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The Environmental Cost of Shopping: A Comparison Between Online and In-Person Shopping

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by

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Acknowledgments

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Prefatory Essay

It has been a year and a few months since I started thinking about this project. Throwback to beginning of 2022, I attend the first meeting of the Honors Project preparation course and I question my motivation and my ability to follow through with this project. Will I be able to find something interesting enough to keep myself busy for a year? Will all of it go well? Will I finish it on time ? So many questions were going through my mind. Today, as of April 2023, I am so proud to be able to say that I succeeded and that I successfully completed my project.

Taking a step back and reflecting on the past year allowed me to realize how far I have come. Figuring out which form I wanted my project to take was one of my first struggles. As an economics major, I wanted to do something that would be relevant in my field, which did not leave much room for anything else than a research paper, through which I could make use of my quantitative and analytical skills. I also have a deep passion for environmental issues and sustainability, which led me to conclude that I had to combine both of my interest into one project. After hours of brainstorming and re-orienting my topic and reshaping my project, I finally settled for the current topic. Started then a long and frustrating period of literature reviews and datasets research. Literature on this topic tended to be outdated, and datasets with the information I was looking for were scarce. Nevertheless, I kept going, and my efforts paid off.

As an economics research paper, this project involved a lot of econometrics knowledge, quantitative skills and data analysis, skills that I was building as I was writing my paper through my econometrics class. This project involved hours and hours spent staring at my laptop and experimenting with STATA software, a statistical software that allowed me to work the data to get results. Learning STATA was sometimes frustrating, but looking back, working on this project with STATA truly enhanced my coding skills, as well as my quantitative and

econometrics skills. This project allowed me to build and strengthen skills that will be valuable in my future, and I am proud to say that it highly contributed to making me comfortable with the use of STATA. I am no longer dreading opening STATA, and I also learned to enjoy learning the software.

Overall, this project was enriching in many ways. As stated above, it helped me reinforce skills that are highly valuable as an economist, such as quantitative and analytical skills, but this project also developed my decision-making and problem-solving skills. Indeed, I had to make a lot of decisions regarding which variables to pick, which model to use, and how to lead the analysis. Making decisions is not always something easy for me, but this project pushed me out of my comfort zone and pushed me to make choices, make mistakes, and learn from them. Because this project involved a lot of moving parts, it was essential for me to solve small problems individually but simultaneously before bringing all of the results together and solve the giant project-puzzle that I was facing. Working closely with my advisor and committee members was also an enriching experience as I learned a lot from their feedback and tried to apply their insightful comments to my project to the best of my ability.

This project also comforted me in the idea that, as much as I love doing research, I do not want to work in research, but I do want to work in a field where I would make use of my quantitative knowledge. I also realized that being passionate about the environment can be used as a strength that is valuable in the workforce as we evolve in a climate of urgency regarding global warming. I came to the conclusion that I care a lot about ethics and environmental ethics, and I do not see myself working for a company or organizations that would disregard those topics.

Looking into the future and future studies, I think the topic I choose to investigate is very interesting but would need to be approached differently. In the hypothesis that I will need to write a master thesis in the future, it would be interesting to keep going in the same direction, but I would do my research differently, and would start my work by finding a more complete data set. It would also be very interesting to investigate the impact of Covid on online shopping, which would highlight interesting conclusion on how Covid impacted our consumerist society, but also to fill in the gaps on this topic in the literature. Looking into the future from a broader lens, I think there is a lot of work to be accomplished regarding sustainability. It seems like a lot of individuals do not consider the impact of their action on the environment due to a lack of information or education. I believe that more education is needed to push people to understand that individual actions matter and that individual actions build collective actions towards change, and to understand that we all have a role to play in fighting climate change.

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Honors Project

Abstract

This paper aims to investigate how consumers' gas consumption patterns vary depending on their consumption behavior and interpret those results from a sustainability point of view. The shopping behavior correlated with decreasing gas consumption will be ruled as the more environmentally responsible practice. Consuming less fuel can mean a decrease in greenhouse gas emissions, holding constant the price of fuel. It is theoretically possible that online shopping would replace in-person shopping trips, leading consumers to drive less and use fewer fuels, benefiting the environment. It is also possible however, that online shopping increases greenhouse gas emissions if there is a complementary relationship between both shopping patterns. My study hypothesizes that online and traditional shopping are complementary, increasing overall greenhouse gas emissions. By looking at the relationship between online and traditional shopping and gas consumption, I estimate whether online shopping is more environmentally friendly than traditional shopping from a consumer point of view. I use data from the National Household Travel Survey data set from 2017 to investigate consumers behavior for both in-person and online shopping. I find evidence that online and in-person shoppers share the same characteristics, implying that both practices are complementary. I also find evidence that online shopping decreases gas consumption, meaning that, from a gas consumption and consumer point of view, online shopping is better for the environment. However, this conclusion needs to be interpreted with caution. These findings have important

implications for policymakers as focusing on developing regulations for online shopping will help support the environment and create more environmentally aware consumers.

Key terms: online shopping, in-person shopping, gas consumption, greenhouse gas emissions, environment

Introduction

Since the emergence of the internet in the 1990s, online shopping has kept growing as more and more companies began expanding their businesses online, and companies specialized in deliveries kept multiplying. A common belief was that online shopping would take over traditional shopping. However, research has shown a complementary relationship between online and in-person shopping (Chu, 2018; Farag, 2006). This means that consuming more online is not equivalent to consuming less in-store. Quite the opposite, online shopping is often positively correlated with traditional in-person shopping. In some instances, for example when the household lives in a more rural area, a substitution effect from in-store shopping to online shopping is observed, but it is uncommon. Numerous authors have found this complementarity between in-store and online shopping, but those studies used datasets from around ten years ago (Chu, 2018; Cao, 2011). In this paper, I investigate the relationship between online and in-person shopping by comparing the characteristics of consumers who practice both, using the 2017 wave of the National Household Travel Survey.

Other scholarly authors, such as Kavilanz (2020), Cullinane (2009), and Weideli (2013), investigate which shopping behavior is the most respectful of the environment from a greenhouse gas consumption point of view since, as Singer (2021) accentuates it, our consumerist society is responsible for more than 60% of the world's greenhouse gas emissions.

The answer to this investigation is unclear since there is a lack of datasets with all the required variables to efficiently compare online shopping and in-person shopping's greenhouse gas emissions. Comparing greenhouse gas emissions linked to shopping trips versus link to deliveries would have been a great alternative. Unfortunately, delivery companies such as Amazon or UPS keep their dataset private, preventing me from analyzing the direct correlation between deliveries and gas consumption. Therefore, I decided to focus on the consumer side and investigate how much gas households consume when practicing in-person versus online shopping, since, in 2007, cars produced 54% of the C02 emission of transport (Cullinane 2009). Less fuel consumption means fewer greenhouse gas emissions when holding the price of gas constant, which is better for the environment from an individual consumer perspective. The goal of this paper is also to identify the typical sociodemographic, spatial, and behavioral characteristics of consumers who practice in-person and online shopping. I will then investigate which practices have a greater impact on fuel consumption to draw conclusions on which behavior is the most sustainable. Therefore, this paper aims to examine and evaluate the correlation between online and in-person shopping by comparing consumers' characteristics and analyzing fuel consumption patterns for consumers engaging in shopping trips and online shopping, in light of sustainability.

