIY, garden and pets
    - Medications
    - Prepared food from restaurants, coffee shops, cafes, etc.
    - Other, please specify_____
- **[26]** What types of products did you **STOP** to purchase online after the pandemic? ***(choose up to three)***
    - Clothing and shoes
    - Consumer electronics (phones, tablets, headphones, etc.)
    - Books, movies, music and games (excluding digital downloads)
    - Cosmetics and body care
    - Bags and accessories
    - Food and drink (non-perishable)
    - Food and drink (perishable)
    - Household appliances
    - Household furnishings
    - Sports and outdoor
    - Toys and baby products
    - Stationery and hobby supplies

    - DIY, garden and pets
    - Medications
    - Prepared food from restaurants, coffee shops, cafes, etc.
    - Other, please specify_____
- **[27]** Has the pandemic affected the way you have your purchases delivered? ***(choose one)***
    - No, I use the same methods of delivery as before the pandemic
    - Yes, I use more methods of delivery than before the pandemic.
    - Yes, I use fewer methods of delivery than before the pandemic.
- [28] What methods of delivery did you START using after the pandemic? ***(choose all that apply)***
    - Delivered to my home address
    - Delivered to my work address
    - Pick up at the store of purchase
    - Pick up at a manned pickup point like UPS Access Point
    - Pick up at an automated locker like Amazon Locker
    - Other, please specify_____
- **[29]** What methods of delivery did you **STOP** using after the pandemic? ***(choose all that apply)***
    - Delivered to my home address
    - Delivered to my work address
    - Pick up at the store of purchase
    - Pick up at a manned pickup point like UPS Access Point
    - Pick up at an automated locker like Amazon Locker
    - Other, please specify_____
- **[30]** Will you continue your pandemic habit of online shopping in the future (even after the pandemic)?
    - Yes, I will continue
    - No, I like how I shopped before the pandemic
    - Maybe, I am not sure yet

Most Recent Online Shopping

- This section asks about your **most recent** online shopping purchase. A purchase means a single order from one online retailer or platform. A purchase may include one or more items. Please respond to the following questions.

- **[31]** When was your most recent online shopping purchase **RECEIVED**?
    - Today
    - Within the last week
    - Within 2 weeks but more than 1 week ago
    - More than 2 weeks but less than a month ago
    - More than a month ago
- **[32]** What did you buy? ***(choose all that apply)***
    - Clothing or shoes
    - Consumer electronics (phones, tablets, headphones, etc.)
    - Books, movies, music and games (excluding digital downloads)
    - Cosmetics and body care
    - Handbags and accessories
    - Food and drink (non-perishable)Food and drink (perishable)
    - Household appliances
    - Household furnishings
    - Sports and outdoor
    - Toys and baby products
    - Stationery and hobby supplies
    - DIY, garden and pets
    - Medications
    - Prepared food from restaurants, coffee shops, cafes, etc.
    - Other, please specify_____
- **[33]** What device did you use for your online purchase?
    - Smart phone
    - Laptop or desktop
    - Tablet
    - Alexa, Google or Siri devices
    - Other, please specify_____
- **[34]** Did you receive free shipping?
    - Yes
    - No
- **[35]** How much did you pay for shipping? *(in US Dollars)*
    - _____
- **[36]** How many packages did you receive?
    - One
    - More than one

- **[37]** How long did it take you to receive your purchase?
    - Same day
    - One day
    - Two days
    - More than 2 days but within 1 week
    - More than 1 week but within 2 weeks
    - More than 2 weeks
- **[38]** How long did it take you to receive package 1?
    - Same day
    - One day
    - Two days
    - More than 2 days but within 1 week
    - More than 1 week but within 2 weeks
    - More than 2 weeks
- **[39]** How long did it take you to receive package 2?
    - Same day
    - One day
    - Two days
    - More than 2 days but within 1 week
    - More than 1 week but within 2 weeks
    - More than 2 weeks
- **[40]** Did you receive three or more packages?
    - Yes
    - No
- **[41]** How long did it take you to receive the rest of your packages?
    - Same day
    - One day
    - Two days
    - More than 2 days but within 1 week
    - More than 1 week but within 2 weeks
    - More than 2 weeks
- **[42]** How did you receive your most recent online purchase? ***(choose one)***
    - Delivered to my home address
    - Delivered to my work address
    - Pick up at the store of purchase
    - Pick up at a manned pickup point like UPS Access Point

