Estimating the Impact of COVID-19 on Travel Behavior and Perceptions: An Investigation of Commuting Travel and Intercity Travel in the Northeast Megaregion

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<tr><td colspan="4">16. Abstract
The impact of COVID-19 on transportation– both for routine commuting and for less routine intercity transportation trips – has been significant and uneven across modes. As traveler concerns, beliefs, behaviors, and actual travel needs have changed, there are concerns related to the use of pre-COVID-19 travel data to predict travel demand going forward. The extent to which the COVID-19 pandemic will shift the propensity to travel and the mode of travel – both because of changing norms and changing needs – is an open and highly consequential question. The goal of this project is to understand future travel demands (both in trip generation and mode choice) for trips generated from a major anchor institution for both routine commuting and intercity transportation. Through a survey of more than 400 members of the faculty and staff at the University of Pennsylvania – the largest trip generator in the Delaware Valley Region in the Northeast Megaregion – and other sites about travel behaviors prior to the COVID-19 pandemic and their perceptions and plans for travel in the future – the research team will build models that provide new understanding into how changing perspectives and travel needs will shape the future of commuting and intercity travel. The analysis will provide planners, from those looking to incentivize sustainable behavior and control congestion</td></tr>
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to those planning scheduled transportation modes, with a spatial scenario analysis tool to evaluate future local, regional, and megaregional travel patterns.			
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UNIVERSITY OF PENNSYLVANIA COMMUTER SURVEY 2023

Penn Praxis

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Penn Facilities & Real Estate Services

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Penn Praxis

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EXECUTIVE SUMMARY

In February and March of 2023, PennPraxis and the Center for Safe Mobility deployed an employee travel survey on behalf of The Sustainability Office of the University of Pennsylvania Division of Facilities and Real Estate Services (FRES) and Business Services Division (BSD). The survey collected information about employee travel patterns and attitudes. It was designed to allow FRES and its University partners to work towards decreasing the University's carbon footprint using incentives to promote lower-carbon travel.

The Research Team found that University of Pennsylvania commuters make strong use of sustainable transit options. **Penn employees use transit at a rate seven times the average commuter in the Philadelphia region, bike more than three times as much, and they walk almost ten times more than the regional rate.** However, there is still some unmet demand for sustainable commute options.

Penn employees reported varied travel behavior - most traveling to work 3, 4 or 5 days per week**.** Roughly ⅕ of commuters use a mix of transportation modes depending on the trip and the day. Some include periodic driving in their mix. There is no dominant commuter type or pattern - there is a collection of user groups.

Over half of Penn commuters make use of university commuter benefit programs, including WageWorks, and the Bicycle Commuter Reimbursement Program. However, these programs don't align well with the ways employees choose to travel to work, and participation could be increased if pass options and discounts catered to the frequency and mix of existing patterns.

The high level of sustainable transit use is associated with the fact that many Penn employees live in locations with good access to work via transit, walking, or biking. Users who have access to transit tend to use it. Others want to use it, and have access, but can't for a variety of reasons. These impediments include barriers related to service - access, convenience, and perceptions of safety, and the fact that transit is not an attractive option in some areas of the region.

Many subjects expressed interest in purchasing electric vehicles (EVs), which might mean a need for more charging facilities. However, EV purchases are likely not going to change current commute patterns. There is also demand for sustainable long-distance transportation options.

The University can encourage increased sustainable transit use with strategic messaging campaigns and savvy programs. Public transit options can be interpreted with campus signage and messaging. Subsidies can be tweaked to meet employees where they are and nudge them towards transit use. Programs can be promoted selectively to likely users. There is also an opportunity to work with transit agencies in an attempt to facilitate better travel options for groups of Penn employees who are predisposed to using transit but don't have options that work for them.

Traffic on South Street Bridge. Photo by Eric Sucar, University of Pennsylvania Office of University Communications

BACKGROUND

The Sustainability Office of the University of Pennsylvania Division of Facilities and Real Estate Services (FRES) and Business Services Division (BSD) commissioned the Weitzman School of Design's PennPraxis and the Center for Safe Mobility ("the Research Team") to design and execute a commuter behavior survey. The survey, deployed in Spring, 2023, collected information about employee travel patterns and attitudes. It was designed to allow FRES and its partners at the University to work towards decreasing the University's carbon footprint using incentives to promote lower-carbon travel. Commuting and long-distance travel are key contributors to the carbon footprint of the University, which is the region's largest employer[1].

This survey was commissioned to fill an information gap regarding travel behavior. The University relies on observations, travel-related purchasing, and commuter benefits program participation to understand travel behavior. However, since only half of Penn employees enroll in transit benefits programs, a lot was unknown. With new, up-to-date data, FRES and other University divisions can make more informed decisions about programs to encourage sustainable community choices - taking transit, walking, carpooling, and biking, and choosing lower-carbon long-distance travel.

Locust Walk, University of Pennsylvania (Pre-pandemic image). Photo by Eric Sucar, University of Pennsylvania Office of University Communications.

METHODS

Consultations

This project was initiated in early 2021. The Research Team began by interviewing stakeholders with FRES and Penn Business Services about University programs, sustainability goals, and scenarios for future transportation at the University[2]. This process was iterated as the survey was redesigned to adjust to changes in the commuting environment related to the COVID-19 pandemic. The Research Team consulted the Office of Diversity, Equity and Inclusion and vetted the survey questions. University Office of Institutional Review Board was consulted about the risk of human research in this study and approved for an exempt in Category 2 (Protocol number 848821).

Survey Design

The survey was designed to collect information from paid faculty, staff, and contractors to the University *who are eligible for subsidized transit programs*. It does not include students (except those employed by the University). Questions covered demographic and economic information, weekly commuting travel behaviors, participation in Penn commuter benefit programs, environmental awareness, work-related long-distance travel choices. The initial survey was written in April 2021 and rewritten in Fall 2022, The survey was administered using Qualtrics, including the Team's custom-built applications to collect geo-located origin/destination information using interactive mapping applications.

Dissemination

The survey was launched on February 20, 2023, after a promotional campaign led by FRES communications staff. Participation was encouraged through emails to staff and faculty from numerous channels across the University. It was open for 37 days.

Survey Sample

Survey participation was strong. Across 28 schools and divisions, there were 4111 valid responses - over 11% of Penn's 35,239 employees[3]. The responses are generally even across schools and divisions[4]. Staff were oversampled slightly relative to faculty[5].

Analysis

The Research Team analyzed the data in April and May of 2023. The Research Team created driving, walking, and transit itineraries for each subject using Google Maps API. The travel itineraries calculation allowed researchers to understand each survey participant's travel time and distance constraints. Using reported subject attributes, behavior, and preferences, the Research Team built descriptive statistics, cross-tabulations, and statistical models to comprehend the importance of economic, locational, and behavioral factors on subject commuting choices and the utilization of subsidy programs.

[1] Source: https://selectgreaterphl.com/doing-business/largest-employers/

[2] The following were among those interviewed or consulted regarding the nature or content of this survey: Anne Papageorge, Mark Mills, Marie Witt, Nina Morris, Jack Heuer, Brian Manthe, Natalie Walker, Heidi Wunder, Elizabeth Main, Taylor Berkowitz, Mark Kocent.

[3] Data source: Division of Human Resources University of Pennsylvania, data retrieved in June 2023.

[4] Importantly, the Perelman School of Medicine (32.9% of employees at Penn) accounted for 30.4% of all responses.

[5] 64% of respondents were staff, 17% were faculty,19% of survey respondents were graduate students. The staff/faculty ratio at Penn is about 1.7.

HOW PENN EMPLOYEES GET TO AND FROM WORK

Penn employees use sustainable transit far more than average commuters

Of the 4111 valid travel survey responses, 2143 (52.1%) respondents said that they take public transit at least once a week, and 1321 (32.1%) reported that they take transit three or more days in a week. Transit, driving alone, and walking were the most popular ways to get to work, in that order (**Figure 1**). The percentage of frequent transit users (32.1%) substantially outnumbers the transit mode share in the City (24.0%) and metro region (6.4%).

	Penn Employees[6] (Survey data)	Philadelphia County (Census data)	Philadelphia Region (Census data)
	27.6%	54.2%	79.8%
	44.6%	24.0%	6.4%
	6.4%	2.2%	0.6%
	11.9%	8.6%	3.2%
Other Modes	9.5%	2.3%	1.4%

Figure 1. Mode share of Penn employees vs. Philadelphia region (excluding people working from home). Other mobility includes carpool, rideshare, scooter, etc. Census data source: US Census Bureau, 2017-2021 American Community Survey 5-Year Estimates

Many commuters use a mix of transportation modes throughout the week

Approximately 21.5% of people who visit campus more than once per week use 2 or more different "main" modes of transportation in a week[7], and the remainder use only one mode (**Figure 2**). A small minority of subjects report taking 3 or more modes - implying some ad-hoc commuting approaches.

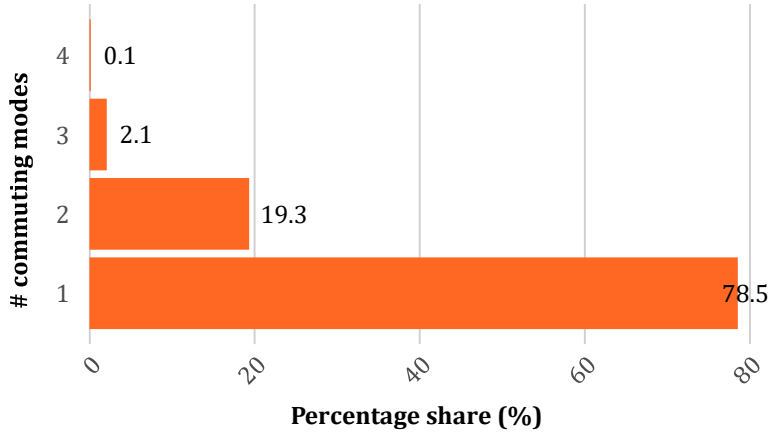

Figure 2. Number of transport modes used for commuting to campus

[6] Employee mode choice is weighted by the percentage of each mode used by each person in a week: e.g., a person who drives 2 days and rides transit 2 days per week is counted as 0.5 for driving alone and 0.5 for taking transit.

[7] This figure corresponds to the "main mode" of transportation - it is not considered using two modes if you link trips, i.e. walking to the train, and taking the train to campus.

While everyday commuting is not the norm, most arrive at peak hours

Everyday commuters are the plurality, not the majority. The most commuting frequencies are five days per week (31.3%), three days per week (24.7%), and four days per week (18.9%). Staff are the most likely to be 3-day commuters (**Figure 3**).

However, a peak hour commute is still the norm. Over 78% of subjects report arriving on campus between 6 AM and 10 AM, and the peak of arrival is between 8 AM to 10 AM when about 62% arrive on campus (**Figure 4**).

Travel trends don't vary by school or unit

Average employee behavior didn't vary much between schools, and school affiliation was not a significant factor in modeling employee commuting choices. Other factors, such as schedule, frequency of commute, and geography, tended to be associated with employee travel choices. It is notable that Perelman School of Medicine employees (the most numerous employee group) are more likely to work on-site every day.

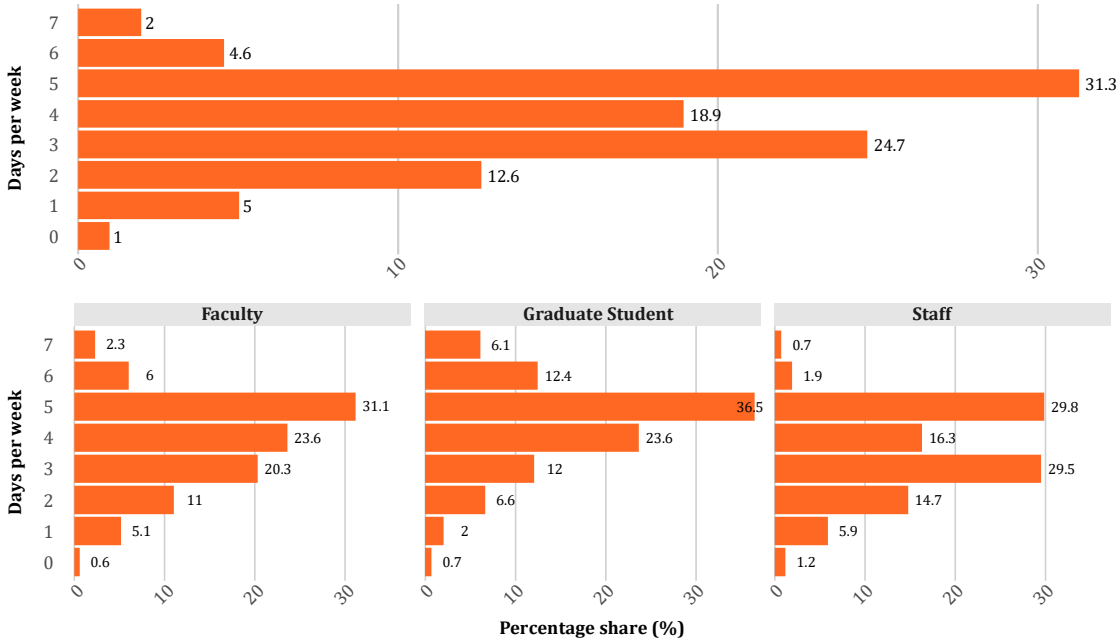

Figure 3. Number of days that people commute to campus per week. Above: all subjects; below: subjects by working status.

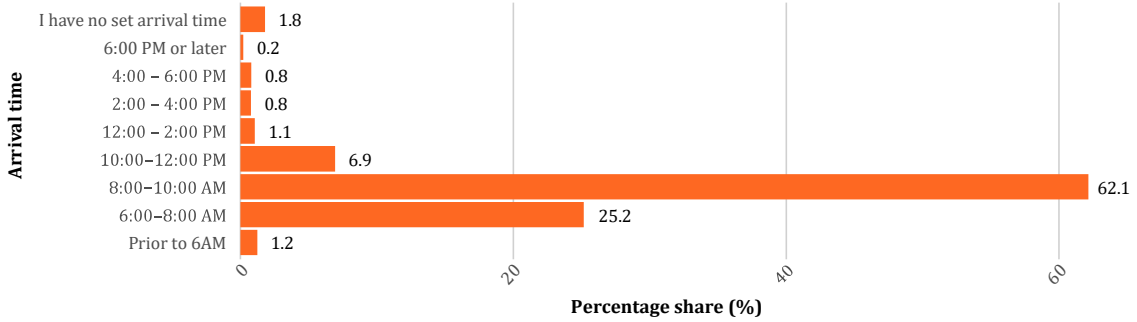

Figure 4. Arrival time during the day.

The geography of commuting at Penn

Survey subjects live throughout the Philadelphia region but are most densely clustered in areas near the University and in the suburban areas of Montgomery and Delaware counties close to the Philadelphia border (**Figure 5**). A small number of subjects report living in other regions - New York, Central Pennsylvania, Washington, D.C., or elsewhere - and visiting campus relatively infrequently.