Background

Many studies have examined the correlation between online and traditional shopping and tried to identify which behavior is more respectful of the environment, but conclusions tend to diverge. In most instances, online and in-person shopping are complementary. This means that the gas consumption related to deliveries adds to the gas consumption of in-person shopping

instead of replacing it. An increase in the frequency of one does not lead to a decrease in the frequency of the other, which means that there is no reduction in the number of trips taken (Cao, 2011; Farag 2006). Using the National Household Travel Survey dataset from 2009, Chu finds a positive correlation between online and in-person shopping, meaning that online shopping leads to an increase in traditional shopping, which increases vehicle miles traveled (VMT) (Chu, 2018). However, online shopping was found to be a substitute for in-person shopping in the Netherlands, which highlights the importance of the context of our analysis since the Netherlands is known to be a country where environmentally friendly practices are part of the culture (Cao, 2011). The importance of online shopping is also heightened by changes in consumption patterns during and after the covid pandemic. Indeed, 75% of US consumers have used online shopping during the pandemic and are likely to incorporate this consumption behavior into their daily life (Torkington, 2021). There has been an increase of 21 million people consuming online between 2016 and 2020 (Singer, 2021). This shows that the share of online shopping in consumption patterns is increasing and that the context in which people live can impact their consumption behaviors.

Identifying which consumer behavior is the most respectful of the environment is difficult because it involves a lot of decision-making regarding the variables of interest and which model to use. According to Dimitri Weideli, if the consumer goes through the process of consumption -- searching, purchasing, and returning the product-- online, then this consumer will have a lower environmental impact (2013). These findings are consistent with Boudreau, who found that online shopping is the most sustainable option (2021). In addition to investigating online and in-person shopping, Shahmohammadi looked at the environmental impact of "bricks and clicks," which consist of ordering online but the delivery arriving at a retail store (2020). The

theory behind this is that there is only one truck full of different packages delivering to one retail store. This one should be relatively close to the household for the distance between the household and the retail store to be smaller than the distance between the retail store and a traditional shopping place (Shahmohammadi 2020).

All those authors highlight that online shopping is the best environmental practice under certain conditions. Online shopping is better for the environment only if speed delivery is left out of the equation (Weideli, 2013). Fast deliveries are worse for the environment because a short delivery delay requires a company to ship their product on planes, which is eight times more energy intensive than a truck. The products are then delivered to a household in trucks that are not at full capacity, which leads carbon emissions to be greater than what they would be under regular shopping (Kavilanz, 2020). The packaging coming with online deliveries also represents the primary source of carbon emission for online shoppers, mainly because the recycling of those packaging is not optimal yet (Weideli, 2013; Boudreau, 2021). Returns of products are also more likely to happen when online shopping, which means that the greenhouse gas emissions linked with the goods delivered can be doubled or tripled (Shahmohammadi, 2020). The type of truck used for deliveries, the weight of the merchandise transported, and the packaging are elements that will impact the greenhouse gas emissions of online delivery. Still, those variables are hard to account for, meaning we might be under-evaluating the actual impact of online shopping on the environment (Boudreau, 2021). Therefore, as Cullinane highlights, the impact of shopping on the environment is not clear cut, and the only way to successfully study the difference in greenhouse gas emissions would be to set equal the greenhouse gas emissions of one delivery trip to a number of vehicle trips generating the same amount of greenhouse gas (Cullinane, 2009).

Kavilanz also showed some reservations about the sustainability of online shopping. Indeed, she states in her article that online consumers will buy fewer items per purchase but order more frequently, while in-store shoppers usually buy more in bulk and get more items in one trip, using less packaging (Kavilanz, 2020). In addition, one trip to a traditional store can give you a selection of products in one trip. In contrast, deliveries from different products would mean deliveries from different trucks (Cullinane, 2009). Likewise, the mode of transportation used for traditional shopping, choosing to buy in bundles, and avoiding returns are small details that will positively impact greenhouse gas emissions in the long run. Hence, consumption decisions need to be made mindfully (Boudreau, 2021; Shahmohammadi, 2020; Kavilanz, 2020).

From an economic theory point of view, I investigate if shopping travel is subject to the fundamental law of supply and demand. In theory, an increase in price leads to a decrease in the quantity demanded since the consumers should be less willing to buy a product when its price increases. I investigate whether gas is subject to the law of demand by examining if an increase in the annualized fuel cost in dollars per gallon leads to a decrease in gas consumption. Overall, the paper underlines the negative externalities of shopping since it investigates the correlation between shopping behaviors and gas consumption. Negative externalities exist when the production or consumption of a product results in a cost to a third party. With both in-person and online shopping, fuel is consumed either with a personal car or with a delivery truck. In both cases, it leads to greenhouse gas emissions, which are responsible for air pollution and climate change on a bigger scale. In this paper, I aim to see which shopping behavior creates the least negative externalities and is, therefore, the best for the environment.

This paper also investigates what would motivate consumers to choose one shopping pattern over the other by looking at their demographic characteristics. Farag showed that online

shopping can be explained by sociodemographic, spatial, behavioral and attitudinal characteristics (2005). One key finding is that respondents with higher income who frequently use internet are more likely to practice online shopping (Farag 2005). Another important characteristic was the residential area of the respondent. Opposing the hypothesis that respondent living in rural areas would consume more online because of the distance to be covered to practice in-person shopping, Farag found that -shopping is more connected with an urban lifestyle (2005). Indeed, online shopping is found to be an innovation that respondent following a more urban lifestyle are more likely to adopt (Farag, 2005). This highlights that consumers display certain sociodemographic but also behavioral characteristics that will either dictate or influence their consumption behavior.

Consumers are also subject to time and money constraints shaping their consumption behavior. Household income and type of position occupied can play a role in the money constraint theory. According to the time constraint theory, the sum of the time spent on all activities each day must equal 24 hours. Therefore, the opportunity cost of time spent on one activity is the time taken away from another. In the same idea, individuals are subject to the money constraint theory as they need to allocate their money depending to the earnings in their possession (Github, n.d). Having children and needing to take care of them can represent an element in the time constraint theory. Indeed, parents need to allocate their time to care of their children but also keep proceeding to their daily activities such as working and subsist to their needs with running errands. Therefore, they might need to make choices between allocating their time to their children or go shopping, in which case online shopping can appear as a great alternative. Shopping patterns can also, for example, be constrained by the number of vehicles and drivers in the household. I aim to identify consumers' constraints and relate them to shopping

behaviors. The choice of shopping online or in person is also motivated by the consumer's utility, which is referred to as the amount of happiness or satisfaction consumers derive from, in this case, shopping online or undertaking in-person shopping trips.

Data

To study the effect of online shopping on fuel consumption, I used the 2017 wave of the National Household Travel Survey (NHTS). The NHTS data is a cross-sectional dataset that looks at daily trips taken by households and household individuals over the course of 24-hour periods. The NHTS survey is split into four different files: a household file, the person file, the vehicle file, and the trip file. Merging those files was necessary to be able to look at our consumer characteristics, shopping behavior, and gas consumption, and it yielded a total of 760,660 observations and 249 variables. This merged dataset includes personal demographic information as well as information on trips and vehicles to investigate the variables related to gas consumption and trip purposes. The sample was then restricted to individuals who responded to be running errands or buying food to the survey question assessing the purpose of the trip. The number of shopping trips and the number of miles traveled for shopping variables were created after recoding and reshaping variables related to trip purposes and distances.

