

"Would You Be Willing to Wait?":
Consumer Preference for Green Last Mile Home Delivery

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ABSTRACT

The growing trend of e-commerce has led to new ways of selling and delivering products, resulting in increasing scale and complexity of last mile home delivery. The drive to provide convenience to consumers has led companies to offer faster delivery times. As a result, companies have focused on facility location, network design, and asset utilization (trucks, drivers), in order to improve service and speed. Few, however, have questioned whether consumers truly want convenient and fast delivery. Rather than focusing on a company's operations, we approach the last mile home delivery from the perspective of the consumer. Our research considers whether consumer preferences for home delivery options can be influenced by environmental incentives, which include CO₂ equivalent, electricity, trash, and trees. A case study with a corporate partner, Coppel S.A. de C.V. ("Company"), one of Mexico's largest retail companies, reveals ways to incentivize consumers to wait longer. The case study involves a field study of approximately 1,000 home deliveries to predominantly low socioeconomic households across ten regions of Mexico. The results suggest that consumers are willing to wait longer for their home deliveries when given the environmental impact reduction. Moreover, information on trees saved is the most effective at incentivizing consumers to wait longer, regardless of education, occupation or socioeconomic status. Finally, using this extended delivery lead time, we provide an alternative methodology for improving vehicle utilization in last mile deliveries of a one-warehouse-N-customer system. The improved utilization results in lower fuel consumption and reduced carbon emissions.

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List of Acronyms

AMAI	Mexican Association of Marketing Research and Public Opinion Agencies
GHG	Greenhouse Gas
INEGI	National Institute of Statistics, Geography and Informatics
NTM	Network for Transport and the Environment

Glossary

Carbon footprint	The total amount of greenhouse gases that is emitted into the atmosphere each year by a person, family, building, organization, or company. A person's carbon footprint includes carbon emissions from fuel that he or she burns directly, such as by heating a home or riding in a car. It also includes greenhouse gases that come from producing the goods or services that the person uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash gets sent.
Carbon dioxide equivalent	A unit of measurement that can be used to compare the emissions of various greenhouse gases based on how long they stay in the atmosphere and how much heat they can trap. For example, over a period of 100 years, 1 pound of methane will trap as much heat as 21 pounds of carbon dioxide. Thus, 1 pound of methane is equal to 21 pounds of carbon dioxide equivalents.
Greenhouse gas	Also sometimes known as "heat trapping gases," greenhouse gases are natural or manmade gases that trap heat in the atmosphere and contribute to the greenhouse effect. Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and fluorinated gases.

Chapter 1. Introduction

Companies provide various delivery schedules (one-day, three-five-day, two-week) to consumers for home delivery. Shorter delivery times, while convenient for the customer, present logistical difficulties for companies, both in scheduling deliveries and managing their private vehicle fleet. Extending delivery times provides opportunities to improve truck utilization and reduce a company's carbon footprint, but how can a company convince its customers to wait longer for their deliveries? In this research, we study environmental incentives to drive consumer behavior. A 2015 Nielsen report (Nielsen, 2015) found increased consumer interest in sustainability offerings. Our research is interested in learning whether consumers are willing to wait longer for their deliveries when given the environmental impact information of shorter delivery times. Our corporate partner operates approximately 1,300 stores that specialize in household goods and clothing. The Company, as well as many other Consumer Packaged Goods (CPG) and retail companies that provide home delivery, are looking for additional delivery options that tap into consumers' demand for sustainable delivery options. Currently, the Company provides customers with a one-day delivery option; however, this offering reduces the Company's transportation efficiency; more trucks are sent out half-full, increasing the number of trips and vehicles on the road. Carbon emissions per customer per product are higher as a result. This research analyzes the environmental impact of a one-day delivery promise and finds key drivers that affect the Mexican customer's willingness to wait for home deliveries.