Access to Penn is uneven. Using subject locations and Google travel itineraries, we analyzed regional access to Penn employee destinations. In some zip codes, average transit times are as much as 5 times longer than drive times. In other places, multiple modes are viable. (**Figure 6**). While some lifestyle and economic factors affect commuter behavior, location is the strongest predictor of mode choice (See Sustainability Implications of Travel Behavior for more - p. 12).

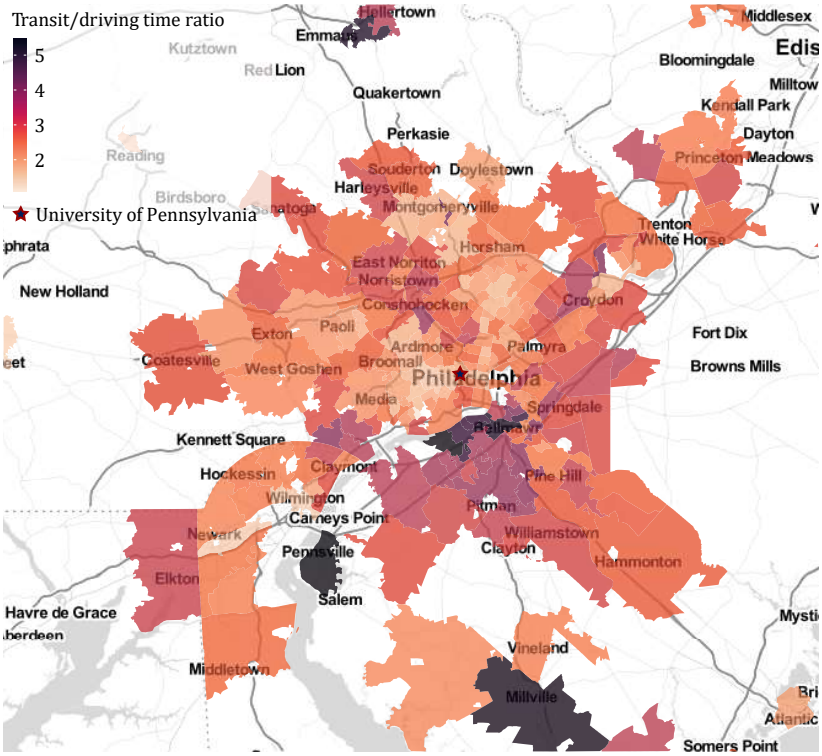

Figure 5. Ratio of average transit time to average drive time for survey subjects - by zip code. A ratio of 5 means that it takes, on average, 5x longer for subjects from that zip code to commute via transit than via car. Data from Google Directions API.

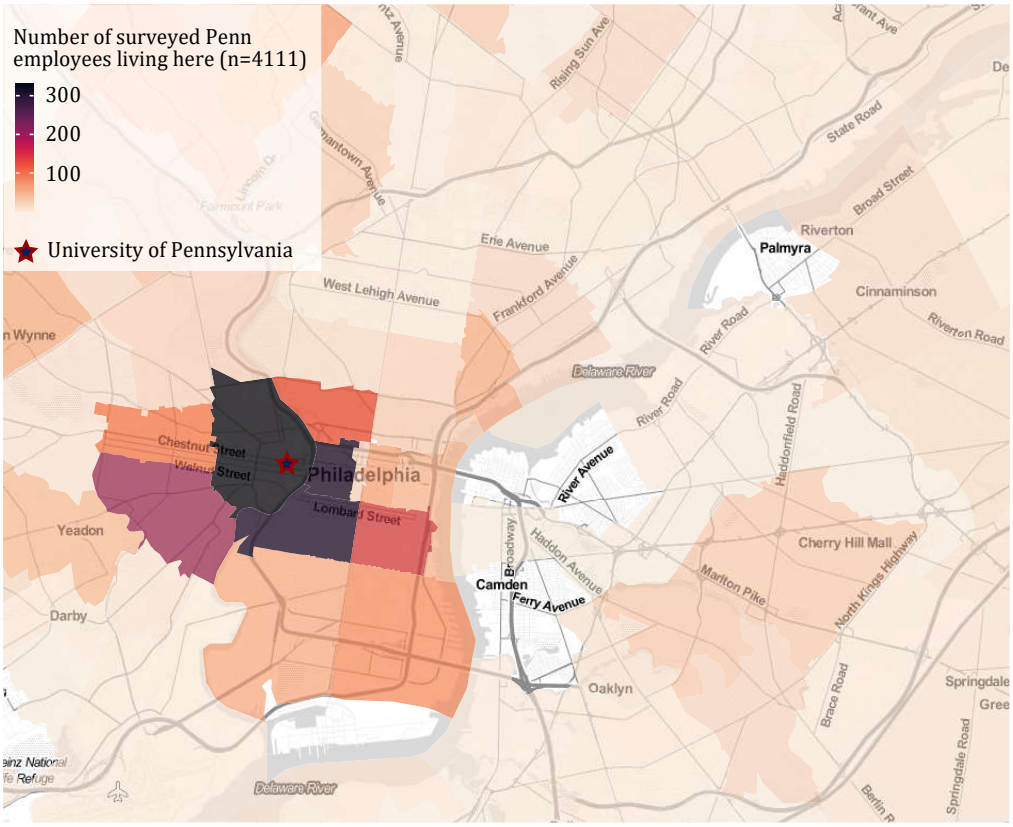

Figure 6. Map of total number of subjects living in each zip code.

There are distinct "types" of Penn employee commuters

We identified five "types" of commuters based on the number of days these employees chose to use the four dominant modes (driving, biking, walking, and transit). This was done with an algorithm that identifies clusters in multi-dimensional data. These types were as follows:

Frequent transit commuter

32.7%

Commutes to campus 3-5 days, uses transit overwhelmingly, and uses other modes periodically.

Infrequent commuter

27.2%

Commutes ***fewer*** than 3 days, uses car and/or transit. Roughly ⅓ of this group use multiple modes per week.

Drive-only commuter

19.6%

Drives to campus 3-5 days, does not use other modes, and has a relatively high transit time relative to drive time.

Frequent walker

13.0%

Commutes to campus 3-5 days, mostly walks but uses other modes as needed.

Biker

7.3%

Commutes to campus 2-5 days, mostly bikes but uses other modes as needed.

More than half participate in commuter benefit programs, but familiarity with programs is low

54.5% of subjects reported using a commuter benefit program. The WageWorks Commuter Card (23.9%) and Monthly Parking Permit (15.3%) were the most commonly used. "Drive-only commuters" were the only user group likely to use the Monthly Parking Permit.

No more than half of the subjects reported familiarity with any one program. The Monthly Parking Permit (49.9%), WageWorks Commuter Card (40.0%), and Bike Reimbursement Program (25.9%) were the most well-known (**Figure 7**).

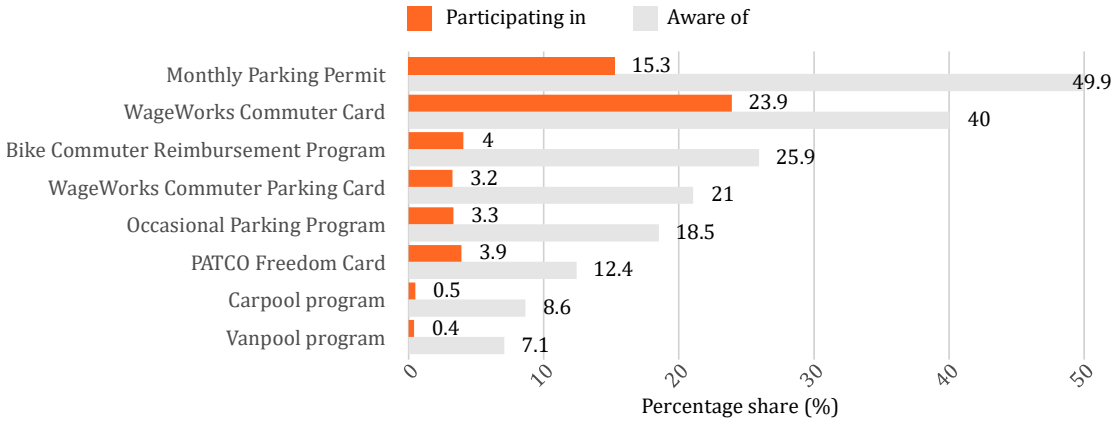

Figure 7. Awareness and participation of Penn Commuting Benefit Programs.

SUSTAINABILITY IMPLICATIONS OF TRAVEL BEHAVIOR

Many employees locate in areas with sustainable commuting options

A significant portion of survey subjects live relatively close to work**.** The top five subject zip codes form a contiguous block around campus (**Table 1**). The top 20 comprise core city areas and nearby suburbs (**Figure 8**). Philadelphia's walkability and expansive transit network means these subjects have good access to work. Half of the subjects have a rush hour transit option of under 40 minutes. A quarter of subjects can walk to campus in under 35 minutes.

Generally, there is a strong preference for sustainable commuting and a willingness to pay for it among the Penn community (through real estate choices). Since nearby zip codes contain some of the more expensive real estate in the city and region, this also implies something about the purchasing power of Penn employees to satisfy their location-commuting preferences.

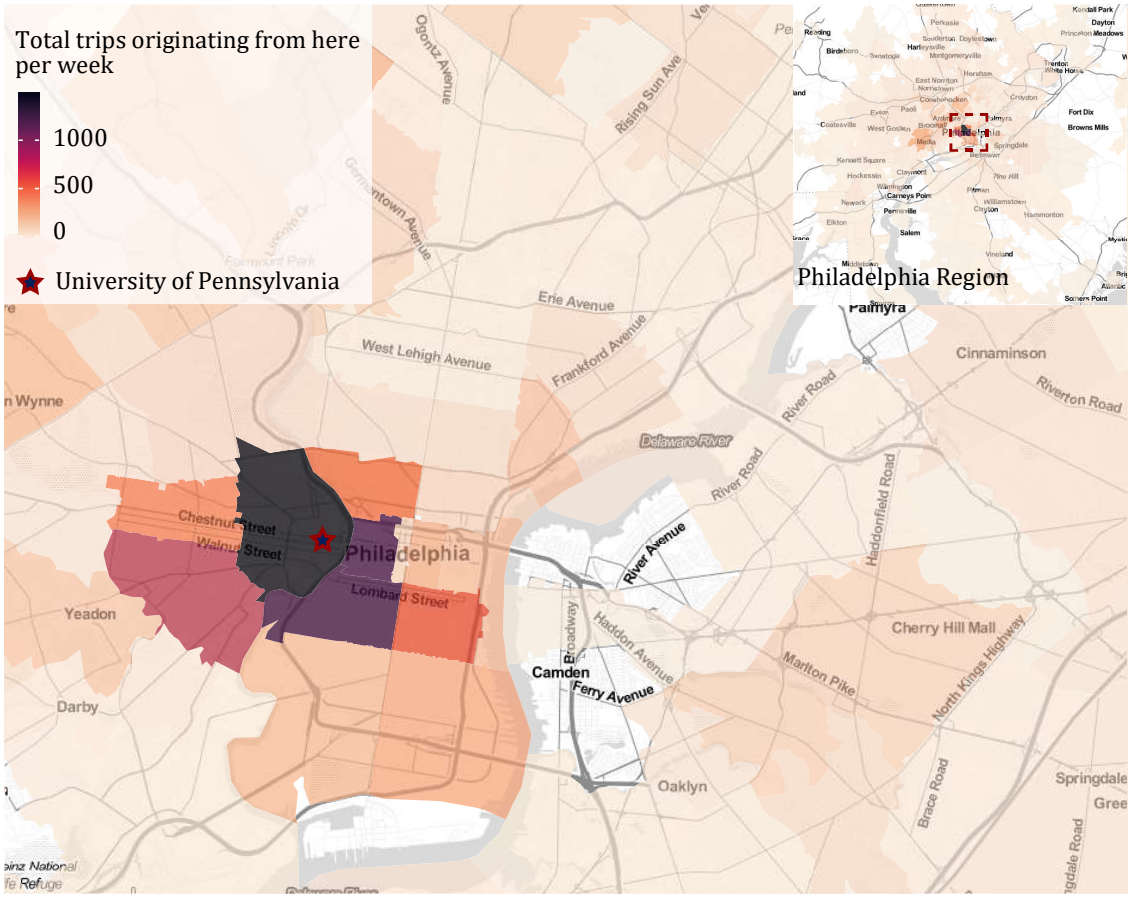

Figure 8. Total trips made by all subjects in each zip code per week.

Some drivers are interested in reducing the impact of their work travel

We consider roughly 6% of the survey sample as strong candidates to shift from regular driving to a more sustainable mode of transportation[10]. These "change candidates" are regular drivers who agree that "It is important to me to reduce the environmental impact of my travel to work" and say they could reasonably access sustainable modes.

Getting these drivers to shift might require addressing the barriers they face to using transit.

Table1. Top 10 zip codes for commuter origin[8]

Zip code Neighborhood	Total employees (% share)	Average commuting days per week	% days driving	% days riding transit	% days walking	% days riding bike	Driving duration (mins)	Transit duration (mins)	Walking duration (mins)	Median household income ($)[9]
19104 University City	331 (8.1%)	4.5	3.3	15.1	50.6	9.7	7.6	14.3	26.5	30,734
19103 Center City West	283 (7.0%)	4.1	1.1	35	40	7.3	8.3	14.6	28.4	83,988
19146 Graduate Hospital/ Point Breeze	278 (6.8%)	4.2	6.4	22.6	33.8	21.3	9.3	21.5	31.8	86,372
19143 Kingsessing	199 (4.8%)	4	7.6	38	20.7	16.8	10.3	17.2	37	38,928
19147 Passyunk Square/ Queen Village/ Bella Vista	156 (3.8%)	3.7	9.6	59.2	7	17.5	14.8	32.1	56.5	93,996
19130 Franklintown/ Market West/ Fairmont	133 (3.2%)	3.6	13	48.1	9.7	20	11.8	27.3	49.6	92,097
19139 West Philadelphia (Haddington)	98 (2.4%)	4.3	11.5	38.3	23.9	8.9	9.3	16.4	33.3	32,531
19148 South Philadelphia	80 (1.9%)	3.3	19.2	50.4	1.1	15.4	15.5	38	73.8	63,497
19063 Media, Delaware County	74 (1.8%)	3.8	40.6	50	1.1	1.4	27.8	60.8	239.9	107,030
19083 Havertown, Delaware County	66 (1.6%)	3.8	42.3	47.2	0	2	25.5	46.9	140.4	108,665

[8] For suburban zip codes such as Media in Delaware County, walking trips are likely input mistakes.

[9] Data source: 2017-21 American Community Survey (ACS) 5-Year Estimates ZCTA Tables.

[10] These subjects represent 30.8% of the 19.4% of subjects who drive 3+ days per week.