The outcome variables are annual fuel consumption in US gallons and number of in-person shopping trips. Gas consumption is used as a proxy variable for greenhouse gas emissions and respect for the environment since greater quantity of gas consumed leads to greater greenhouse gas emissions and a negative environmental impact. The number of in-person shopping trip outcome variable was derived from the survey questions investing the number of shopping trips taking on the day of the survey. The key explanatory variables are annualized gas

cost, the number of deliveries in the past 30 days, and the number of miles traveled for traditional shopping. For comparative purposes between online and in-person shopping, the variable for the number of shopping trips was multiplied by 30 and therefore recoded as a monthly variable. The "number of shopping trips" variable represents monthly in-person shopping, and the "number of deliveries" variable accounts for online shopping. A definition and description of the outcome variable, the key explanatory variables, and other relevant variables are presented in Table A1, in the appendix.

Figure 1. shows the frequency of the key shopping variables. Having both variable in the histogram allows for simpler comparison of frequency and trends. The purple bars in the histogram show the frequency of online deliveries that the household contracted over the past month. Most people did not order online during the month of the survey, but there is still an important proportion of households who ordered online between once and fifteen times per month. The light green bars shows the frequency of shopping trips a respondent in the household take on a typical month, derived from their daily shopping trips. Similarly to the number of deliveries, a lot of respondents did not have any shopping trips on their assigned day, which therefore translated into a lack of shopping trips during the month, but there is still a large proportion of people who undertook between 30 and 60 shopping trips per month. This comparative histogram allows for the comparison between both shopping patterns and reinforces that the comparison between online and in-person shopping is feasible. Both shopping patterns display a downward slopping trend, with a steeper slope for the number of deliveries, highlighting that there is less people participating in online shopping compared to in-person shopping.

Figure 1. Frequency of Deliveries and Shopping Trips

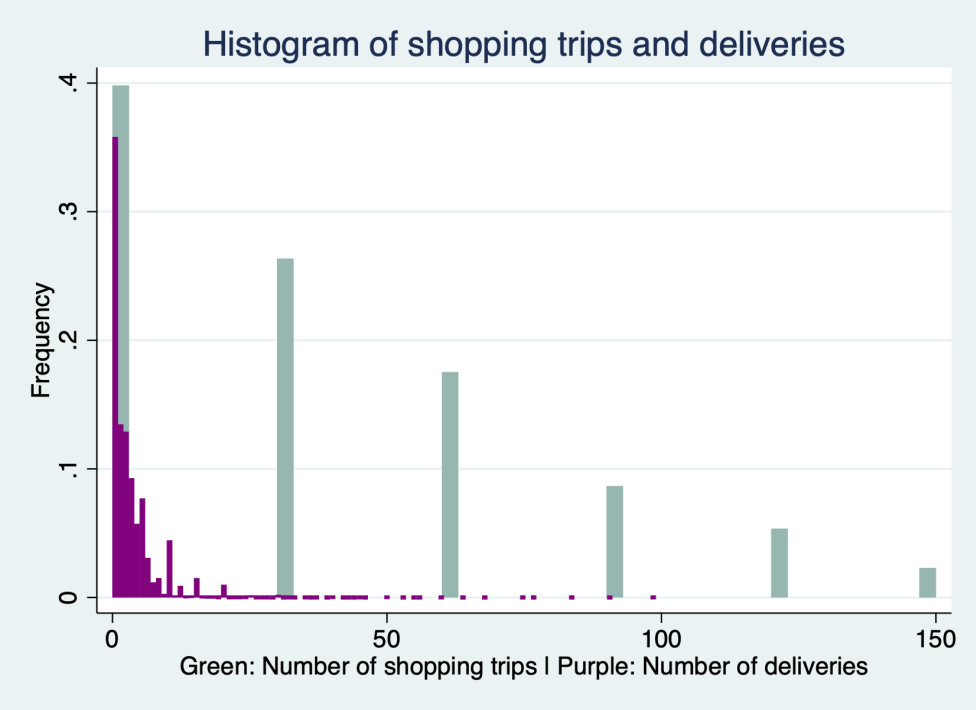

Table 1 lists the results of descriptive statistics with the mean, minimum, maximum, and standard deviation of each variable. The definition and description of each variable are shown in Table A1 in the appendix. As indicated, on average, respondents take 42.06 monthly shopping get 3.03 deliveries per month. This suggests that in a month, respondents take, on average, 13 more in-person shopping trips compared to the number of deliveries, which are synonyms for online shopping. Thus, respondents of this sample are more likely to engage in in-person shopping than online shopping. The descriptive statistics also highlights that respondent spend on average drive, on average, 11,168.69miles per year and consume, on average, 532.25 gallons of gas.

Table 1. Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Number of shopping trips	101174	42.06	52.33	0	720
Number of deliveries	101174	3.03	4.56	0	99
Annual gas consumption	101174	532.25	551.66	0.02	33333.33
Gas cost per day	101174	2.41	0.296	2.13	9.86

Miles driven per year	101174	11168.69	10658.99	0.46	200000
Household income	101174	6.32	2.48	1	11
Miles driven for shopping trips	101174	9.86	43.51	0	5482.76
Miles driven for other purposes	101174	69.89	232.65	0	17056.67
Race (=1 white)	101174	0.85	0.36	0	1
Gender (=1 female)	101174	0.51	0.5	0	1
Age	101174	55.56	16.14	16	92
Level of education	101174	3.62	1.08	1	5
Working status (=1 employed)	101174	0.56	0.50	0	1
Number of children	101174	0.39	0.85	0	8
Household size	101174	2.22	1.18	1	13
Residential Area (=1 urban)	101174	0.78	0.42	0	1
Price opinion	101174	0.46	0.50	0	1
Number of vehicles	101174	2.11	1.11	1	12
Number of drivers	101174	1.78	0.71	1	9
Time traveled (minutes)	101174	24.34	39.99	0	1200
Number of workers	101174	1.11	0.89	0	7

Methodology

The merged 2017 NHTS dataset presented a count of 760,660 observations and 249 variables. I then restricted the sample to people for whom the purpose of the trip was shopping or errands. This new dataset showed the different household members' trips on a specific day. The number of observations dropped after I generated a unique household variable that would account for the total number of members in the household and the total number of trips. With each household present once in the dataset, and after controlling for missing values, the number of observations in the final sample was 110,174. Adding the number of miles related to shopping and reshaping the dataset allowed for the creation of a dataset where one household is matched with the total number of miles traveled for shopping. This reshaped data set makes it possible to run multiple regressions to analyze gas consumption in correlation with additional miles traveled for

shopping. I used a simple ordinary least square regression model to investigate the demographic characteristics of people who take monthly in-person shopping trips and people who participated in online shopping and received monthly deliveries. The first regression is:

$$Number\ of\ shopping\ trips = \beta_0 + \beta_1\ Number\ of\ deliveries + \beta_2\ Household\ income + \beta_3\ Household$$

The variable "number of shopping trips" represents the number of shopping trips the respondent takes per month. The explanatory variables are the number of monthly deliveries as well demographic characteristics, such as household income, household size, race, gender, level of educational attainment, employment status, number of children, and age. I also control for the rurality of where the respondent lives, the number of workers in the household, and if an increase in the gas price affects the respondent's decision to take a trip. I use categorical variables for household income and education level. The household income variable is coded by ranges of approximately $15,000, starting at less than $10,000 and going up to $200,000 or more. The education level variable presents categories for people with less than a high school degree, a high school degree, some college or associate degree, a bachelor's degree, or a higher diploma. Squaring the "age" variable helps us to analyze if an increase in age leads to different shopping trip behaviors. The quadratic expression will show that as people get older, they take shopping trips, but at a slower rate. Using the same regression and outcome variable, I then conducted a heterogenous analysis, which aims to separate my analysis by different subgroups relating to sociodemographic information. For this research, the goal of the heterogenous analysis is to investigate how the number of in-person shopping trips varies depending on the gender of the respondent, the residential area of the respondent and the income level of the respondent. The gender variable is a binary variable with one for being a women, and zero men, and the residential area of the respondent is coded as one for urban and zero for rural areas/ The repartition of income level variable was recoded following the American class system (Walrack,

2023). Respondents reporting earning less than $50,000 were considered as low income, respondents earning between $50,000 and $150,00 were coded as middle income, and respondents earning above that threshold were considered as upper income.