In order to evaluate consumer preference, we established the following hypotheses based on the Nielsen study, which suggests that consumers across regions, income levels are willing to pay more as long as doing so keeps them in line with their values (Nielsen, 2015):

1. The following groups prefer green delivery options over other groups:
 - a. Age: Millennials over other generations
 - b. Education: Highly educated (University or higher) population over the rest of the population
 - c. Socioeconomic Status: High income and status population over the rest of the population
 - d. Region: Urban population (Mexico City) over suburban population
2. Providing environmental impact information increases consumer preference towards a green delivery option

3. Different types of environmental impact information results in different consumer preferences toward a green delivery option. We test four equivalent expressions for 10 tons of CO₂ emissions, calculated using the Greenhouse Gas Equivalencies Calculator¹
 - a. CO₂ equivalent: 10 tons of CO₂ emissions
 - b. Electricity: 1 Homes' electricity use for 2 months
 - c. Trash: 500kg of waste recycled instead of landfilled
 - d. Trees: 45 tree seedlings grown for 10 years

Our research capstone is organized as follows: Chapter 2 provides a review of existing research on last mile delivery and consumer demand for sustainable product. In Chapter 3, we conducted a field study to test our hypotheses to better evaluate the consumer preference and profile groups (type of consumer) who are more likely to prefer green delivery option. Next, using the Network for Transport and Environment (NTM) methodology (Bäckström & Jerksjö, 2010), we calculated the carbon emissions reduction for vehicles performing last mile deliveries in a one-warehouse-to-N-customers system (Chapter 4). In our analysis, we assume customer adoption of green delivery in a selected region of Mexico: Culiacan, Sinaloa. We conclude with a summary of the results of our hypothesis testing (Chapter 5).

¹ United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator: <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

Chapter 2. Literature Review

In recent years, results from a number of research papers have concluded that anthropogenic emissions likely pose a serious threat to our environment. The temperature is expected to raise 2°C -4°C on average by 2100 largely due to the six Green House Gases that trap heat within the earth's atmosphere which cause the temperature raise. Gupta and Palsule-Desai (2011) analyzed how businesses can consider strategic change towards sustainable supply chain. Some topics include the value consumers place on the environmental attributes of product, and advertising and promotion strategies for a “green” product. Other research papers (Rokka & Uusitalo, 2008) also emphasize the increasing importance of the ethical and environmental dimension in product choices.

Prior literature has focused on factors that affect green freight transportation (Demir, Bektas, & Laporte, 2012), but few studies have shed the light on the consumer's preference. We argue the lack of information is largely due to the difficulty in gathering information on consumers (Jaffe & Stavins, 1994).

The Nielsen report (Nielsen, 2015) is one of few research reports that provides analysis showed increased consumer interest in sustainability offerings. Sixty-six percent of global respondents say they are willing to pay more for sustainable goods, up from 55% in 2014, with Millennials (born between 1980 and 1997)² saying they would be the most willing to pay extra for sustainable offerings (almost three-out-of-four respondents in the latest findings, Nielsen Report 2015). Also, Millennials make up more than half of those who intend to buy online (Nielsen report 2014).

While several methodologies exist to calculate CO₂ emission, such as The Greenhouse Gas Protocol (World Resources Institute, 2018), NTM model (Bäckström & Jerksjö, 2010), and the Comprehensive Modal Emissions Model (Barth et al., 2005), few studies have considered changing consumer preferences for delivery as a method for extending delivery lead time. Isley, Stern, Carmichael, Joseph, and Arent (2016) explored potential options for companies to reduce their carbon footprint including the example of non-rush deliveries with Amazon and still maintain their customer satisfaction. Customer density and delivery window length have a statistically significant and substantial effect on route efficiency. A delivery window of one day costs substantially more than a delivery window of four days (Boyer, Prud'homme & Chung, 2009).

² The exact definition of a Millennial varies depending on source, but general consensus holds that individuals born in the 1980s up to around 2000 are considered Millennials. The authors of this paper chose to denote Millennials as being born between 1984 and 1993.

As Nielsen report pointed out with the increased demand for home delivery due to e-commerce (2014) and consumer focus on sustainable offerings (2015), this research provides a profile of consumers in the retail industry who are most interested in sustainable home delivery offerings and presents effective ways to incentivize consumers to choose longer delivery times. Questionnaire design for recording consumer preferences followed the methodology set forth by Iacobucci and Churchill (2010). Finally, we apply the NTM model (Bäckström & Jerksjö, 2010) to evaluate the impact of a change in delivery policy from one day to four days.