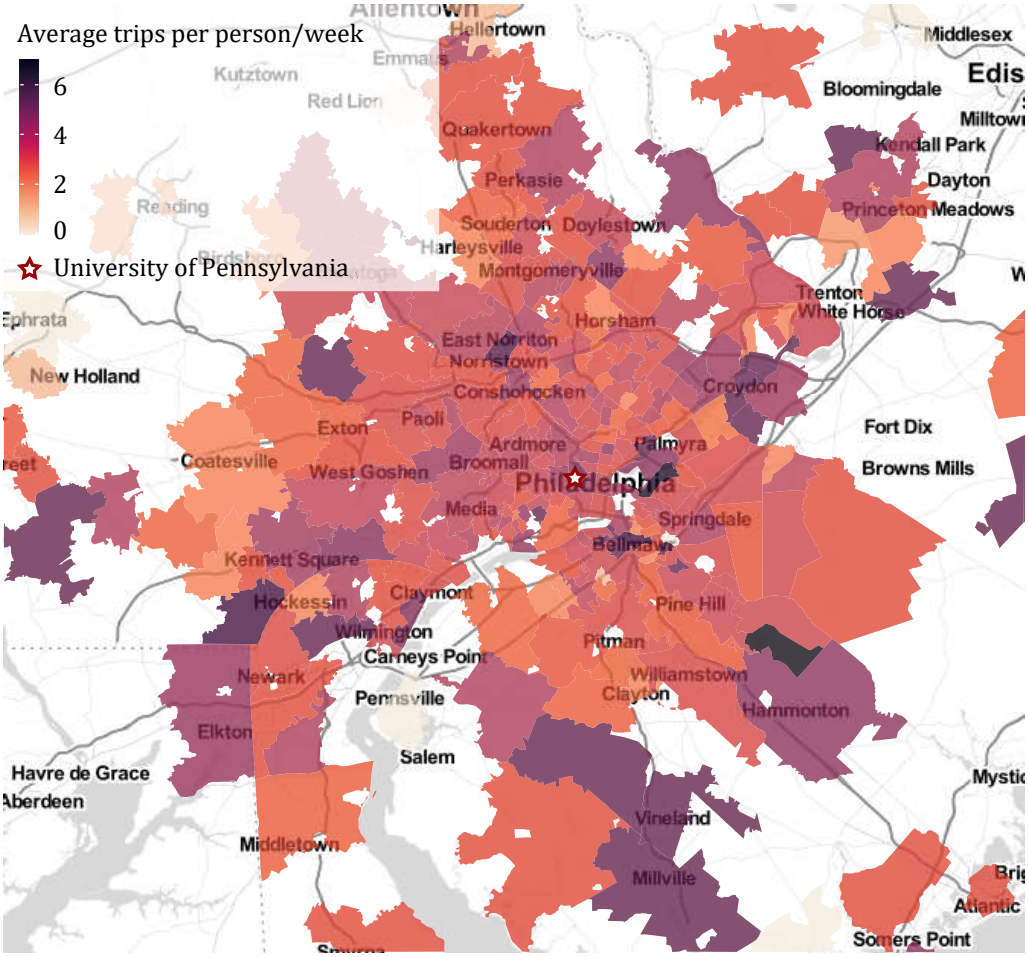

Figure 9. Average trips made by individual subjects in each zip code per week.

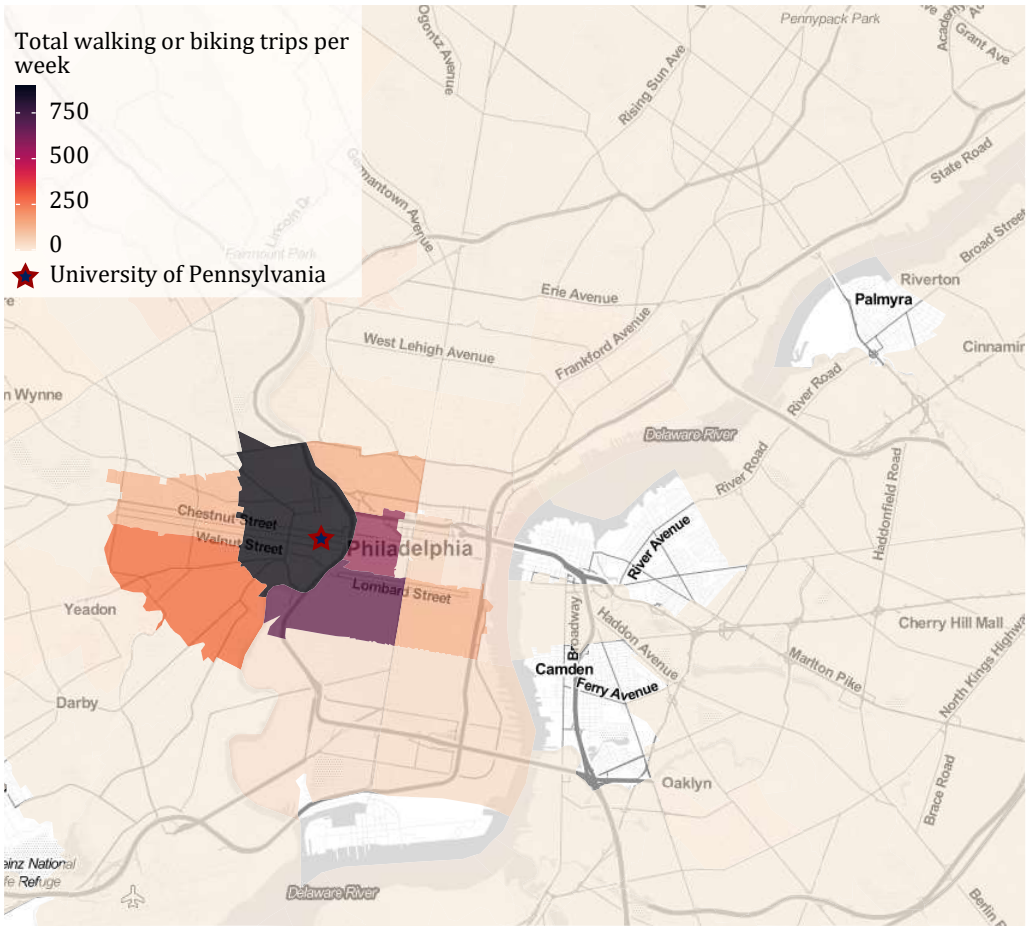

Figure 10. Total walking or biking trips made by all subjects in each zip code per week.

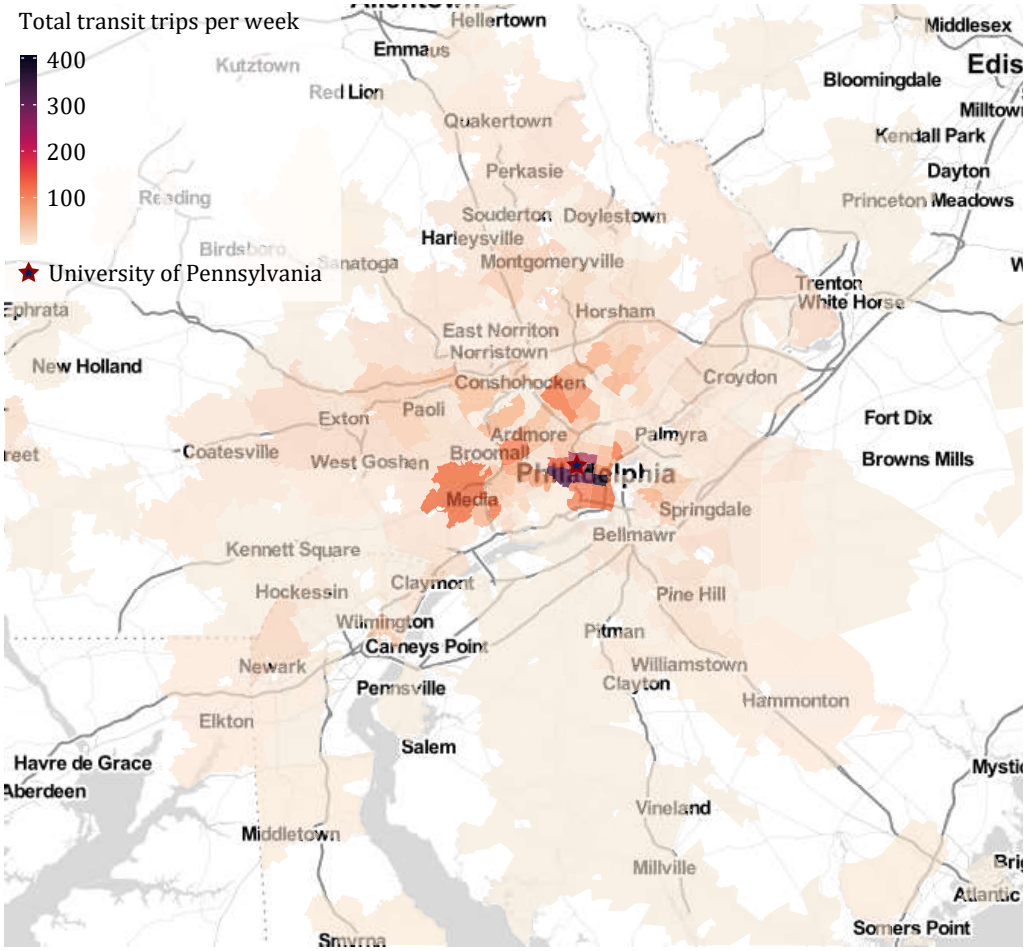

Figure 11. Total public transportation trips made by all subjects in each zip code per week.

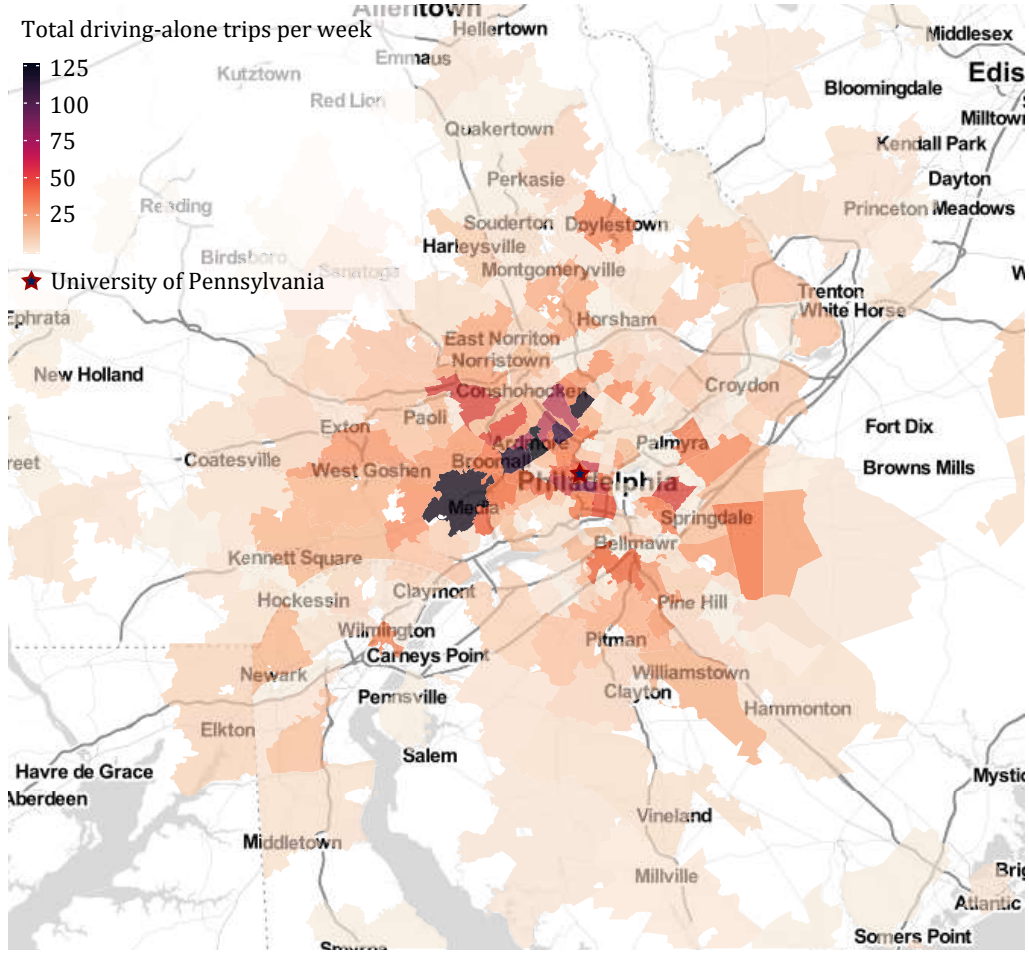

Figure 12. Total driving-alone trips made by all subjects in each zip code per week.

There are important barriers to transit use, many related to the quality of service

Why do some Penn faculty and staff avoid transit?

- **Predictability** - Those with predictable, regular commutes are the most likely to take transit: the converse is that non-daily, non-morning commuting is correlated with not taking public transportation.
- **Compatibility** - 12.6% of those who can but do not take transit say it is "not compatible with my schedule."
- **Availability** - there are "transit deserts" in the region that have high drive-share. These include areas of Gloucester County, NJ, exurban parts of Montgomery County, and some pockets of the western suburbs inaccessible to regional rail.
- **Access** - Some lack a practical transit option, or they have age or mobility concerns that preclude using transit.
- **Safety** - 10.9% of those who could but do not take transit say it "doesn't seem safe." This sentiment is concentrated in areas of Philadelphia, including western zip codes in West Philadelphia.
- **Convenience** - Transit times are too long in some areas. 19.4% of those who could but do not take transit say it "takes too long." The relative utility of transit was also found to predict transit use.
- **Cost** - Cost was not listed as a top deterrent to taking transit (perhaps owing to the price insensitivity of Penn employees, who are, as a group, relatively well compensated).

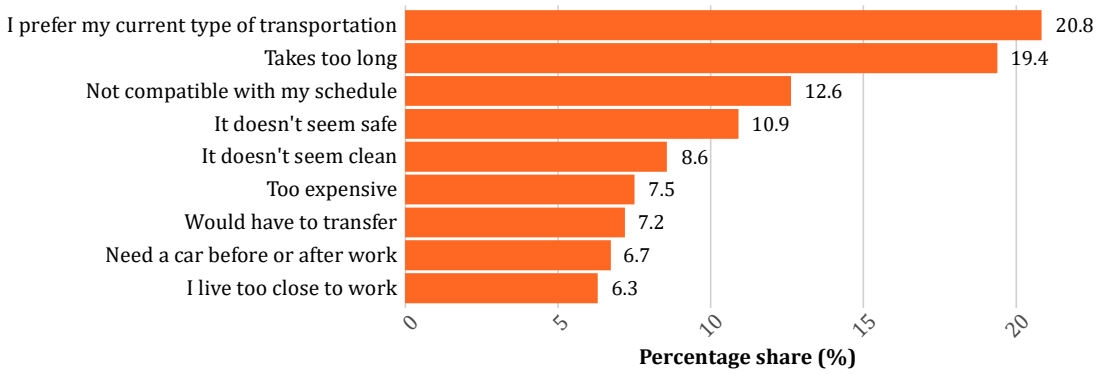

Figure 13. Reasons given for those who could "reasonably" take transit but do not, for not taking transit.

Commuting patterns often don't align with benefit programs

Program participation can drive sustainable choices. Subjects' real program participation in parking or transit programs was strongly associated with their choices in hypothetical scenarios[11]. Several things are depressing the impact of sustainable travel programs.