The second equation helps investigate the correlation between driving behaviors and gas consumption and is as follows:

$$Total\ gas\ consumption = \beta_0 + \beta_1\ Gas\ cost\ per\ day + \beta_2\ Total\ miles\ driven\ per\ year + \beta_3 Number\ o$$

In this equation, total gas consumption is an estimation of annual quantity of gas consumed, in US gallons. Gas cost per day represents gas prices throughout the year, and the total miles driven are an estimation of the number of miles traveled during the year. I also look at the number of drivers in the household, as well as the time spent traveling in minutes on a given trip. This regression permits me to see household gas consumption behaviors depending on the gas cost and the distance traveled. The assumption is that the $\beta_1$coefficient, gas cost per day, would be negative. This would mean that, on average, an increase in gas prices would lead to a decrease in gas consumption. Indeed, according to the law of demand as the price of an item increases, consumers are less willing to buy it which leads to a decrease in quantity demanded. Therefore, if the price of gas increases, the quantity of gas consumed should decrease. However, because gas is a necessary good for many households, the amount of gas respondents buy is relatively inelastic, meaning that the quantity of gas consumed should not change much as price goes up (EIA, 2014). Then, the total miles driven per year variable should display a positive coefficient, meaning that, on average, an increase in the total number of miles driven would lead to an increase in total gas consumption. The other independent variables are also expected to present positive coefficients.

The last regression is built upon the previous one but now incorporates our key variables: the number of in-person shopping trips and number deliveries.

$$Total\ gas\ consumption = \beta_0 + \beta_1\ Gas\ cost\ per\ day + \beta_2\ Total\ miles\ driven\ per\ year + \beta_3 Number\ o$$

After testing for collinearity, the number of miles traveled for other purposes than shopping and the number of miles traveled for shopping during the given day of the survey were kept in the regression. Because consumers have budget constraints, household income was chosen as a key independent variable that can explain gas consumption behavior in relation to shopping patterns. The variables counting the number of monthly shopping trips and deliveries were kept as key variables. Driving behavior variables were kept in this regression because they are relevant to evaluating the correlation between the key and dependent variables. Therefore, this regression allows us to see the correlation between driving behavior, shopping trips, deliveries, and gas consumption. I expected the driving behavior variables to stay the same as in the second regression. I also expect the household income variable to have a positive coefficient, meaning that, on average, a higher income will lead to more gas consumption. The coefficients for the number of miles driven, the number of miles driven for shopping per household, and the number of shopping trips are also expected to be positive, meaning that, on average, an increase in those quantities would lead to an increase in gas consumption. However, I presume to find either a negative correlation between gas consumption and deliveries that would highlight the facts that, on average, online shopping leads to a decrease in gas consumption or find a small coefficient that would show that, on average, online shopping leads to a minor increase in quantity of gas consumed.

Lastly, to verify the main results found, I will conduct a robustness check by analyzing if there is a variation in results when restricting the regression to people who took a positive number of shopping trips. As shown above in the histograms, a critical proportion of people do

not participate in shopping trips or participate in online deliveries during a given month, so it is important to understand if null responses influenced my results. The robustness check will display a nested table in which the first column represents the first regression. The second column will have the same independent variables but will be regressed on the dependent variable representing any shopping trips. The last column will investigate the impact of those variables on the number of shopping trips, only if this number is positive. In the three models, the outcome variable remains the number of shopping trips, but is coded differently. The goal of this robustness check is to evaluate if changes in results are explained by changes in the intensive or extensive margin, meaning looking at if the number of shopping trips drives the results or if doing any shopping is the driving component. In a separate table, I will also rerun the third regression by restricting it to a positive number of shopping trips.

Results

Table 2 examines the demographic characteristics of people who are the most likely to take shopping trips and order online. For that, I regressed different the number of monthly deliveries and demographic characteristics on the number of shopping trips taken during a month. The table shows that an additional delivery leads to an increase in 0.31 in-person shopping trips. This statistically significant result starts shedding light on the fact that in-person and online shopping are complementary. Indeed, if deliveries were a substitute for in-person shopping, the coefficient would be negative, showing that an increase in the number of deliveries leads to a decrease in the number of shopping trips. Since it is not the case, the positive coefficient shows that people contract deliveries in addition to effectuating in-person shopping trips.

Next, the table shows that the household income variable is also positively correlated with number of shopping trips, meaning that an increase in income leads to an increase in the number of shopping trips. A more in-depth analysis of income level will be displayed in a subsequent section. An additional member of the household also increases, on average, the number of shopping trips by 8.40 trips. However, it is interesting that an additional child decreases the number of shopping trips by -9.35, and those results are both statistically significant. Therefore, I can conclude that the bigger the household size, the more likely the household is to take an increasing number of in-person shopping trips. However, the composition of the household matters since an additional child decreases the number of shopping trips, which can be interpreted as a substitution from in-person to online shopping when there are children in the household. The number of children was derived from the difference between the household size and the number of adults, older than 18 years old, in the household. Looking in absolute values, the magnitude of the coefficient for an additional child is greater than the one for an additional member. These finding highlights that having children in the household play a more important role in the decision to consume online or in-person in contrast to looking solely at the number of household members without accounting for their ages.

The table also shows that, on average, white people take 2.54 more shopping trips than their counterparts of different races and ethnicities. On average, women are also more likely to participate in traditional shopping and online shopping compared to men, and the results are statistically significant. The table also shows that being employed is negatively correlated with in-person shopping, with 15.84 fewer trips. This can be explained by the time constraint theory, according to which people must allocate the hours available during the day. In theory, it is accurate that someone who is employed has less free time to go in-person or online shopping

because more hours of the day are already allocated towards working. An increase in education level also leads to an increase in shopping trips. The theory behind it can be that higher education is correlated with higher income, which is associated with more shopping.

Living in an urban setting leads to a 3.87 decrease in the number of shopping trips this result is statistically significant, and those results are not entirely in agreement with the theory. As discussed in a previous section, some findings showed that people living in rural settings are more likely to order online, while other found that respondents living in urban areas are more likely to order online because they are more likely to be influenced by new trends and innovations (Farag, 2006). A more in-depth analysis if the residential area will follow in the heterogenous analysis section to try to understand better the spatial characteristics of respondents effectuating in-person shopping trips. Looking at behavioral characteristics, respondent who agree that an increase in price affects their trip decisions, on average, undertake 0.91 additional deliveries. This can either means that the respondent will still take an increasing number of shopping trips but at a decreasing rate, or that they are more likely to order online to avoid spending money on gas.