    - Pick up at an automated locker like Amazon locker
    - Other, please specify_____
- **[43]** How did you travel to and from the pickup location?
    - I drove myself (including car, vans, trucks, motorcycles)
    - Friend or family took me in their car
    - I used the bus or train
    - I took taxi or ridehail (Uber or Lyft)
    - I walked
    - I biked
    - I rode a scooter or a skateboard
    - Other, please specify_____
- **[44]** Did you combine other trips with your LAST pickup trip?
    - Yes
    - No
- **[45]** Approximately how far was the pickup location you used from your home? *(in miles)*
    - _____
- **[46]** Approximately how long did it take to travel to the pickup location you used? *(in minutes)*
    - _____

General Information

- Congratulations! You have finished the majority of the survey. Now just a few more questions about yourself.
- **[47]** Do you have internet access at your home?
    - Yes
    - No
- **[48]** Which of the following devices do you own? ***(choose all that apply)***
    - Smart phone
    - Laptop computer
    - Desktop computer
    - Tablet
    - Alexa, Google or Siri devices
- **[49]** Are you currently employed?
    - Yes, full time
    - Yes, part time
    - No

- **[50]** How many persons in addition to you are living in your household?
    - None
    - One
    - Two
    - Three
    - More than three
- **[51]** How many automobiles, and trucks of one-ton capacity or less are kept at home for use by members of your household?
    - None
    - One
    - Two
    - Three
    - More than three
- **[52]** What type of residential housing are you living in?
    - Single-family (detached) house
    - Townhouse (single-family attached)
    - Apartment
    - Condominium
    - Other, please specify_____
- **[53]** Do you own or rent?
    - Own
    - Rent
- **[54]** Please mark your age category:
    - Under 18 years
    - 18-24 years
    - 25-44 years
    - 45-64 years
    - 65 or older
    - Decline
- **[55]** Please mark your gender identity:
    - Male
    - Female
    - Other
    - Decline

- **[56]** Please mark your highest level of education:
    - Less than high school
    - High school degree
    - Some college
    - Bachelor's degree (four-year college degree)
    - Post-graduate degree
- **[57]** Please mark your race:
    - White
    - African American
    - American Indian or Alaska Native
    - Asian
    - Native Hawaii or Pacific Islander
    - Decline
- **[58]** Please mark your ethnicity:
    - Hispanic
    - Not Hispanic
    - Decline
- **[59]** Please provide your home location:
    - City _____
    - Zipcode _____
- **[60]** Please mark your household income category:
    - Under $15,000
    - $15,000 to $24,999
    - $25,000 to $49,999
    - $50,000 to $74,999
    - $75,000 to $99,999
    - $100,000 to $149,999
    - $150,000 or more
    - Decline
    - I don't know

Appendix C: Survey 2

Survey Questions

****Surveyors should manually check*

1. *how many parcels*
2. *how heavy and large are the parcels*

Experience Using Amazon Locker

- **[1]** Is this your first time using the Amazon locker service?
    - Yes
    - No
    - **[1-2]** When was the first time you used the Amazon locker service?
        - Less than six months
        - More than six month and less than a year
        - More than a year and less than two year
        - More than two year
        - Do not know
- **[2]** Thinking about your purchases from Amazon, how often do you use the locker service?
    - For all my purchases
    - For some of my purchases
    - Rarely
- **[3]** Why did you choose to have the parcel(s) you are picking up today delivered to the Amazon locker? (Choose up to three)
    - It is the most convenient option for me
    - It is the safest option for my package (not be stolen or broken) - package security
    - It is the safest option for myself to get my package - personal security
    - It is the fastest option
    - It offers free shipping option
    - I get a discount when I use the locker
    - I do not have any other delivery choice when I shop online
    - Other, please specify_____
- **[4]** What types of products did you pick up today? (choose all)
    - Clothing, shoes, other personal items
    - Groceries and other household goods
    - Consumer electronics (phones, tablets, headphones, etc.)
    - Books, movies, music and games (excluding digital downloads)

- Toys, Sports and outdoor
- Other, please specify_____

Information of Parcel(s)

- **[5]** How long did it take you to receive your package(s)?
  - Same day
  - One day
  - Two days
  - More than 2 days but within 1 week
  - More than 1 week but within 2 weeks
  - More than 2 weeks
- **[6]** When did you get your notification that your parcel(s) arrived in the locker?
  - Today
  - Yesterday
  - 2 days ago
  - 3 or more days ago
  - Do not know
- **[7]** How much time did you have to pick up your packages?
  - Less than 2 days
  - More than 2 days