- Many employees commute too infrequently to have some programs fit their needs.
  - A discounted SEPTA TransPass or TrailPass (40+ trips per month) is not economical unless you use it 5 days per week. Only 11.0% of subjects take public transportation that frequently (**Figure 14**).
- Some benefits are focused on the commuter that makes routine, everyday choices. Over 20% of employees use multiple modes in a week.

- Many don't know about programs that could suit their choices.
  - Of the 17.5% who use transit 3+ days and don't participate in a program, the majority (74.1%) of them have never heard of WageWorks and PATCO Freedom.
  - Of those who reported they could reasonably bike to work, 29.5% reported being unaware of the Bike Commuter program.
- The Bike Commuter Program is geared towards those who bike 50% or more of the time[12]. 59 program participants reported less than 50% usage in the survey week, while 39 non-participants reported biking over 50% of the time.

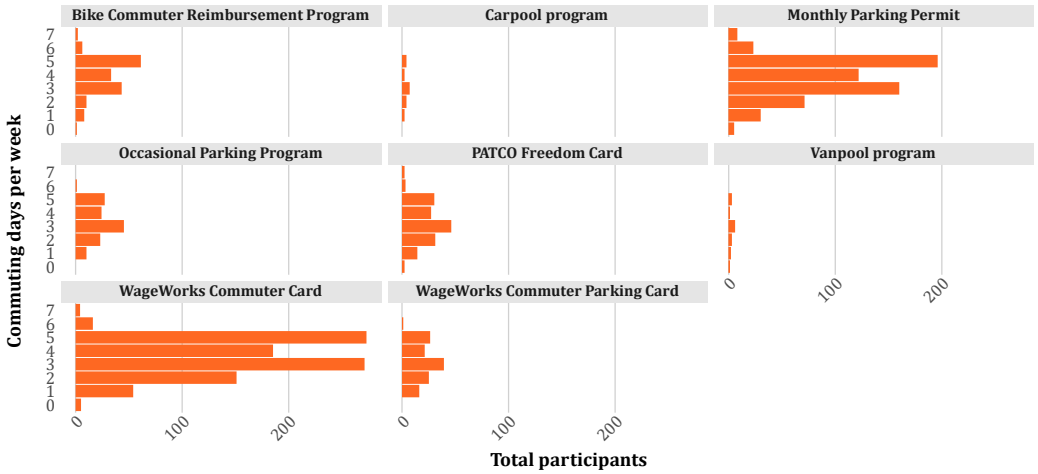

Figure 14. How many days do Penn commuting benefit program participants commute to campus in a week.

Demand for electric vehicles is strong, but adoption is unlikely to change commuting patterns

Right now, 6.3% of survey subjects report owning electric vehicles (EVs). This group makes up roughly 11.1% of the driving days to campus in a given week. An additional 37.9% of subjects, (representing 43.3% of driving days) are considering purchasing an EV. There will likely be an increased need for charging facilities around campus as EVs make up a larger proportion of the vehicle fleet. However, we believe interested buyers' travel behavior seems unlikely to change - The factors that are most strongly associated with travel choices (location, schedule, availability, etc.,) are not likely to be affected by an EV purchase.

Long-distance travel behavior: there is latent demand for sustainable transit

Roughly a quarter (23%) said they travel long-distance for work. We asked about preferences for modes where reasonable alternatives were available. For short trips, like to New York, subjects overwhelmingly favored rail (88%). On longer trips, this percentage favoring rail was predictably lower (i.e., 34% to Boston) and the preference for alternatives like air travel was higher (53% to Boston).

The proportion preferring sustainable transportation is higher than expected – typically once a rail trip is over 3.5 hours, the percentage of possible passengers drops precipitously. This means that Penn employees favor sustainable long distance travel options more than the general population.

[11] Controlling for relative and total driving and transit time, environmental preferences, income, age, having children, frequency of commute, and arrival time.

[12] Reference: https://cms.business-services.upenn.edu/transportation/walking-biking/bike-commuter-reimbursement.html

RECOMMENDATIONS

1 Publicly promote and interpret transit with installations. For instance, posting transit maps and wayfinding information above ground on campus. Dr. Ryerson's wayfinding research, collaborating with numerous transit agencies and airports, finds that branded wayfinding and information develops a sense of place for transit and normalizes the act of taking transit. By branding and providing signage for the current service, we can increase ridership.

2 Share transit information with new hires– transit use is infectious! It's clear that home location and commuting choice are tied together. Therefore, communicating transit options and information to new hires needs to be shared in a coordinated effort. Highlighting the survey data that the Penn community overwhelmingly chooses sustainable commuting options can also help influence choice.

Dr. Megan Ryerson biking in Philadelphia. Photo by Thomas Orgren

3 Consider Penn's role in the parking market. The University dedicates valuable, well-located land to parking structures. The University also subsidizes parking. It's well demonstrated that private parking operators price parking according to demand. They influence commuter behavior by passing the real cost of driving and parking along to consumers[13]. Should the University diminish its role in the parking market? Can on-street parking in the area be better managed? Consider studying how market calibrated prices could affect the elasticity of demand for parking, and support sustainable commuting provided options from public agencies.

Map of public parking facilities at University of Pennsylvania. Source: https://facilities.upenn.edu/

4 Provide expanded options for transit passes, considering an opt-out model rather than an opt-in. It was recently announced that the University will discount transit passes by 50%. This is excellent. We still do think it's important that city dwellers have options for discounted transit passes that support the casual, flexible rider. Currently, even with the 50% discount on the monthly pass, a rider would have to take 20 SEPTA rides a month to break even. A further idea is to make the transit pass program "opt-out," instead of "opt-in."

5 Create flexible options that suit how Penn employees actually travel, e.g., fewer than 40 trips. One of our most significant findings is that the Penn community values options – people don't commute the same way every day, and they don't come in 5 days a week. Therefore, having flexible options for commuter benefits (like daily parking passes that are easy and transparent to purchase; discounted SEPTA passes for casual riders; discounted Indigo bike share and other benefits) need to be explored. A large proportion of the Penn population doesn't participate in commuter benefits because they are flexible commuters.

6 Work with SEPTA and other agencies to provide needed options for Penn Employees. Penn should be advocating for improving sustainable options for employees in transit deserts and improved service (frequency and time-coverage) in key areas. Penn has well established relationships with SEPTA[14] and there is also a history of Penn's advocacy for service changes. This partnership is multifaceted and built on mutual success. If Penn can boost SEPTA ridership, it will help SEPTA solve some issues with service (more demand leads to more frequency) as well as safety "(eyes on the street"). Penn can possibly also make their financial contribution to SEPTA through the guaranteeing of the purchase of a certain number of SEPTA passes per year contingent on improvements (increases in service/cleanliness/etc.).

7 Message campaigns to improve participation in programs, including geographically focused approaches. Communication and information can go a long way in encouraging the Penn community to make more sustainable choices. We can target certain groups of "change candidates" and inform them about options and opportunities. The goal should be to clearly explain a person's options and the relative benefits of each choice.

8 Provide EV rental options for long-distance trips as an alternative to flying, where no train is available. Members of the Penn community need options that are efficient and sustainable for long distance travel. Amtrak is simply not extensive; flying is energy and fuel intensive. Providing EV rental options for long-distance trips could help those who want to choose sustainable options to do so for long distance travel.

9 Study this commuter data set in more detail and consider replicating the survey. The data set created through this survey is incredibly rich and detailed, and elements of it remain unexplored. Students at Weitzman can do this through courses, through studios, and through research experiences. This can be done for minimal cost, and also showcases Penn's commitment to integrating research, education, action, and sustainability. Replicating the survey can be done in a cost-efficient way since an analysis code and survey design are already complete.

[13] Donald Shoup's "The High Cost of Free Parking" (2005, 2011) and other work demonstrates the utility of dynamic pricing in decreasing congestion, generating revenue and ensuring availability.

[14] It should be noted that SEPTA CEO Leslie Richards works alongside the Research Team as a Professor of Practice of City and Regional Planning.

APPENDIX - RESEARCH QUESTIONS

1. Survey introduction questions

The survey starts with a short introduction including the purpose of this survey, a realistic estimate of the time the survey will take, and an anonymity statement. The first questions ask about subjects age and work status at Penn. People who answered under 18 for the age question were directed to the end of the survey.

"We need your help! Take this survey to help inform future University programs and policies for biking, driving, long distance travel and public transit. This survey will take approximately 10 minutes.

This survey is being conducted by PennPraxis on behalf of University of Pennsylvania Facilities and Real Estate Services. The information in this study will be used only for research purposes and in ways that will not reveal who you are."

#	Question	Type	Answers
Q1	What is your age? *End of survey if "Under 18" is selected*	Single-choice	Under 18 18-24 25-34 35-44 45-54 55-64 65+
Q2	Which of the following best describes your primary affiliation at the University of Pennsylvania?	Single-choice	Faculty Post-Doc Staff Graduate Student Undergraduate Student Contractor None of the above

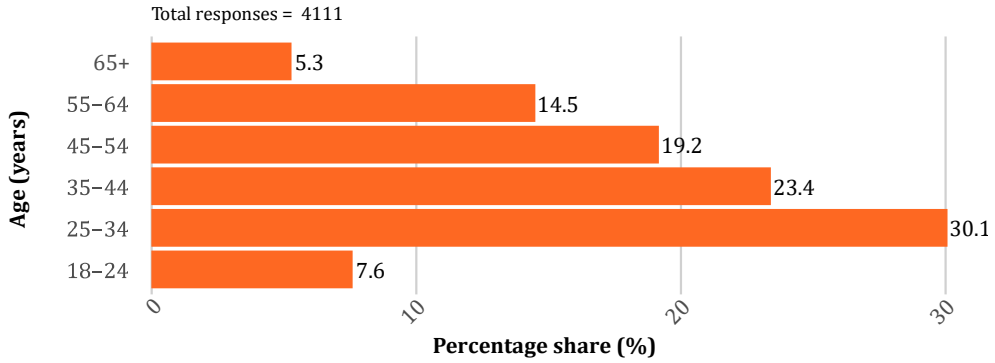

Figure A1. Survey subjects' age distribution.

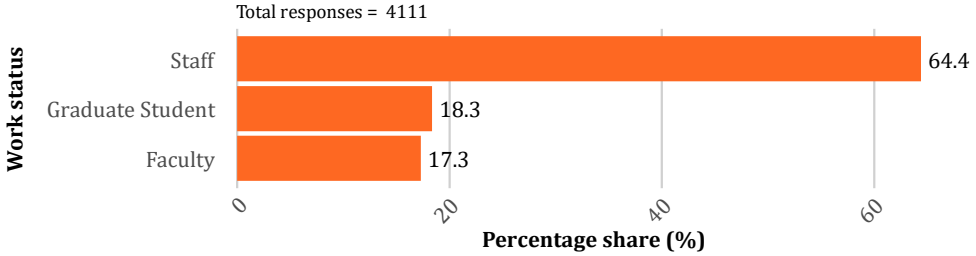

Figure A2. Survey subjects' work status distribution.

2. Demographic questions

This section focuses on survey subjects' demographics, including gender, race/ethinicity, living status with children or adult dependents, income, and school/division.

#	Question	Type	Answers
Q3	How would you identify your gender?	Single-choice	Woman Man Non-binary Transgender Another Gender Identity Not Listed (fill)
Q4	How would you describe your racial or ethnic background (choose as many as apply)	Multi-choice	White Black or African-American Hispanic or Latinx Asian American Indian or Alaska Native Native Hawaiian or Pacific Islander Prefer not to answer User specified [text entry]
Q5	What was your household income in 2021?	Single-choice	Less than $20,000 $20,000-39,999 $40,000-59,999 $60,000-79,999 $80,000-99,999 $100,000-119,999 $120,000-139,999 $140,000-149,999 $150,000 or more

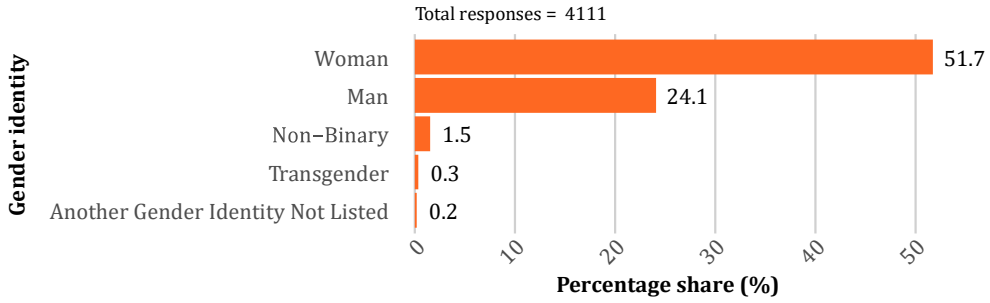

Figure A3. Survey subjects' gender distribution.

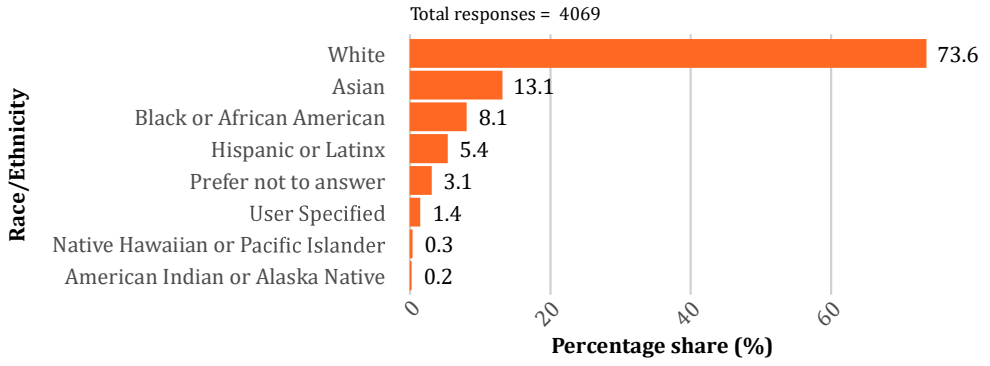

Figure A4. Survey subjects' race/ethinicity distribution.

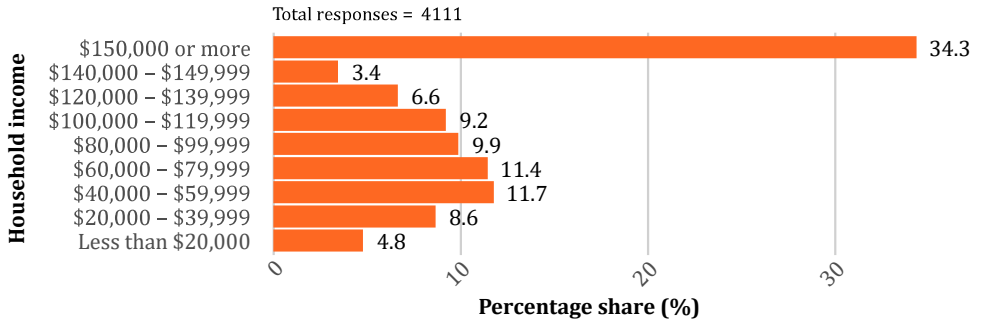

Figure A5. Survey subjects' income distribution.