Lastly, the variable "age" demonstrates that the older you get, the more in-person shopping trips. This is consistent with the fact that older people are unfamiliar with technology and are more likely to consume in person. The quadratic form of age shows that, indeed, as people get older, they take more shopping trips, but at a slowing rate. This implies that the younger generation is more likely to take additional trips. Overall, this table informs us on who is the most likely to practice in-person shopping. The positive correlation between the outcome and the key variables of in-person trips and number of deliveries highlighted the complementarity between in-person and online shopping. It is also important to notice the value of the r-squared at

the bottom of the table. The r-squared value represents the proportion of variance in the dependent variable explained by the independent variables in the regression model. In this case, the r-squared is relatively low, which means that they are other variables that I did not control for, which could explain more the variance in the number of shopping trips.

Table 2. Demographic Characteristics of Online and In-person Shoppers

Number of shopping trips	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Number of deliveries	0.31	0.04	8.29	0	0.24	0.38	***
Household income	0.32	0.08	3.89	0	0.16	0.49	***
Household size	8.40	.029	28.54	0	7.82	8.98	***
Race (=1 white)	2.54	0.46	5.52	0	1.64	3.44	***
Gender (=1 female)	3.54	0.33	10.72	0	2.89	4.19	***
Level of education	1.26	0.17	7.47	0	0.93	1.59	***
Working status (=1 employed)	-15.84	0.48	-33.21	0	-16.78	-14.91	***
Number of children	-9.35	0.37	-25.31	0	-10.07	-8.62	***
Age	1.49	0.06	23.32	0	1.36	1.61	***
Age squared	-0.01	0.001	-19.70	0	-0.01	-0.01	***
Residential Area (=1 urban)	-3.87	0.39	-9.86	0	-4.64	-3.10	***
Price opinion	0.91	0.34	2.67	0.01	0.24	1.57	***
Number of workers	-1.50	0.31	-4.80	0	-2.12	-0.89	***
Constant	-14.61	1.86	-7.84	0	-18.26	-10.95	***

Mean dependent var	42.061	SD dependent var	52.330
R-squared	0.055	Number of obs	101174
F-test	453.065	Prob > F	0.000
Akaike crit. (AIC)	1082228.231	Bayesian crit. (BIC)	1082361.575

**** p<.01, ** p<.05, * p<.1*

The previous table highlighted some key sociodemographic characteristic of in-person shoppers, but some surprising coefficients shed light on the necessity to deepen the results through the use of a heterogenous analysis. Prior research has indicated the existence of gender, residential and income differences in the practice on in-person shopping. Indeed, Farag found that female respondents and low-income respondents display a higher frequency of in-person shopping trips, and that respondent living in urban settings are more likely to practice online shopping (2006). However, there is a gap in the existing literature on this topic, hence the

necessity to conduct a heterogenous analysis. I decided to conduct a heterogenous analysis by gender, residential area, and level of income.

The first part of **Table 3** examines how the number of shopping trips is correlated with the key variables depending on if the respondent is a female or male. An additional delivery in the month leads to an increase in the number of shopping trips by 0.239 if the respondent is a female, compared to 0.411 if the respondent is a male, and those results are significant. This shows that male respondents are more likely to engage in in-person shopping while practicing online shopping. It might be interesting to hypothesize that the complementarity relationship between online shopping and in-person shopping is stronger for male respondent than female respondents, which can be seen as surprising, but could potentially be explained with a further analysis of the type of goods consumed during shopping. The rest of the variables seem to have similar coefficients between male and female, but it is interesting to notice that women with higher earnings are more likely to take an increasing number of shopping trips compared to their counterparts. An increase in the number of children also seems to impact female's shopping trips more negatively than for males, which would reflect the patriarchal patterns that can still be observed in our society.

The second part of **Table 3** looks at the relationship between online and in-person shopping depending on the respondent's residential area. An additional delivery leads to a 0.247 trips increase in the number of shopping trips for a respondent living in an urban area, compared to a 0.568 trips increase for respondent coming from a rural area. These findings can signify that there is a stronger complementarity relationship between online and in-person shopping for respondents living in a rural area, which is not in accordance with the findings of substitution from previous research. From those results, it seems like respondent living in urban areas are

more likely to reduce their in-person shopping trips when practicing online shopping. One hypothesis is that urban respondents are more likely to use internet and at a higher frequency, multiplying their opportunities to consume online. This hypothesis would be consistent with Farag's findings stipulating that the urban population has a greater frequency of internet usage and is more incline to adopt early innovations such as online shopping (2006).

Table 3. Heterogenous Analysis by Gender and Residential Area

	Gender		Residential Area	
Ind. Variable= Number of shopping trips	(1)	(2)	(3)	(4)
	Female	Male	Urban	Rural
Number of deliveries	0.239***	0.411***	0.247***	0.568***
	(0.053)	(0.053)	(0.041)	(0.087)
Household income	0.66***	0.544***	0.563***	0.752***
	(0.116)	(0.117)	(0.089)	(0.199)
Race (=1 white)	0.838	3.616***	2.532***	-0.081
	(0.626)	(0.677)	(0.477)	(1.402)
Age	0.248***	0.269***	0.26***	0.262***
	(0.018)	(0.02)	(0.014)	(0.035)
Level of education	1.028***	1.318***	0.916***	1.915***
	(0.239)	(0.239)	(0.187)	(0.382)
Working status (=1 employed)	-14.383***	-14.405***	-13.995***	-15.797***
	(0.639)	(0.719)	(0.515)	(1.125)
Number of children	-9.542***	-9.136***	-8.397***	-12.339***
	(0.503)	(0.553)	(0.405)	(0.882)
Household size	8.603***	8.222***	7.689***	10.8***
	(0.42)	(0.42)	(0.323)	(0.694)
Residential Area (=1 urban)	-4.503***	-4.049***		
	(0.555)	(0.557)		
Price opinion	2.034***	1.064**	1.543***	1.653**
	(0.473)	(0.487)	(0.372)	(0.79)
Number of workers	-1.125**	-0.957**	-0.46	-2.556***
	(0.457)	(0.433)	(0.347)	(0.71)
Gender (=1 female)			3.589***	4.466***
			(0.363)	(0.775)
Constant	17.229***	9.673***	8.802***	6.944**
	(1.8)	(1.834)	(1.352)	(3.318)
Observations	51163	50011	78428	22746
R-squared	0.049	0.054	0.048	0.052

*Standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1*

Table 3.1 helps me examine if respondents with different level of income display different shopping behaviors. For the analysis, respondents were split in three groups: lower income,

middle income and upper income. Looking at an increase in the number of deliveries across the three different income groups, there is a consistent decrease in the coefficients. This shows that, for the respondents belonging to lower income group, an additional delivery leads to a 0.409 additional in-person shopping trips. There is a stronger complementarity relationship between both shopping patterns for the lower income group. It seems that the upper income population is more likely to substitute in-person shopping for online shopping. The table also shows that as the respondents get older, they take more in-person shopping trips as their level of income increases. Another interesting finding relates to the working status. Being employed is negatively correlated with the number of shopping trips across the level of income, but it is interesting to look at the variations in the coefficients. Indeed, lower income respondents take on average 12.4 fewer in-person trips when they are employed, against 15.7 for the middle-income population and 13.7 for the upper income population. In relation to the time and budget constraint theory, it is interesting to see that the population who earns the less will still take more shopping trips than the other groups, while earning less, while the respondents earning relatively more, is not participating in more shopping trips. Overall, those results showed that the level of income and residential areas are great indicator of the characteristics of in-person shoppers.