Chapter 3. Field Study

3.1. Methodology

This research assesses changes in preferences for delivery times in Mexican consumers, when given economic and environmental incentives.

The project consisted of four phases as depicted in Figure 1:

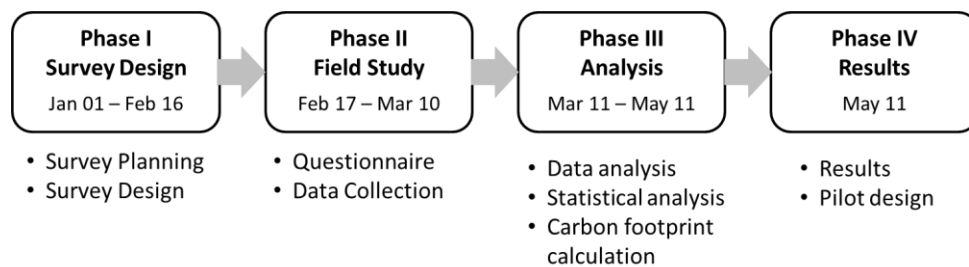


Figure 1: Project Overview

We designed a questionnaire, deployed the questionnaire in a field study of over three thousand households, receiving 961 responses), analyzed the responses, and present our results.

3.1.1. Phase I: Questionnaire Design

Several communication methods exist for collecting data: in-person, telephone, email, and mail. We chose an in-person questionnaire over the other methods because of the high response rate (see Appendix A) and ability of interviewers to observe respondents and collect qualitative information not asked on the questionnaire.

We designed a structured-undisguised questionnaire. Structured observation is applicable when the problem is defined precisely enough to clearly specify the behaviors that will be observed and the categories that will be used to record and analyze the observations (e.g. answer choices that are multiple choice or numeric answers). Undisguised in observational methods refers to the consumers' knowing they are being observed. Personal interviews were conducted at the front door of households during home deliveries. Questionnaires were provided using the Fulcrum mobile application on iOS and Android

enabled smartphones³. The questionnaires were designed as follows (see Table 1): The set of questions are designed to evaluate the consumer's willingness to wait longer for their current delivery under three scenarios 1) when given no incentive or information, 2) when given economic incentive and 3) when given environmental impact information. Under each condition, interviewers asked consumers how many days they would be willing to wait in addition to the days spent for the current delivery.

Table 1: List of questions for the field study

No.	Question	Type
1.	How long did this delivery take?	Multiple choice
2.	How did you find this delivery? Fast, Normal or Slow?	Multiple choice
3.	Would you be willing to wait longer?	Multiple choice
4.	If so, how many additional days?	Numeric
5.	Would you be willing to wait longer if an economic incentive was offered?	Multiple choice
6.	If so, how many additional days?	Numeric
7.	<p>If we told you that the impact made of waiting for additional day would be [environmental impact information], would you be willing to wait longer?</p> <p>➤ One of the following pieces of environmental impact information was given:</p> <ol style="list-style-type: none"> 1. 10 tons of CO₂ emission 2. 1 Homes' electricity use for 2 months 3. 500kg of waste recycled instead of landfilled 4. 45 tree seedlings grown for 10 years 	Multiple choice
8.	If so, how many additional days?	Numeric
9.	What is your gender?	Multiple choice
10.	What is your age?	Multiple choice
11.	What is your highest education level attained?	Multiple choice
12.	What is your occupation?	Multiple choice

In addition to the above, we collected location data (longitude and latitude). For the complete survey, please see the Appendix B.

³ Website: <http://www.fulcrumapp.com>

3.1.2. Phases II: Field Study

We conducted a field study of approximately one thousand Mexican households in ten regions across Mexico. Through Monterrey Institute of Technology and Higher Education (ITESM, Monterrey Tech)⁴, students from Monterrey Tech would meet at one of the Company's regional distribution center and to join the Company truck driver and navigator on that day's deliveries. For each delivery stop, the students would follow a script (see Appendix B) and typically request to conduct the questionnaire at the end of the delivery stop, as the trucks were being closed up. The actual field study was conducted over a period of three weeks across ten regions in Mexico (See Figure 2).