Location of the Parcel Locker

- **[8]** How many different locker locations have you used to get your delivery in the past?
  - One
  - Two
  - Three
  - Four
  - Five or more
- **[9]** Why did you choose this Amazon locker to have your parcel(s) delivered? (choose all)
  - Locker availability
  - Safety concerns
  - Parking availability
  - Proximity to home
  - Proximity to work/work related location
  - Proximity to school
  - Proximity to nearby stores or shops

- Other, please specify_____

- **[10]** Approximately how far is this Amazon locker from your home?
  - Less than a mile
  - More than a mile and less than 3 miles
  - More than 3 miles and less than 5 miles
  - More than 5 miles and less than 10 miles
  - More than 10 miles
- **[11]** Approximately how far is this Amazon locker from your place of work or school?
  - Less than a mile
  - More than a mile and less than 3 miles
  - More than 3 miles and less than 5 miles
  - More than 5 miles and less than 10 miles
  - More than 10 miles

Online Shopping Experience

- **[12]** Thinking about a typical month, how often do you usually shop online?
  - Almost every day
  - A few times per week
  - About once per week
  - More than once per month but less than once per week
  - Less than once per month
  - Refused or don't know
- **[13]** Mark all the possible ways you could receive the purchases you make online (Choose all)
  - Delivery to my home address
  - Delivery to my work address
  - Pick up at the store of purchase
  - Pick up at a manned pickup point, like UPS Access Point
  - Pick up at an automated locker, like Amazon Locker
  - Other, please specify_____
- **[14]** How do you usually receive your online purchase?
  - Delivered to my home address
  - Delivered to my work address
  - Pick up at the store of purchase
  - Pick up at a manned pickup point, like UPS Access Point
  - Pick up at an automated locker, like Amazon Locker
  - Other, please specify_____

- **[15]** Have you ever experienced delivery failure when trying to receive your parcel(s) at your home or work?
    - Yes
    - No

Trip-related Information

- **[16]** Where did you travel from today?
    - Home
    - Work or work-related location
    - School
    - Nearby shops (to buy goods such as groceries, clothes, appliances, gas)
    - Nearby services (dry cleaners, banking, service for car, pet care)
    - Nearby restaurants or cafv© (meal, snack, carry-out)
    - Nearby recreational activities (parks, movies, bars, museum)
    - Other, please specify_____
- **[17]** How did you travel to this pickup location?
    - I drove myself (including car, vans, trucks, motorcycles)
    - Friend or family took me in their car
    - I used the bus or train
    - I took taxi or ridehail (Uber or Lyft)
    - I walked
    - I biked
    - I rode a scooter or a skateboard
    - Other, please specify_____
- **[18]** How long did it take you to travel to this pickup location?
    - In minutes _____
- **[19]** Where do you plan to go after picking up your package?
    - Home
    - Workplace
    - School
    - Nearby shops (to buy goods such as groceries, clothes, appliances, gas)
    - Nearby services (dry cleaners, banking, service for car, pet care)
    - Nearby restaurants or cafv© (meal, snack, carry-out)
    - Nearby recreational activities (parks, movies, bars, museum)
    - Other, please specify _____

- **[20]** Do you usually combine other trips with your pick-up trip?
    - Yes
    - No

Demographic Information

- **[21]** Please mark your age category
    - Under 18 years
    - 18-24 years
    - 25-44 years
    - 45-64 years
    - 65 or older
    - Decline to state
- **[22]** Please mark your gender identity
    - Male
    - Female
    - Other
    - Decline to state
- **[23]** Please mark your highest level of education
    - Less than high school
    - High school degree
    - Some college
    - Bachelor's degree (four-year college degree)
    - Post-graduate degree
- **[24]** Please mark your race
    - White
    - African American
    - American Indian or Alaska Native
    - Asian
    - Native Hawaii or Pacific Islander
    - Decline to state
- **[25]** Please mark your ethnicity
    - Hispanic
    - Not Hispanic
    - Decline to state

- [**26]** How many vehicles are available for regular use by the people who currently live in your household?
    - One
    - Two
    - Three
    - Four
    - Five or more
- **[27]** Please provide the city and zipcode of where you live
    - City_____
    - Zip Code_____
- **[28]** Are you currently employed?
    - Yes, full time
    - Yes, part time
    - No
- **[29]** Please mark your household income category (per year)
    - Under $15,000
    - $15,000 to $24,999
    - $25,000 to $49,999
    - $50,000 to $74,999
    - $75,000 to $99,999
    - $100,000 to $149,999
    - $150,000 or more
    - Decline to state
    - I don't know