Table 3.1 Heterogenous analysis using linear regression model, by income level

	Level of Income		
Ind. Variable= Number of shopping trips	(1)	(2)	(3)
	Lower	Middle	Upper
Number of deliveries	0.409***	0.348***	0.313***
	(0.078)	(0.052)	(0.078)
Race (=1 white)	0.752	2.81***	4.515***
	(0.659)	(0.701)	(1.429)
Gender (=1 female)	4.168***	3.359***	4.199***
	(0.52)	(0.474)	(0.981)
Age	0.23***	0.272***	0.435***
	(0.019)	(0.02)	(0.046)
Level of education	1.517***	1.183***	-0.326

	(0.25)	(0.24)	(0.592)
Working status (=1 employed)	-12.434***	-15.733***	-13.735***
	(0.759)	(0.679)	(1.345)
Number of children	-8.245***	-10.164***	-8.27***
	(0.593)	(0.543)	(1.084)
Household size	7.249***	9.296***	8.48***
	(0.437)	(0.44)	(0.937)
Residential Area (=1 urban)	-4.621***	-3.785***	-5.298***
	(0.595)	(0.567)	(1.261)
Price opinion	1.711***	1.268***	0.482
	(0.523)	(0.476)	(1.123)
Number of workers	-0.877	-1.508***	1.152
	(0.541)	(0.436)	(0.866)
Constant	15.82***	14.845***	7.689*
	(1.955)	(2.05)	(4.63)
Observations	36501	51707	12966
R-squared	0.047	0.057	0.045

*Standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1*

After gathering elements showing the complementarity relationship that unites in-person and online shopping, it is important to consider the impact of in-person shopping trips and online shopping on the environment. Number of deliveries is a proxy for online shopping, and gas consumption is a proxy for the environmental variable, since an increase in greenhouse gas emissions has a harmful impact on the environment and global warming as a whole. The first column of **Table 4** shows how gas consumption patterns vary in accordance with different driving behaviors, which was explained in the third regression. The table shows that an increase in gas cost per day leads to a decrease in the quantity of gas consumed, which blend with the law of demand since an increase in price leads to a decrease in quantity. However, since fuel is a relatively inelastic good, I was expecting the magnitude of the coefficient to be smaller, which would have shown that an increase in price only leads to a small decrease in gas consumption since fuel is considered a necessary good, as it is consumed by most household on a daily basis.

Then, as expected, the total number of miles driven throughout the year is positively correlated to the dependent variable total gas consumption. In the same way, an additional vehicle in the household leads to statistically significant 19.207 gallons increase in total gas

consumption. This can be explained by the fact that those vehicles are probably driven by different people in the household and might be used at the same time and both drivers are, therefore, both consuming gas at the same time. An increase in the time traveled in minutes also leads to an increase in gas consumption by 0.033 on average, keeping the other variables constant. Thus, it is likely that for the same number of miles driven, an increase in travel time increases gas consumption. Taking into consideration the presence of traffic on the roads would account for the increase in time traveled and would lead to an increase in gas consumption.

So far, our results are in accordance with the hypotheses stated earlier. However, it was surprising to see that an additional driver in the household leads to a decrease in gas consumption, and that this result is significant. This finding is inconsistent with the theory displayed above relating to the number of vehicles. The expectation follows that a driver is associated with a car and that both variables should have the same sign, if not the same magnitude. However, this allows us to conclude that an additional vehicle has a more significant negative impact on gas consumption and, therefore, on the environment than having an additional driver.

Table 4. Factors Impacting Annual Gas Consumption

	(1) Annual gas consumption	(2) Annual gas consumption
Gas cost per day	-55.916***	-53.872***
	(2.27)	(2.278)
Miles driven per year	0.048***	0.048***
	(0)	(0)
Number of vehicles	19.207***	20.322***
	(0.756)	(0.766)
Time traveled (minutes)	0.033*	0.044**
	(0.017)	(0.018)
Number of drivers	-3.044**	-0.93
	(1.186)	(1.21)
Number of shopping trips		0.015
		(0.014)

Number of deliveries		-0.507***
		(0.153)
Household income		-2.604***
		(0.303)
Miles driven for shopping trips		0.021
		(0.016)
Miles driven for other purposes		-0.004
		(0.003)
Constant	99.49***	104.974***
	(5.845)	(5.904)
Observations	101174	101174
R-squared	0.85	0.85

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

The second column of **Table 4** is the equivalent of my fourth regression, which means I combined driving behaviors, key variables, and other relevant variables. Compared to column one, there is a slight increase in the coefficients for gas cost per day which would be consistent with the theory of fuel being a relatively inelastic good. The coefficient on in miles driven per year remained the same, and the coefficients on the number of vehicles and time travelled also increased. Thus, those variables are still strongly correlated with an increase in gas consumption. However, one noticeable difference is the number of drivers variable; the coefficient decreased but also became statistically insignificant, highlighting the fact that number of drivers might not be a key variable in the determination of gas consumption.

Surprisingly, the table shows that an additional shopping trip increases gas consumption by 0.015 gallons, but this result is statistically insignificant, which makes it complex to make sense of those findings. Nevertheless, with respect to the sign to the coefficient, an increase in shopping trips still leads to more gas consumption, implying more greenhouse gas emissions and a more negative impact on the environment. In comparison, an additional delivery in the month is correlated with a decrease in gas consumption by 0.507 gallons, and this result is statistically

significant. An increase in deliveries leads to less gas consumption, suggesting less greenhouse gas emissions. Based on those results, I conclude that online shopping leads to a decrease in gas consumption, which infers that shopping online is better for the environment in the sense that it leads to fewer greenhouse gas emissions from driving.

The rest of the variables are more correlated with shopping habits. The table shows that an increase in income is also negatively correlated with gas consumption, which signifies that an increase in income leads to a decrease in gas consumption, holding the other variables constant. It is hard to make sense of this variable as, from an economic perspective, an increase in income should lead to more gas consumption since the household would be subject to a higher budget constraint and would have more money to allocate on towards fuel. Another theory would be that since fuel is a relatively inelastic good, an increase in come would not impact the consumption of fuel. A potential explanation to this negative coefficient respondents with higher income decide to allocate their money towards other goods, or that their higher earnings give them access to newer vehicles that consume less fuel and would be less harmful on the environment. The hypothesis behind it would be that wealthier households use other forms of transportation, such as electric vehicles, hence the decrease in gas consumption. This hypothesis cannot be verified but could be the subject of future research.

Lastly, the table also shows that, on average, any additional miles driven for purposes other than in-person shopping decrease the total gas consumption, and an additional mile driven for shopping leads to 0.021 gallons increase in gas consumption. Even if the results are statistically insignificant, the difference between both coefficients can be explained by the fact that shopping facilities might be located further away from the respondent's house compared to other daily trip destinations such as work. This also shows that people are driving more for

traditional shopping, which leads them to spend more on gas, increasing their greenhouse gas emissions. Their shopping trips have a more significant adverse environmental impact than other trips.