#	Question	Type	Answers
Q6	Do you have children under the age of 18 or adult dependents living in your household?	Single-choice	Yes No
Q7	Which of the following best describes your primary affiliation at the University of Pennsylvania?	Single-choice	Weitzman School of Design The Wharton School School of Arts and Sciences School of Engineering and Applied Science Division of Facilities and Real Estate Services Housing & Dining Services School of Social Policy and Practice School of Nursing Division of Business Services Athletics & Recreation Annenberg School for Communication School of Dental Medicine Graduate School of Education Penn Carey Law Perelman School of Medicine School of Veterinary Medicine Division of Public Safety Division of Finance Division of Human Resources Information Systems and Computing Institute of Contemporary Art Penn Libraries Penn Museum Office of the President Office of the Executive Vice President Provost Center Vice Provost for University Life Morris Arboretum Annenberg Center for Performing Arts Other (fill)

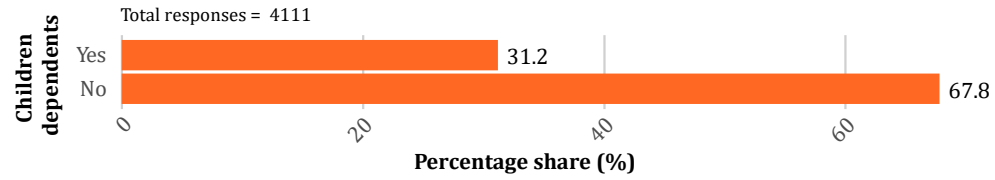

Figure A6. Survey subjects' distribution of living status with chilfren or adult dependents.

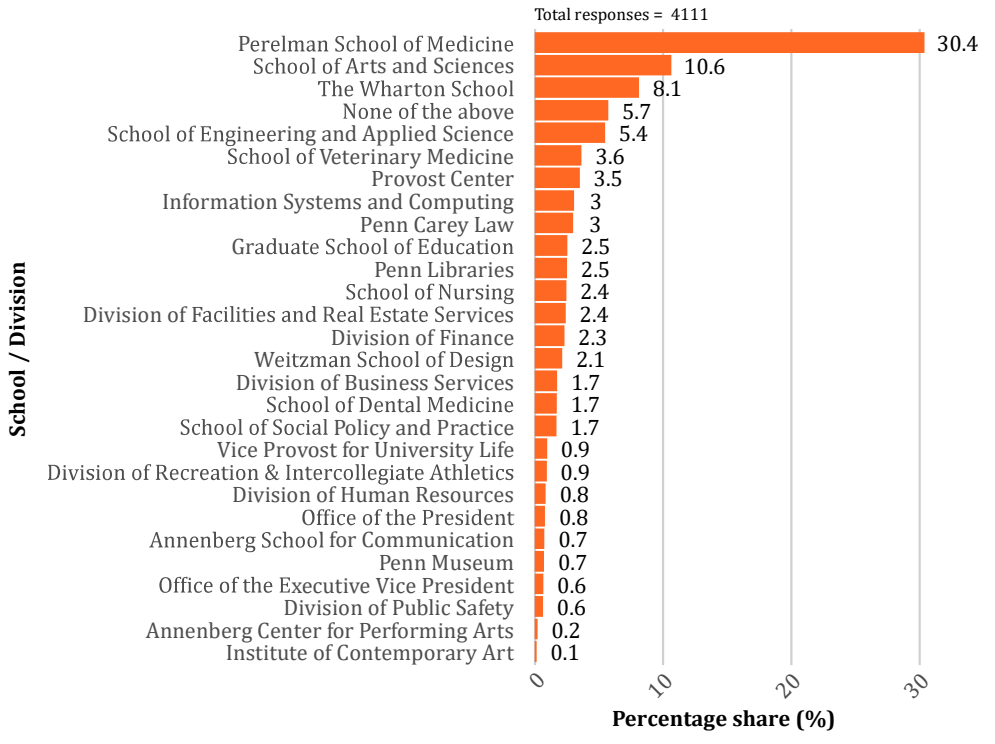

Figure A7. Survey subjects' school/ division distribution.

3. Commuter behavior questions

This section is centered around subjects' basic commuting behaviors - including arrival time, days per week, and modes - their awareness of Penn Commuter Benefit programs, reasons for not using certain modes, and preferences over different modes in designed scenarios.

#	Question	Type	Answers
Q8	Please enter the approximate origin (home) and destination (work) locations of your current commute. You can type in addresses or drag the map markers. If you commute to multiple locations, input your most common destination for this question.	Geolocation	Pin via a web map
Q9	In the last week, how many days did you commute to campus?	Slider	Slider 0-7

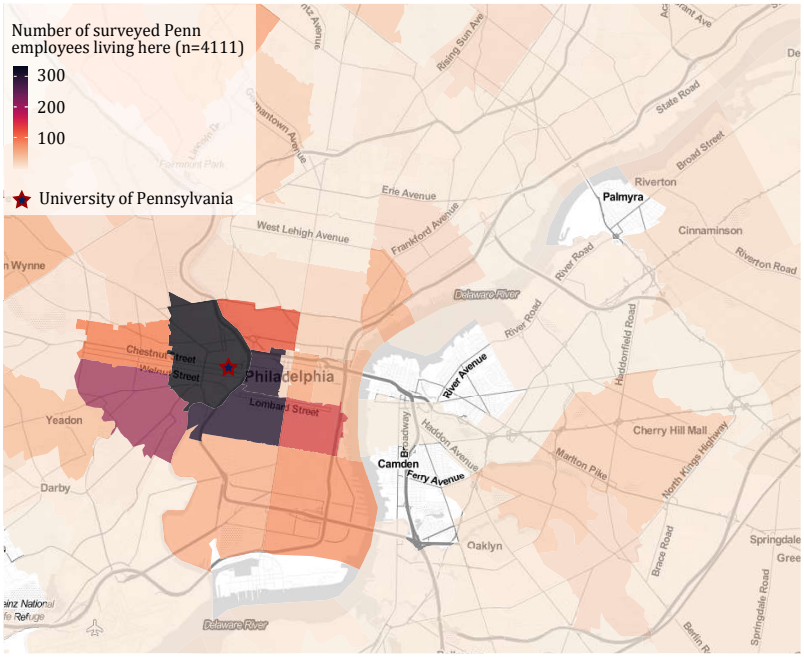

Figure A8. Map of total number of subjects living in each zip code.

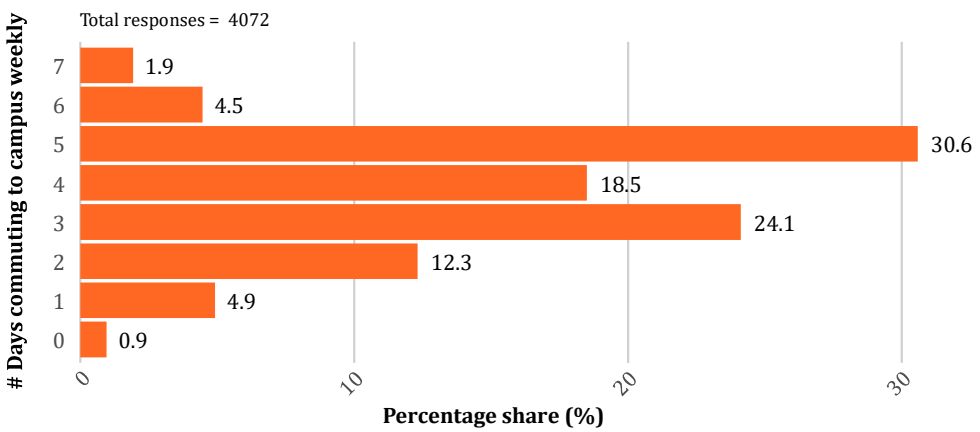

Figure A9. Survey subjects' weekly commuting days distribution.

#	Question	Type	Answers
Q10	In the last week, how many days do you use each of the following types of transportation to commute to campus?	Sliders	Drive alone Public transit Walking Bicycle (Including Indego Bike Share) Carpool (driver) Carpool (rider) Vanpool Penn Transit Ride share (e.g. Uber, Lyft) Other mobility device (hoverboard, scooter)

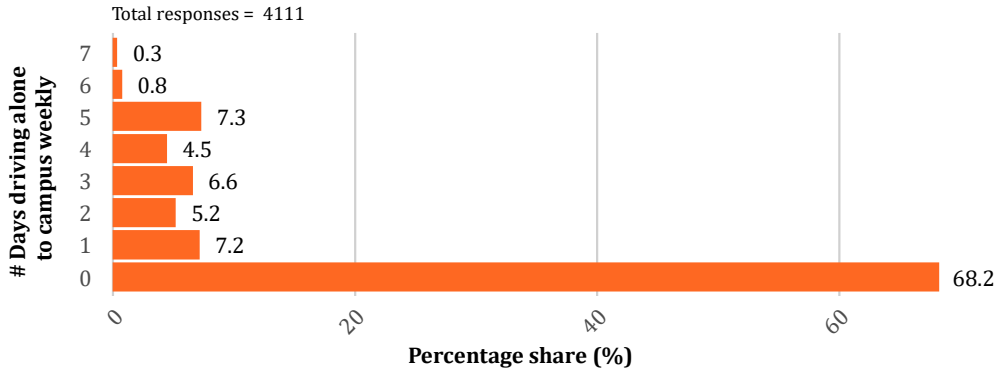

Figure A10.1. Distribution of survey subjects' # days driving alone to campus in a week.

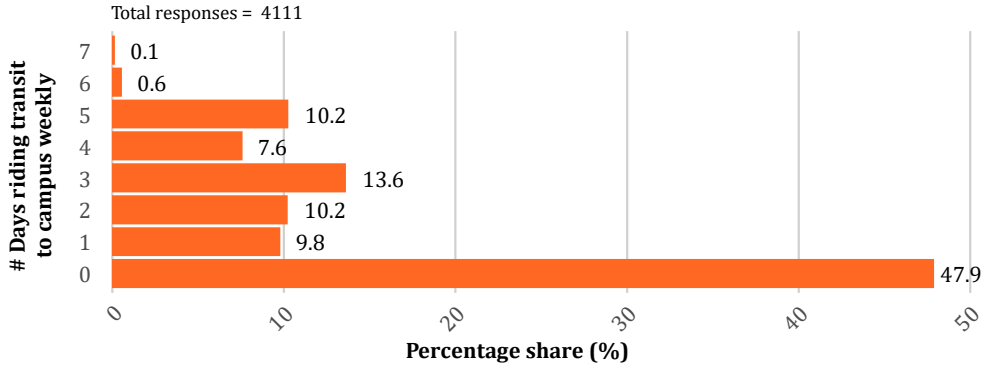

Figure A10.2. Distribution of survey subjects' # days riding transit to campus in a week.

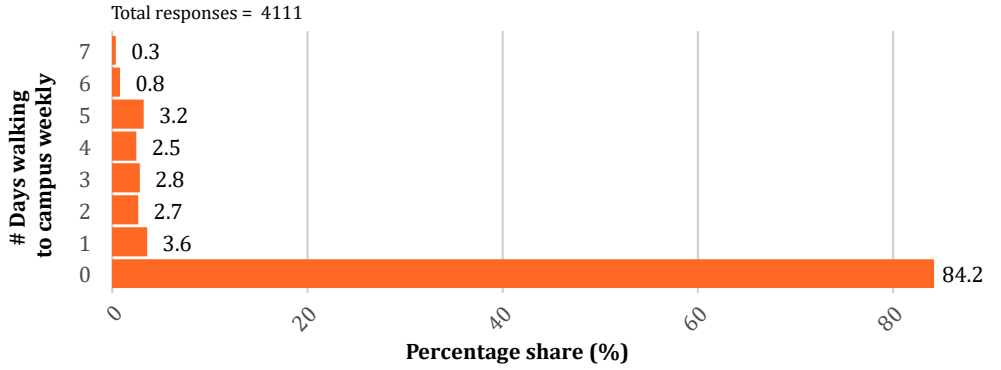

Figure A10.3. Distribution of survey subjects' # days walking to campus in a week.

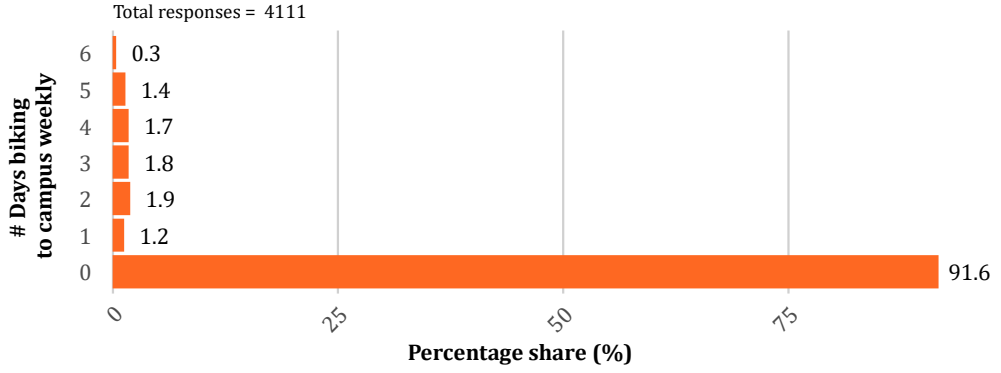

Figure A10.4. Distribution of survey subjects' # days biking to campus in a week.

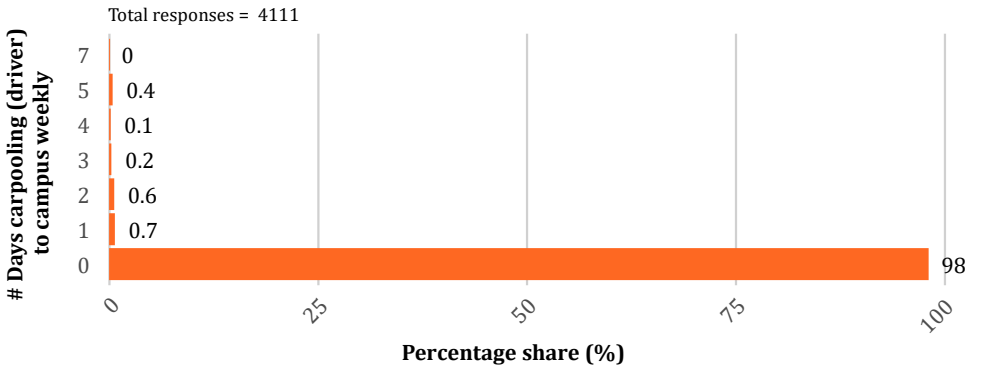

Figure A10.5. Distribution of survey subjects' # days carpooling (as driver) to campus in a week.