Appendix D: Additional Figures & Tables

Table D1. Socio-Economic Status of Respondents (Survey 1)

	Sample		Population (California)	
	N	%	N (1,000)	%
Sex				
Male	267	44.8	19562.9	49.7
Female	325	54.5	19783.1	50.3
Other	2	0.3		
Decline to state	2	0.3		
Age				
18-24 years	74	12.4	3724.2	12.3
25-44 years	205	34.4	11241.8	37.0
45-64 years	217	36.4	9778.8	32.2
65 or older	98	16.4	5644.5	18.6
Decline to state	2	0.3		
Education				
Less than high school	11	1.8	4286.5	16.1
High school degree	87	14.6	5431.4	20.4
Some college	182	30.5	7690.3	28.8
Bachelor's degree (four-year college degree)	192	32.2	5764.8	21.6
Post-graduate degree	124	20.8	3492.0	13.1
Race				
White	392	65.8	22053.7	72.1
Asian	102	17.1	5834.3	19.1
African American	51	8.6	2251.0	7.4
American Indian or Alaska Native	6	1.0	311.6	1.0
Native Hawaii or Pacific Islander	4	0.7	149.6	0.5
Decline to state	41	6.9		
Hispanic				
Hispanic	110	18.5	15380.9	39.1
Not Hispanic	469	78.7	23965.1	60.9
Decline to state	17	2.9		
Income				
Under $15,000	56	9.4	1122.3	8.6
$15,000 to $24,999	55	9.2	909.5	6.9

	Sample		Population (California)	
	N	%	N (1,000)	%
$25,000 to $49,999	101	16.9	2245.8	17.1
$50,000 to $74,999	97	16.3	2007.5	15.3
$75,000 to $99,999	94	15.8	1616.3	12.3
$100,000 to $149,999	72	12.1	2235.1	17.1
$150,000 or more	82	13.8	2966.6	22.6
I don't know	20	3.4		
Decline to state	19	3.2		
Employment				
Full time	266	44.6	13039.1	40.9
Part time	102	17.1	13755.2	43.1
Unemployed	228	38.3	5113.6	16.0
Home ownership				
Own	301	50.5	21658.3	57.0
Rent	295	49.5	16330.1	43.0

Table D2. Socio-Economic Status of Respondents (Survey 2)

	Sample		Population (Los Angeles-Long Beach-Anaheim MSA)	
	N	%	N (1,000)	%
Sex				
Male	159	46.5	6514.1	49.3
Female	173	50.6	6696.9	50.7
Other	6	1.8		
Decline to state	4	1.2		
Age				
Under 18 year	0	0.0	2876.3	21.8
18-24 years	66	19.3	1242.7	9.4
25-44 years	167	48.8	3871.4	29.3
45-64 years	89	26.0	3381.7	25.6
65 or older	19	5.6	1839.0	13.9
Decline to state	1	0.3		
Education				
Less than high school	3	0.9	1700.6	18.7

	Sample		Population (Los Angeles-Long Beach-Anaheim MSA)	
	N	%	N (1,000)	%
High school degree	46	13.5	1783.2	19.6
Some college	98	28.7	2390.1	26.3
Bachelor's degree (four-year college degree)	132	38.6	2082.6	22.9
Post-graduate degree	63	18.4	1135.5	12.4
Race*				
White	158	46.2	6622.1	67.8
Asian	109	31.9	2156.2	22.1
African American	34	9.9	864.3	8.8
American Indian or Alaska Native	24	7.0	93.7	1.0
Native Hawaii or Pacific Islander	5	1.5	34.6	0.3
Decline to state	35	10.2		
Hispanic				
Hispanic	80	23.4	5922.7	44.8
Not Hispanic	239	69.9	7288.3	55.2
Decline to state	23	6.7		
Income				
Under $15,000	24	7.0	405.1	9.3
$15,000 to $24,999	28	8.2	312.4	7.1
$25,000 to $49,999	61	17.8	758.9	17.4
$50,000 to $74,999	64	18.7	675.0	15.4
$75,000 to $99,999	52	15.2	540.9	12.4
$100,000 to $149,999	46	13.5	745.9	17.1
$150,000 or more	47	13.7	934.3	21.4
I don't know	6	1.8		
Decline to state	14	4.1		
Employment				
Full time	200	58.5	4550.9	42.0
Part time	80	23.4	4459.8	41.2
Unemployed	62	18.1	1820.2	16.8

* Multiple answers were allowed for race.