Robustness Checks

The main goal of my robustness check is to evaluate if respondents who did not take any shopping trips are skewing the results found in the preceding section. As explained previously, the histogram and the distribution of the number of shopping trips variable showed that a high proportion of respondents did not take any shopping trips. Indeed, 42,798 people reported no shopping trips, representing 38.47% of the sample, hence the importance of investigating whether the results are driven by people who are not shopping or if our previous conclusions on the characteristics online shoppers and their gas spending habits hold. Therefore, I want to explore if there are any changes in the coefficients and if those potential disparities are due to changes in extensive or intensive margins. Strictly speaking, it is relevant to know if the variations in results can be explained by if the person is an in-person consumer or if the number of shopping trips can explain the variations in results. Suppose the results are different after limiting our sample. In that case, I can say that variations can be explained through intensive margins, meaning the number of trips taken impacts and shapes our results.

The first column of **Table 5** is the original model and presents the same results as Table 2. The second column represents the restricted model through a regression with the same demographic characteristic as the independent variables. The dependent variable converts to

respondents with a positive number of shopping trips, in other words, respondents who took any shopping trips. Changes in the results are explained by the extensive margin, denoting that the results were impacted by people who did not take any shopping trips. Overall, there is a decrease in all the coefficients. Those who did not take any shopping trips significantly impacted my conclusions about the characteristics of a traditional shopper. Notable changes are the increase in the coefficient for the number of children, number of household members and whether the person is employed. Having an additional child and being employed does not decrease the number of shopping trips as much as it used to with -9.352 versus -0.036 for children and -14.403 versus -0.133 for the employment status. This shows that being unemployed and having children does not have as much as a negative impact on the number of shopping trips as what I previously found. The coefficient on household income variable also increased and got closer to zero, but also became statistically unsignificant.

The third column of the table investigates changes in the intensive margin. I examine if an increase in the number of shopping trips impacts our results. The goal is to understand if what matters the most is doing any shopping or a certain number of shopping trips. Comparing the first and third columns, there is a significant increase in the coefficients for household income, household size, and residential location. However, there is a decrease in the coefficient for the race, gender, and level of education variables. I can determine that the number of shopping trips does matter in shaping our conclusions about the characteristics of shoppers, meaning that some people with certain specific characteristics are more likely to take an increasing number of shopping trips. Still, there is a change in the magnitude of the coefficients but no change in the

signs of the coefficients, which means that overall, the demographics of traditional shoppers hold and online and in-person shopping remains complementary. This robustness check reinforces the results and conclusions drawn previously and shows that a traditional in-person shopper is more likely to earn higher income, be white, be a female, and have a relatively low level of education. The respondent is also more likely to shop in-person if he is unemployed. Living in a urban residential area and having an increasing number of children are characteristics of respondents that would be more likely to practice online shopping by increasing their number of monthly deliveries.

Table 5. Robustness Checks: Extensive and Intensive Margins

	(1) Number of shopping trips	(2) Any shopping trips (Extensive margin)	(3) Nb of shopping trips>0 (intensive margin)
Number of deliveries	0.325***	0.003***	0.263***
	(0.037)	(0)	(0.048)
Household income	0.599***	-0.001	1.019***
	(0.082)	(0.001)	(0.105)
Household size	8.43***	0.033***	9.919***
	(0.295)	(0.003)	(0.371)
Race (=1 white)	2.126***	0.017***	1.752***
	(0.46)	(0.004)	(0.598)
Gender (=1 female)	3.827***	0.034***	2.749***
	(0.331)	(0.003)	(0.42)
Level of education	1.183***	0.009***	0.876***
	(0.169)	(0.002)	(0.213)
Working status (=1 employed)	-14.403***	-0.133***	-8.927***
	(0.472)	(0.004)	(0.595)
Number of children	-9.352***	-0.036***	-10.989***
	(0.37)	(0.003)	(0.473)
Age	0.259***	0.003***	0.118***
	(0.013)	(0)	(0.018)
Residential Area (=1 urban)	-4.274***	-0.008**	-5.822***
	(0.393)	(0.004)	(0.489)
Price opinion	1.56***	0.006**	1.858***
	(0.339)	(0.003)	(0.429)
Number of workers	-1.044***	0	-1.123***
	(0.313)	(0.003)	(0.388)

Constant	11.558***	0.393***	39.766***
	(1.31)	(0.012)	(1.702)
Observations	101174	101174	61974
R-squared	0.051	0.043	0.035

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

The second part of my robustness check uses the fourth regression, where driving behaviors and shopping habits are regressed on total gas consumption but restricted to household members who took at least one shopping trip on the day of the survey, and therefore, at least one monthly shopping trip after recoding of the variable. The results are reported in **Table 6**. The first column is the unrestricted version of the regression, and the second column is the model restricted for respondents with a positive number of shopping trips. Overall, the results are very similar. Notable changes are the increase in the coefficient for the number of shopping trips. An additional shopping trip increases gas consumption by 0.03 gallons, compared to the insignificant 0.015 gallons in the unrestricted model. These new findings are now statistically significance which allows me to conclude with more confidence that an increase in the number of shopping trips leads to more greenhouse gas emissions and is more harmful to the environment. An increase in the number of deliveries decreases, on average, gas consumption by 0.475 gallons which is a smaller coefficient than in the restricted model. This number also lost some statistical significance, which shows that results need to be interpreted with caution.

Table 6. Table 5. Robustness Checks: Restriction of the Model

	(1) Annual gas consumption	(2) Annual gas consumption

Number of shopping trips	0.015	0.03*
	(0.014)	(0.018)
Number of deliveries	-0.507***	-0.475**
	(0.153)	(0.207)
Gas cost per day	-53.872***	-52.744***
	(2.278)	(3.094)
Household income	-2.604***	-2.777***
	(0.303)	(0.408)
Miles driven for shopping trips	0.021	0.024
	(0.016)	(0.018)
Miles driven for other purposes	-0.004	-0.009*
	(0.003)	(0.005)
Miles driven per year	0.048***	0.048***
	(0)	(0)
Number of vehicles	20.322***	19.031***
	(0.766)	(1.024)
Time traveled (minutes)	.044**	0.045
	(0.018)	(0.032)
Number of drivers	-0.93	-0.346
	(1.21)	(1.629)
Constant	104.974***	98.409***
	(5.904)	(8.028)
Observations	101174	61974
R-squared	0.85	0.825

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

As discussed in a subsequent section, other components need to be considered, especially now that the robustness check decreases the significance of my conclusion. The table also shows an increase in the coefficients for the annual gas cost and time traveled variable. There is also a slight decrease in the coefficient for the number of vehicles and driver variables, as well as number of miles driven for shopping trips and other purposes, but they all stayed statistically insignificant. Overall, I can conclude that the results between the standard and restricted models are consistent and that respondents who did not take any shopping trips were not driving my results. Online shopping stays the better alternative to decrease gas consumption. Still, it loses

some significance, highlighting that there is no clear cut for which shopping practice is the best for the environment.

Limitations

One of the limitations is that my results are in accordance with previous research, but conclusions need to be drawn carefully. I concluded that online shopping and in-person shopping are complementary because of the positive correlation between an increase in the number of monthly deliveries and the number of in-person shopping trips. Still, the comparison between the coefficient was only feasible after proportionally modifying the number of shopping trips variable from a daily to a monthly variable, which means that they are some gaps in the respondents' responses since they increase by increment of 30. My analysis also lacked the availability of actual environmentally related variables, which led me to use gas consumption as a proxy for the environmental variable. Therefore, it is possible that a more complete data set with survey questions asked consistently on a monthly basis and an actual variable accounting for environmental well-being would have led to different results.