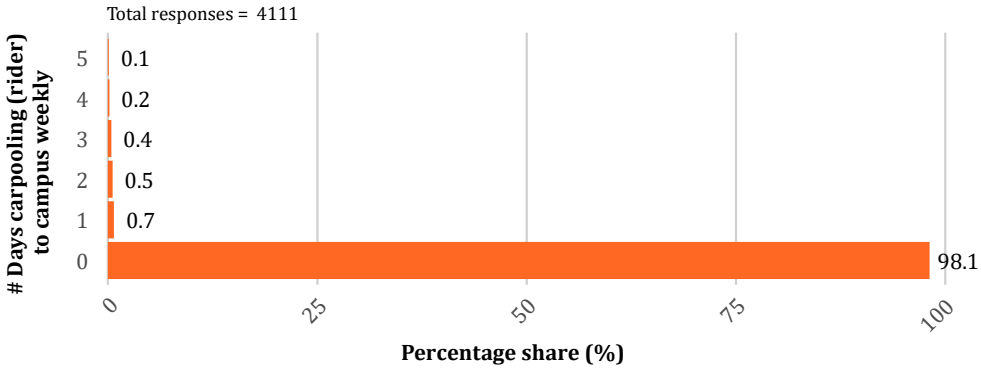

Figure A10.6. Distribution of survey subjects' # days carpooling (as rider) to campus in a week.

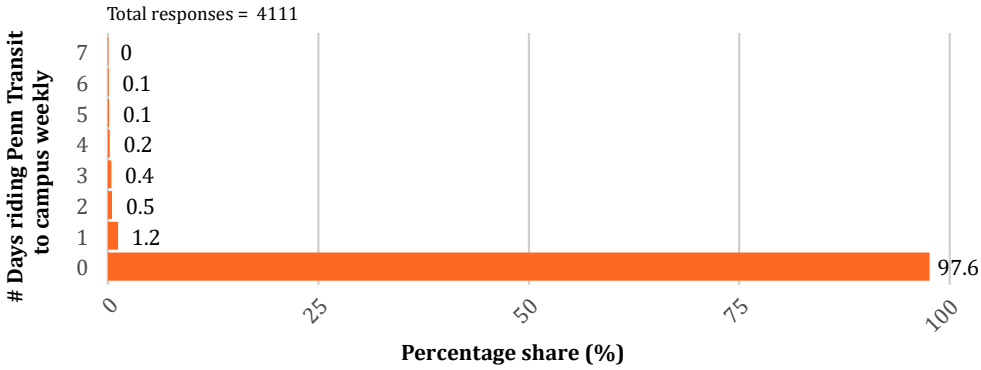

Figure A10.7. Distribution of survey subjects' # days riding Penn Transit to campus in a week.

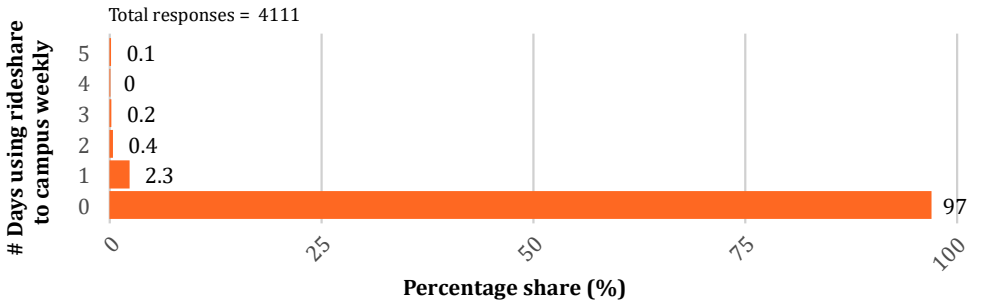

Figure A10.8. Distribution of survey subjects' # days using rideshare to campus in a week.

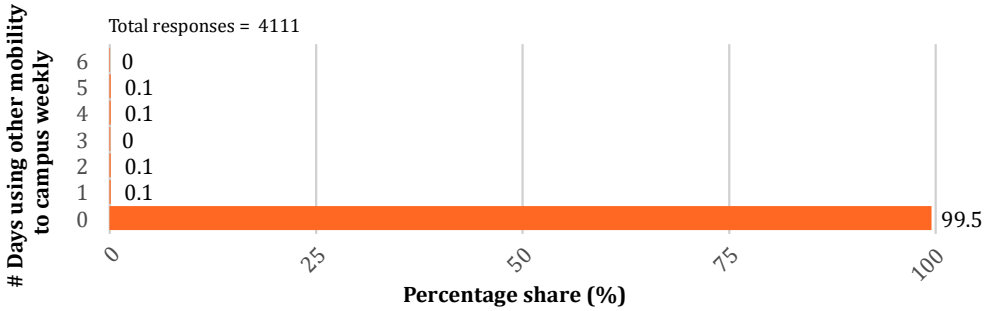

Figure A10.9. Distribution of survey subjects' # days using other mobility to campus in a week.

#	Question	Type	Answers
Q11	On a typical workday, what time do you aim to arrive on campus?	Single-choice	Prior to 6AM 6-7:59am 8-9:59am 10-11:59am 12-1:59pm 2-3:59pm 4-5:59pm 6pm or later I have no set arrival time
Q12	In the last week, how many total hours did you work on campus?	Single-choice	0-10 hours 11-20 hours 21-30 hours 31-40 hours More than 40 hours
Q13	Penn offers a range of commuting programs. Have you heard of any of the following programs? Please select the ones you've heard of. *Only displayed if "Faculty", "Staff", "Contractor", or "Post-Doc" is selected in Q2*	Multiple-choice	Occasional parking program WageWorks Commuter Parking Card WageWorks Commuter Card PATCO Freedom Pass Bike Commuter Reimbursement Program Monthly Parking Permit Vanpool Program Carpool Program

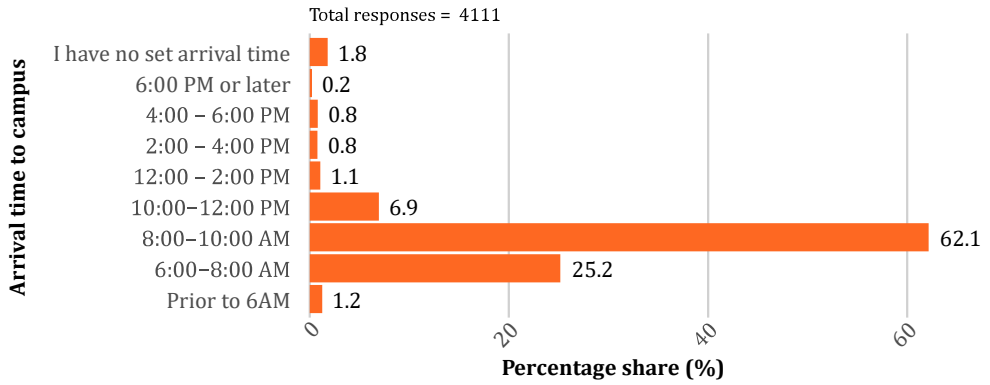

Figure A11. Distribution of survey subjects' arrival time on a typical workday.

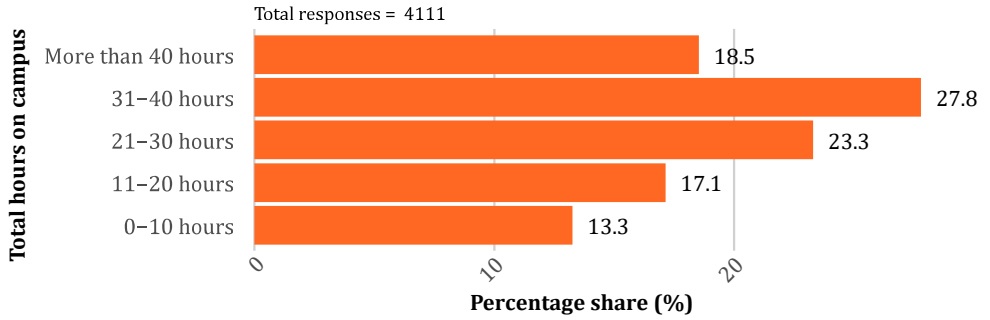

Figure A12. Distribution of survey subjects' total working hours on campus in a week.

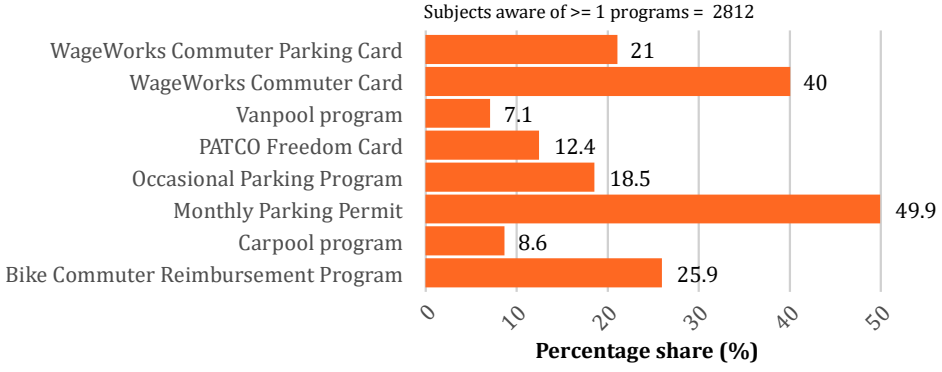

Figure A13. Distribution of survey subjects' awareness of Penn commuter benefit programs.

#	Question	Type	Answers
Q14	You indicated you'd heard of the following programs. Please select any programs you've participated in. *Items carry over based on selections for Q13*	Multiple-choice	Occasional parking program WageWorks Commuter Parking Card WageWorks Commuter Card PATCO Freedom Pass Bike Commuter Reimbursement Program Monthly Parking Permit Vanpool Program Carpool Program
Q15	Which of these types of transportation could you reasonably use to get to work? (Choose all that apply)	Multiple-choice	Personal car Carpool Rideshare or taxi Public transit Bike Walk Vanpool Other mobility device (Scooter, Hoverboard, etc.)
Q16	What reasons kept you from using a bicycle for your trips to work last week? (Choose all that apply) *Only displayed if "Bike" is selected in Q15 and 0 day is selected for "Bicycle" in Q10*	Multiple-choice (up to 3)	I don't own a bicycle I believe it's unsafe Accessibility issues Takes too long Weather I can't park my bike I can't carry my work materials I have to bring a change of clothes I prefer my current type of transportation

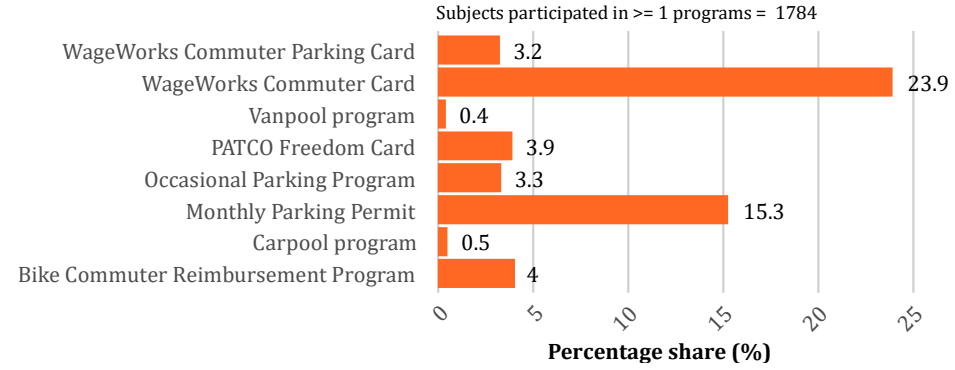

Figure A14. Distribution of survey subjects' participation of Penn commuter benefit programs.

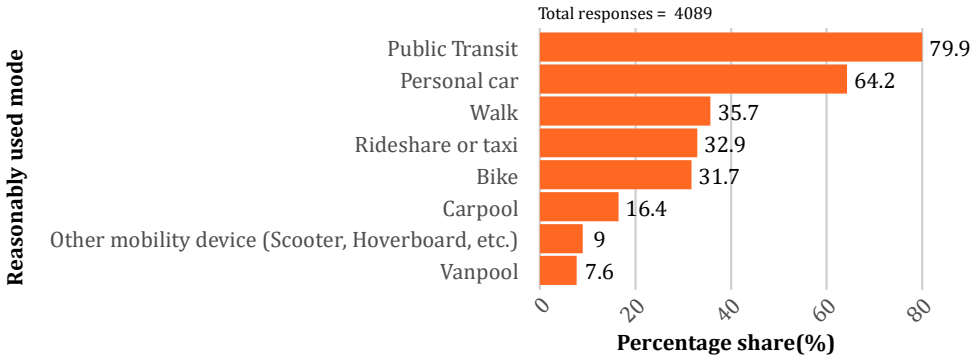

Figure A15. Distribution of transportation modes that survey subjects can reasonably use for commuting.

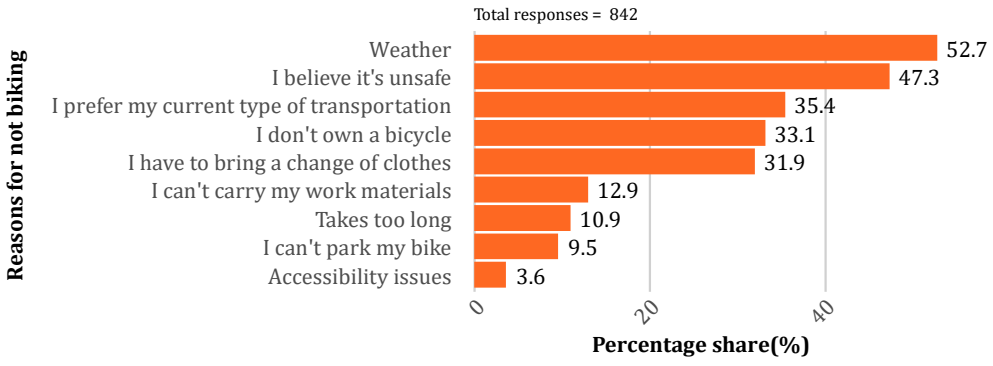

Figure A16. Distribution of reasons kept survey subjects from biking to work.

#	Question	Type	Answers
Q17	What reasons kept you from walking for your trips to work last week? (Choose all that apply) *Only displayed if "Walk" is selected in Q15 and 0 day is selected for "Walking" in Q10*	Multiple-choice (up to 3)	It doesn't seem safe Accessibility issues Takes too long Weather I can't carry my work materials I prefer my current type of transportation
Q18	What reasons kept you from carpooling for your trips to work last week? (Choose all that apply) *Only displayed if "Personal car" is selected in Q15 and 0 day is selected for "Carpool (driver or rider)" in Q10*	Multiple-choice (up to 3)	Not compatible with my schedule Too expensive Takes too long Need a car before or after work Need a car before or after work Don't know how to find a carpool partner I live too close to work I prefer my current type of transportation
Q19	What reasons kept you from vanpooling for your trips to work last week? (Choose all that apply) *Only displayed if "Vanpool" is selected in Q15 and 0 day is selected for "Vanpooling" in Q10*	Multiple-choice (up to 3)	Not compatible with my schedule Too expensive Takes too long Need a car before or after work I live too close to work I prefer my current type of transportation
Q20	What reasons kept you from using public transit for your trips to work last week? (Choose all that apply) *Only displayed if "Public transit" is selected in Q15 and 0 day is selected for "Public transit" in Q10*	Multiple-choice (up to 3)	Not compatible with my schedule Too expensive Takes too long Need a car before or after work Would have to transfer I live too close to work I prefer my current type of transportation It doesn't seem clean It doesn't seem safe

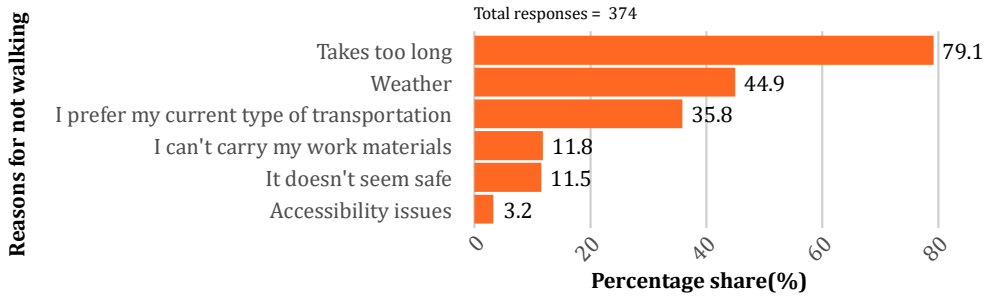

Figure A17. Distribution of reasons kept survey subjects from walking to work.

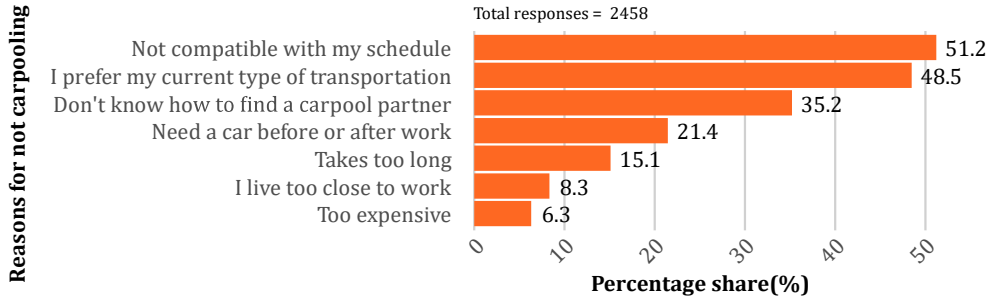

Figure A18. Distribution of reasons kept survey subjects from carpooling to work.

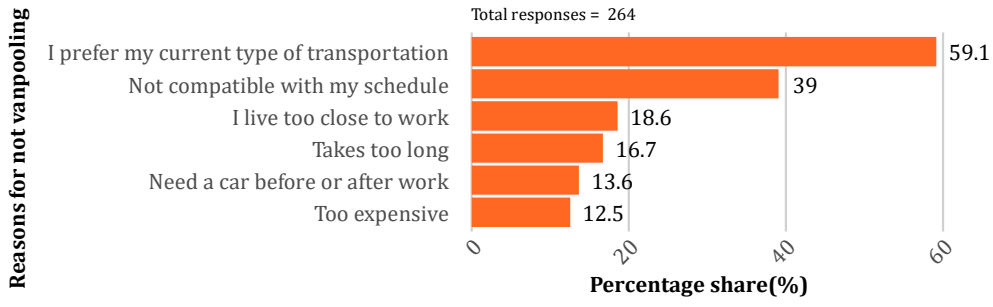

Figure A19. Distribution of reasons kept survey subjects from vanpooling to work.

#	Question	Type	Answers
Q21	Imagine that you are commuting to campus five days per week to do your job. You are planning your transportation for the month. Which of these options would you prefer? *Only displayed if "Walk" and "Personal car" are selected in Q15, or "Bike" and "Personal car" are selected in Q15 and >=1 day is selected for "Drive alone" in Q10*	Single-choice	Option 1: Drive alone to work every day. Pay $210 monthly cost via payroll pre-tax exemption for parking. Option 2: Walk or bike more than three days per week. Drive or take transit as needed. Parking costs $17 per day.
Q22	Imagine that you are commuting to campus five days per week. You are planning your transportation for the month. Which of these options would you prefer? *Only displayed if >=1 day is selected for "Drive alone" in Q10 and "Personal car" is selected in Q15*	Single-choice	Option 1: Drive alone to work every day. Pay $210 monthly cost via payroll pre-tax deduction for parking. Option 2: Carpool to work every day with one other person. Pay approximately $80 monthly cost via payroll pre-tax exemption for parking.
Q23	Imagine that you are commuting to campus five days per week. You are planning your transportation for the month. Which of these options would you prefer? *Only displayed if "Personal car" and "Public transit" are selected in Q15*	Single-choice	Option 1: Drive alone to work every day. Pay $210 monthly cost via payroll pre-tax deduction for parking. Option 2: Drive alone three days a week Take public transit two days a week Pay $210 for monthly parking. Pay for transit fare. Both together are eligible for upto $280 monthly payroll pre-tax exemption.

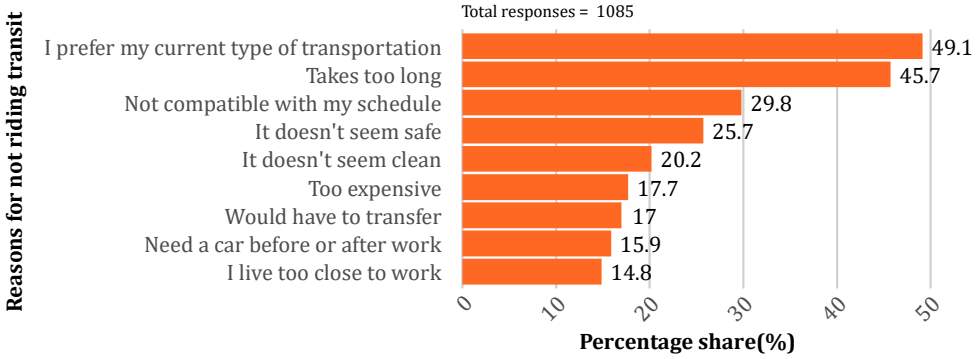

Figure A20. Distribution of reasons kept survey subjects from riding transit to work.

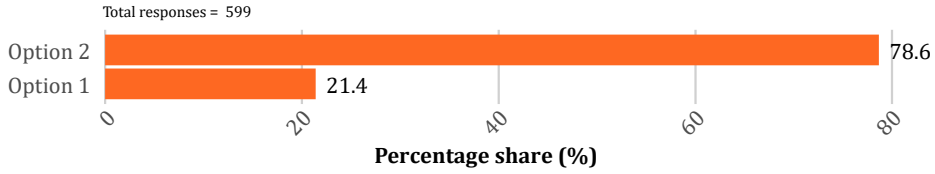

Figure A21. Distribution of survey subjects' options in scenario of driving vs. walking/ biking.

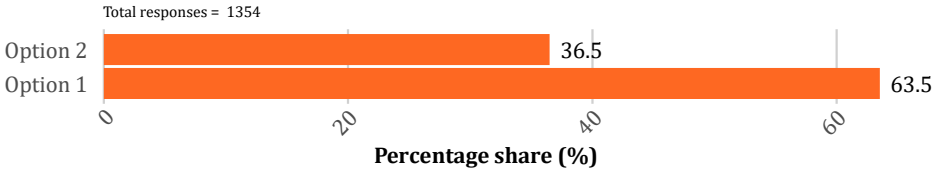

Figure A22. Distribution of survey subjects' options in scenario of driving vs. carpooling.

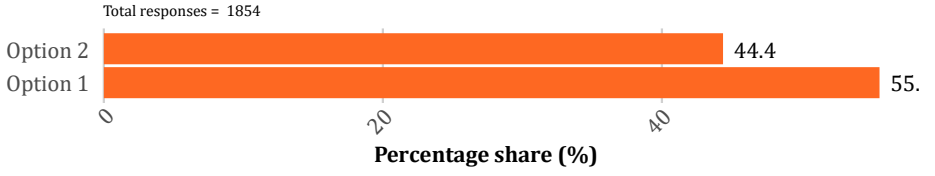

Figure A23. Distribution of survey subjects' options in scenario of driving vs. riding transit.

#	Question	Type	Answers
Q24	Imagine that you are commuting to campus five days per week. You are planning your transportation for the month. Which of these options would you prefer? *Only displayed if >=1 day is selected for "Bicycle" in Q10 and "Public transit" is selected in Q15, or >=1 day is selected for "Walking" in Q10*	Single-choice	Option 1: Take public transit three days per week. Walk or bike two days per week. Pay for monthly transit fare up to $280 via payroll pre-tax deduction. Option 2: Walk or bike three days per week. Take public transit two days per week. Pay for transit fare. Receive $20/ month in bicycle expenses.

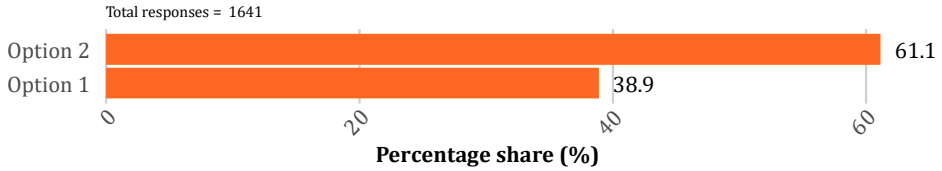

Figure A23. Distribution of survey subjects' options in scenario of riding transit vs. walking/biking.

4. Environmental awareness questions

This section aims to understand Penn commuters' awareness of their travel's environmental impacts and their attitudes towards travel behavior changes that improve sustainability.

#	Question	Type	Answers
Q25	To what degree do you agree with the following statement: "It is important to me to reduce the environmental impact of my travel to work." (Environmental impact Q1)	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
Q26	To what degree do you agree with the following statement: "I think it's worth some personal inconvenience to reduce the environmental impact of my travel to work." (Environmental impact Q2)	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

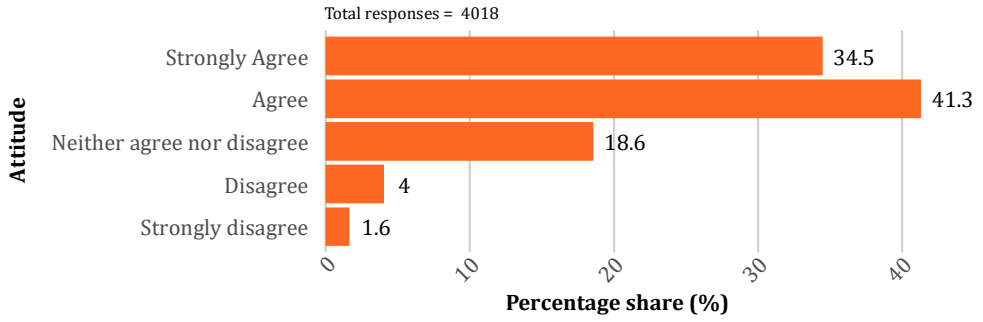

Figure A25. Distribution of survey subjects' attitude towards environmental impact Q1.

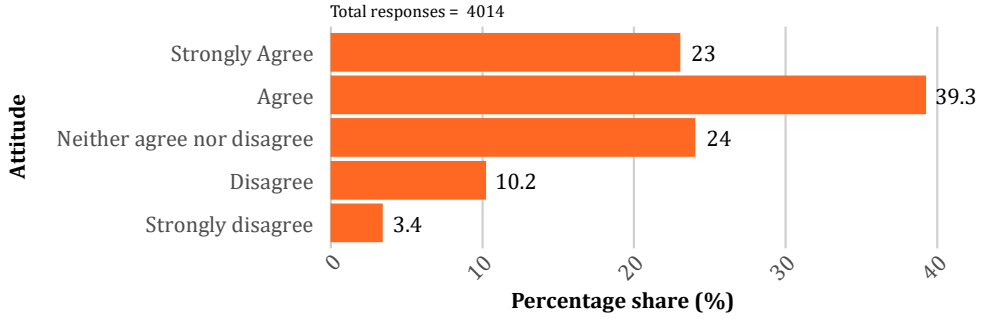

Figure A26. Distribution of survey subjects' attitude towards environmental impact Q2.

5. Electric vehicles questions

This section aims to understand the status of Penn commuters' electric vehicles (EVs) use and demand for EV charging stations.

#	Question	Type	Answers
Q27	Do you own, or are you considering buying an electric vehicle?	Single-choice	Own Considering buying Not considering an electric vehicle
Q28	Are there enough electric vehicle charging stations near your workplace? *Only displayed if "Own" or "Considering buying" is selected in Q27*	Single-choice	Yes No Not sure

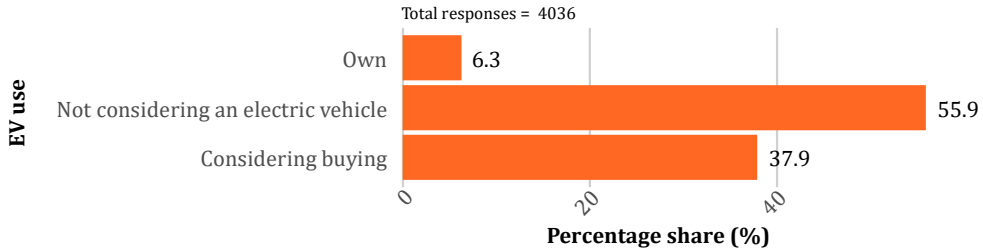

Figure A27. Survey subjects' current EV usage distribution.

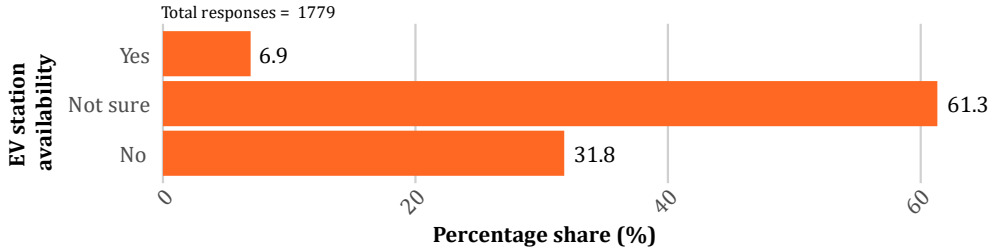

Figure A28. Distribution of survey subjects' access to EV charging station at work place.

6. Long-distance travel questions

This section focuses on Penn commuters' behaviors related to long-distance work travel. The questions are designed to understand commuters' preferences over tranasportation modes at different travel distances.

#	Question	Type	Answers
Q29	Do you travel out of town for work?	Single-choice	Yes No

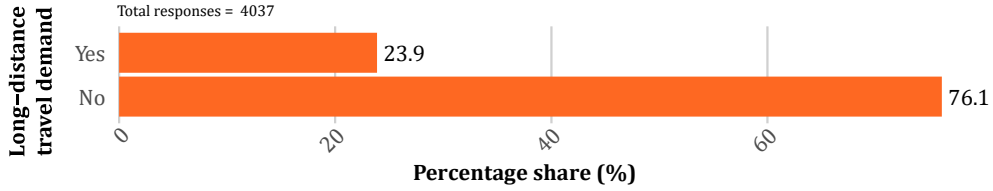

Figure A29. Distribution of survey subjects' demand for long-distance work travel.