Throughout this paper, I also concluded that online shopping was more respectful of the environment since it led to a decrease in gas consumption. Fewer gas consumption means fewer greenhouse gas emissions, and I concluded that getting deliveries was more sustainable than taking shopping trips, but this is solely from a gas consumption point of view. As discussed in the literature review, deliveries are better for the environment but uniquely under certain conditions. In my model, I only account for greenhouse gas emissions produced by consumers driving behavior. Yet, researchers showed that the speed of the delivery and whether the product is returned - since people tend to return their products more when buying online - are key

variables that negatively impact the environment. Access to delivery companies' datasets would have permitted a deeper dive into delivery patterns and habits. For instance, looking at how many people are being delivered with the same delivery trip could have enable the comparison between the individual carbon footprint of people ordering online versus practicing in-person shopping. Although online shopping seems be better for the environment from a consumer perspective, this conclusion does not account for online shopping behaviors that are harmful to the environment.

Another limitation was not being able to use the race category as a categorical variable. The original variable of the dataset was coded in seven different categories, such as white, black, or African American, Asian, Indian or Alaska Native, Native Hawaiian, or other. Yet, there were a few observations per category, making a potential analysis per race category insignificant. Therefore, I decided to use a binary variable with white versus other races, despite the lack of diversity. I hope that future waves of this dataset will have more observations per variable and allow for a categorical analysis of the race variable.

Future Research

In the future, finding more complete data sets on people's shopping habits would be beneficial. It could be thought-provoking to see how shopping patterns vary depending on the type of goods bought, for example, between food and clothes, and get more data on people's shopping preferences. Future research could also take into consideration what people consume quantity-wise. This would give us a better picture of consumers' carbon footprint beyond the gas consumption point of view. As Kavilanz addressed, consumers buying many clothes online might order more often and are more likely to return their product. They have a higher carbon

footprint relative to someone who practices in-person shopping and buys fewer clothes at once (2020). The packaging in which online deliveries come in also plays an important role in the overall greenhouse gas emissions related to shopping. As discussed in the limitations section, having access to delivery companies' data, such as Amazon or UPS, would also be essential to evaluate if their deliveries are environmentally efficient. The most important elements would be looking at the number of households delivered with one truck trip and looking at how full the delivery truck is. Analyzing the difference between consumers who use fast versus regular deliveries would also be interesting since fast deliveries have been found to have a worse adverse effect on the environment (Kavilanz, 2020). Considering all of those variables in future research will be necessary to efficiently conclude which shopping practice is the most respectful of the environment. This is a complex problem, and the answer might not be clear-cut.

There are also some elements that I want to work on for future research. Conducting a more in-depth heterogenous analysis would be beneficial, notably by investigating changes in race, number of children and educational level, in order to establish a clearer picture on the demographic characteristics of online and in-person shoppers. Adding some variables relating to consumers' utility, or satisfaction, when shopping, as well as their internet usage frequency could also play an important role in determining who is more likely to engage in in-person shopping.

Conclusion

This paper investigated the correlation between consumers' shopping behaviors and their environmental impact. Indeed, greenhouse gas emissions are responsible for climate change and the degradation of our environment. Greenhouse gas emissions are partially explained by the fuel that cars burn while driving. Since fuel is essential to drive, investigating gas consumption

patterns in relation to shopping behaviors highlights how shopping behaviors influence consumers' impact on climate change. Theoretically, the more significant the increase in gas consumption, the more greenhouse gas emissions are produced from burning fuels and the greater the negative impact on the environment is. This paper also explored the demographic characteristics of people practicing both in-person shopping. Older people are more likely to participate in in-person shopping trips. Women respondents, as well as white respondents and unemployed respondents are also more incline to participate in in-person shopping. The analysis informed us of the typical profile of consumers who spend the most money on gas and therefore are more responsible for greenhouse gas emissions when shopping. Analyzing the demographics also allowed us to illustrate the budget and time constraint economic theories according to which people need to make choices to allocate their money and time depending on the well-being, or utility, that they will gain from a particular activity.

The positive correlation between an additional monthly delivery and the numbers of in-person shopping trip led to the conclusion that both shopping patterns are complementary. This means that respondents participate in online shopping in addition to participating in in-person shopping, rather than substituting in-person shopping for online shopping. I also find that an additional delivery is correlated with less gas consumption, and an additional shopping trip is positively correlated with increased gas consumption. Therefore, I conclude that in-person shopping has a more adverse effect on the environment than online shopping because participating in online shopping leads to fewer greenhouse gas emissions. However, it does not mean that online shopping is the solution to climate change. As addressed in my limitation section, other factors must be considered to verify if online shopping is better for the environment. It is also important to keep in mind that the conclusion drawn highlights the

complementary effect between the two practices. Thus, even if online shopping is better for the environment from a consumer and gas consumption point of view, it is important to remember that the person ordering online is also likely to consume in person. Overall, because of the complementarity of both, there is an increase in the quantity of gas consumed. A person using both means of shopping will represent a more adverse impact on the environment compared to someone who practices one or the other.

This paper highlighted the complementarity between online and in-person shopping, which overall leads to a more significant increase in greenhouse gas emissions compared to if both shopping habits were substitutes. Thus, those results show us that we live in a capitalist society where everything is made more accessible for people to consume, which leads people to forget about the implications and consequences of their actions. If we want to evolve toward a more responsible and sustainable society, it would be essential to develop some policies and activities that will lead people to be more environmentally responsible. Educating people, from a young age, in school, about the consequences of their actions on the environment might be a great start. It would be interesting to analyze the practices of "greener" countries and implement those strategies in the US. Overall, a change of mindset within our consumer society is necessary to be able to achieve positive change on the environment.

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Appendix

Table A1. List of variables and definitions

Variable Name	**Definition**	**Description**
Age	Age of the respondent	Continuous
Household income	Annual household income	Ranges by 11 increments of 15,000$, from $10,000 to above $150,000
Number of drivers	Number of drivers in the household	Continuous
Gas cost per day	Annualized fixed cost in US$ per gallon	Continuous
Gas consumption	Annual consumption in US gallons	Continuous
Number of deliveries	Count of deliveries in the past month	Continuous
Miles driven for other purposes	Number of miles driven for purposes other than in-person shopping	Continuous
Miles driven for shopping	Number of miles driven for shopping	Continuous
Miles driven per year	Estimate of annual miles driven per year per respondent	Continuous
Number of adults	Number of adults in the household	Continuous
Number of drivers	Number of drivers in the household	Continuous

Employment status	Employment status of the respondent	1=Employed, 0= Unemployed
Time traveled (minutes)	Duration of the trip in minute	Continuous
Race	Race of the respondent	1=White, 0= Other
Gender	Gender of the respondent	1=Female, 0=Male
Price opinion	If increase in price impacts trip decisions	1=Yes(agree), 0=No
Education	Level of education of the respondent	1= Less than high school, 2= High school graduate, 3= some college or associate degree, 4= Bachelor's degree, 5=Graduate degree or professional degree
Residential area	If the respondent lives in an urban area	1=Rural, 0= Urban
Number of workers	Number of workers in the household	Continuous