#	Question	Type	Answers
Q30	In the current academic year, how many trips of the following types do you anticipate taking for work? • Type 1: Between 100-249 miles [ex. Washington, DC] • Type 2: 250-374 miles [ex. Pittsburgh] • Type 3: 375-499 miles [ex. Columbus, OH] • Type 4: More than 500 miles [ex. Houston, TX] *Only displayed if "Yes" is selected in Q29*	Single-choice (4 sub-questions)	0 trips 1-2 trips 3-4 trips 5 or more trips
Q31	We are going to ask you to imagine yourself in a scenario where you have to choose a travel itenerary. You are taking a work trip overnight to New York City. You are travelling alone, and beginning from your home. Which of these travel itineraries would you most prefer? *Only displayed if "Yes" is selected in Q29*	Multiple-choice	1. Take a taxi or use rideshare to get to PHL, fly to LaGuardia 2. Take SEPTA to PHL, fly to LaGuardia 3. Drive to PHL, fly to LaGuardia 4. Take a taxi or use rideshare to get to 30th St. Station, take Amtrak to New York Penn Station 5. Take SEPTA to 30th St. Station, take Amtrak to New York Penn Station 6. Take SEPTA to 30th St. Station, take Megabus to midtown Manhattan 7. Take a taxi or use rideshare to get to 30th St. Station, take Megabus to midtown Manhattan 8. Drive to New York and park overnight.

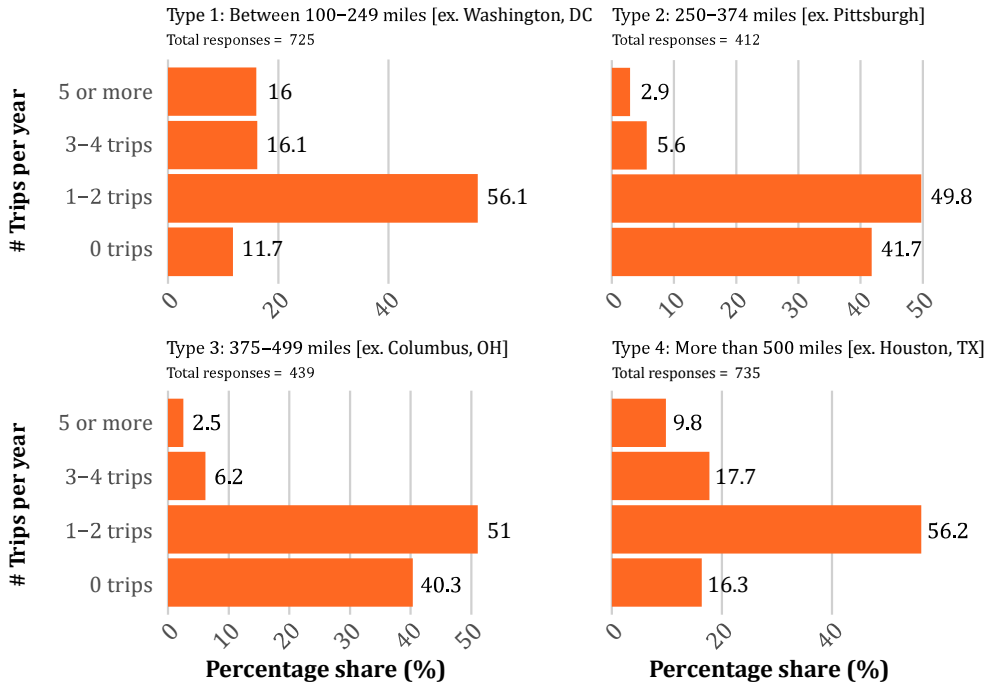

Figure A30. Distribution of survey subjects' # trips in an academic year for different types of long-distane travel.

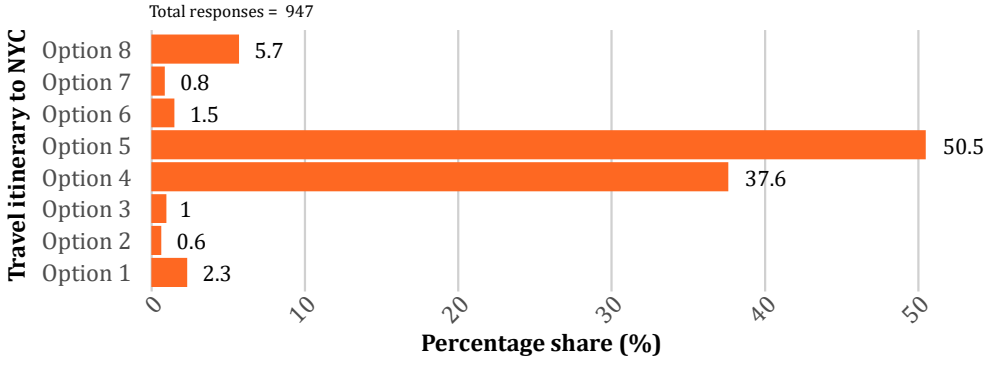

Figure A31. Distribution of survey subjects' itinerary choice of travel to NYC.

#	Question	Type	Answers
Q32	We are going to ask you to imagine yourself in a scenario where you have to choose a travel itenerary. You are taking a work trip overnight to Boston. You are travelling alone, and beginning from your home. Which of these travel itineraries would you most prefer? *Only displayed if "Yes" is selected in Q29*	Multiple-choice	1. Take a taxi or use rideshare to get to PHL, fly to Boston Logan 2. Take SEPTA to PHL, fly to Boston Logan 3. Drive to PHL, fly to Boston Logan 4. Take a taxi or use rideshare to get to 30th St. Station, take Amtrak to Boston 5. Take SEPTA to 30th St. Station, take Amtrak to Boston 6. Take SEPTA to 30th St. Station, take Megabus to Boston 7. Take a taxi or use rideshare to get to 30th St. Station, take Megabus to Boston 8. Drive alone to Boston and park your vehicle overnight
Q33	We are going to ask you to imagine yourself in a scenario where you have to choose a travel itenerary. You are taking a work trip overnight to Pittsburgh. You are travelling alone, and beginning from your home. Which of these travel itineraries would you most prefer? *Only displayed if "Yes" is selected in Q29*	Multiple-choice	1. Take a taxi or use rideshare to get to PHL, fly to Pittsburgh 2. Take SEPTA to PHL, fly to Pittsburgh 3. Drive to PHL, fly to Pittsburgh 4. Take a taxi or use rideshare to get to 30th St. Station, take Amtrak to Pittsburgh 5. Take SEPTA to 30th St. Station, take Amtrak to Pittsburgh 6. Take SEPTA to 30th St. Station, take Megabus to Pittsburgh 7. Take SEPTA to 30th St. Station, take Megabus to Pittsburgh 8. Drive Pittsburgh and park overnight

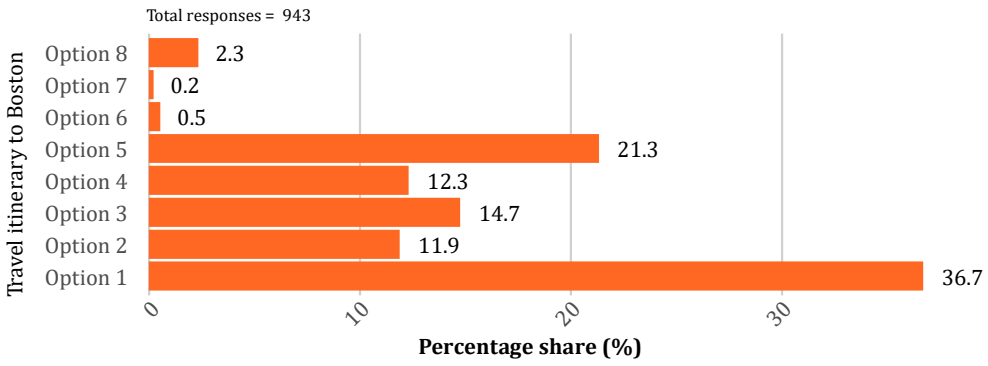

Figure A32. Distribution of survey subjects' itinerary choice of travel to Boston.

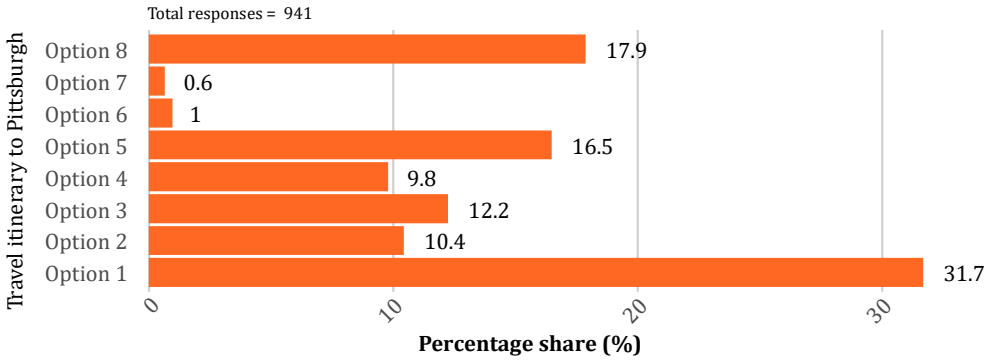

Figure A33. Distribution of survey subjects' itinerary choice of travel to Pittsburgh.

#	Question	Type	Answers
Q34	You indicated that you drive for long-distance trips. Please indicate the degree to which you agree with the following statements: It's hard to access the airport or the train station nearest to my home *Only displayed if "Drive alone to [destination] and park overnight" is selected in Q30, Q32, or Q33*	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
Q35	*(Q34 Cont.)* I like driving, it's convenient	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
Q36	You indicated that you fly for long-distance trips. Please indicate the degree to which you agree with the following statements: I like flying, it's fast and efficient *Only displayed if "Take SEPTA/taxi/rideshare or Drive alone to PHL, fly to [destination]" is selected in Q30, Q32, or Q33*	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
Q37	*(Q36 Cont.)* I'd prefer to take the train but it's slower	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
Q38	*(Q36 Cont.)* If I'm going up and down the Northeast Corridor, I still fly because it's easier than taking the train or the bus	Single-choice	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

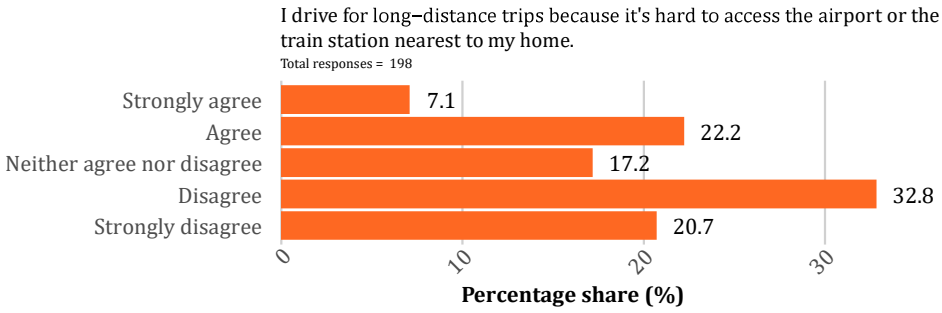

Figure A34. Distribution of survey subjects' attitude towards accessibility as the reason for long-distance driving trips.

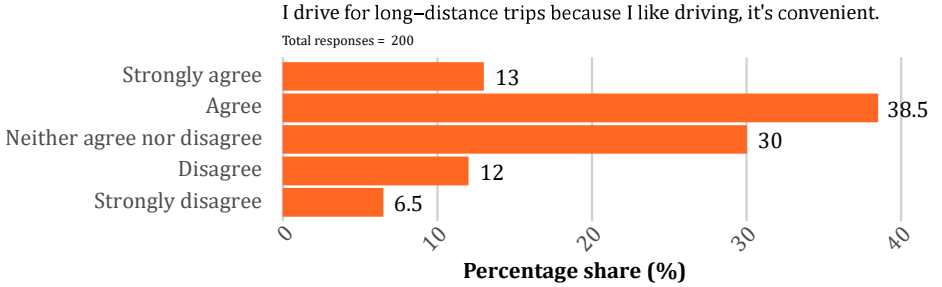

Figure A35. Distribution of survey subjects' attitude towards personal preference as the reason for long-distance driving trips.

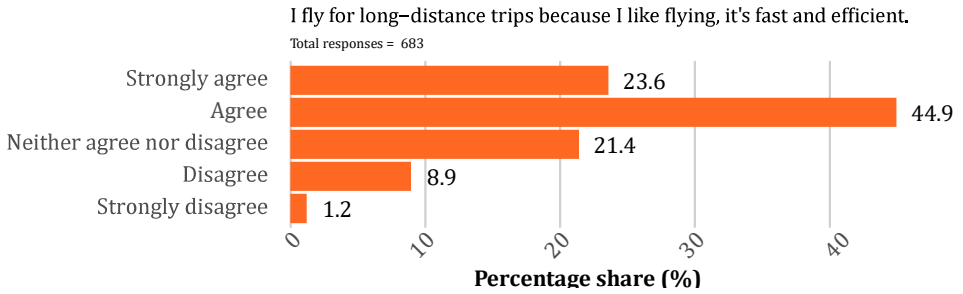

Figure A36. Distribution of survey subjects' attitude towards personal preference as the reason for long-distance flying trips.

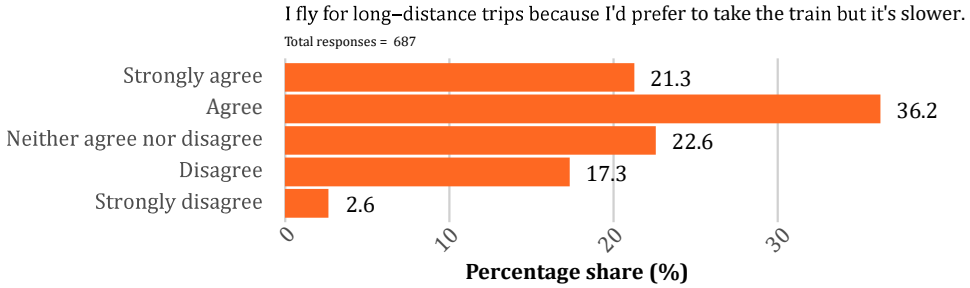

Figure A37. Distribution of survey subjects' attitude towards time costs as the reason for long-distance flying trips.

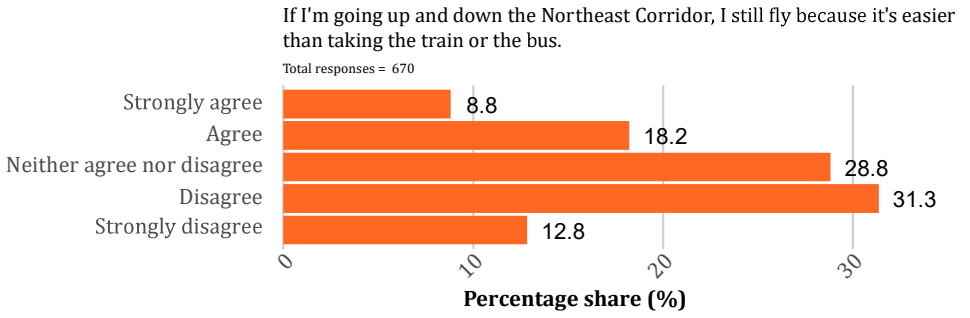

Figure A38. Distribution of survey subjects' attitude towards accessibility as the reason for long-distance flying trips.

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