Figure 2: Regions where field study was conducted

⁴ Website: <http://www.tec.mx/es>

3.1.3. Phase III: Analyzing the Questionnaire

In total, we have data on 961 responses, exported from the Fulcrum application in excel format. We tabulate the data to remove omissions and locate blunders (Iacobucci & Churchill, 2010). When analyzing one set of variables, some subjects DO NOT respond to a question; in these instances, that subject's response is temporarily omitted from that analysis. For the analysis of another set of variables in which the subject DOES respond to those questions, the subject's response is added back to the analysis. In each analysis, the number of cases is reported. We analyze the data for trends and conduct statistical analyses to determine any relationships among the variables (measures of central tendency, Difference of Means, Chi-Square Goodness-of-Fit, ANOVA, and Binary Logistic Regression).

The two factors that we test for are 1) willingness to wait and 2) number of additional days willing to wait. We cross-tabulate the data to discern relationships between an attribute, such as age, gender, education, occupation, and willingness to wait. First, we provide a profile of the respondents according to age, education, occupation, socioeconomic status, and region. In particular, for socioeconomic status, we group the households according to data from the National Institute of Statistics, Geography and Informatics (INEGI, 2005). Then we related the INEGI information with The Mexican Association of Marketing and Research and Public Opinion Agencies (AMAI) socioeconomic level index (AMAI, 2008) which has six levels, the lowest being E (lowest socioeconomic status) and the highest, A/B (highest socioeconomic status). Please see the appendix D for further details on the AMAI index. Next we look at customer willingness to wait.

To assess the statistical significance of our findings, we conduct several tests. First, we compare willingness to wait (yes/no) using the Difference of Means test (one-sample t-test). Next, using the Difference of Means test (two-sample t-test), we compare the effects of three levels (treatments) – no incentives, economic incentives, and environmental incentives – on willingness to wait, and then run the same analysis on the number of additional days willing to wait.

Next, using the Chi-Square Goodness-of-Fit test, we determine whether the proportion of items in each attribute is significantly different from the proportions of the rest of the same attribute. For example, we determine whether the proportion of 25-34 year olds willing to wait (observed frequency) is the same as the proportion of all other ages willing to wait (expected frequency).

To add robustness to the analysis, we complement the Chi-Square Goodness-of-Fit Test with one-way ANOVA (analysis of variance) to determine whether the means of various levels in an attribute are equal. For example, we determine whether the mean willingness to wait (willing to wait = 1, not willing to wait

= 0) of 25-34 year olds is different from the mean willingness to wait of all other ages. For those levels whose means are not equal, we conduct a Tukey HSD (Honestly Significant Difference) test to determine the size of the difference and resulting confidence intervals.

Finally, we run a binary logistic regression analysis on willingness to wait with predictor variables age group, education level, socioeconomic level, occupation, and region. While the Goodness-of-Fit analysis used categorical variables for all demographic groups, the regression uses normalized values for age, education level, and socioeconomic level, allowing us to evaluate each group as a continuous variable⁵.

⁵ Note: age, education level and socioeconomic level normalized as follows.

Age: 1 (18-24), 2 (25-34), 3 (35-44), 4 (45-54), 5 (55-64), 6 (65-74)

Education level: 1 (Primary-Secondary), 2 (High School), 3 (University), 4 (Post-graduate)

Socioeconomic level: 1 (A), 2 (B), 3 (C+), 4 (C), 5 (D+), 6 (D), 7 (E)

3.2. Results and Discussion

3.2.1. Profile of Respondents

The most common profile of respondents is a female housewife with high school or lower education level, socioeconomic level of D or D+, and age between 18 and 54. This group represents 8% of total respondents.

Socioeconomic Status

The AMAI socioeconomic level is a hierarchical structure based on the accumulation of economic and social capital in the Mexican population. The level consists of thirteen variables:

- The economic dimension represents the possession of material goods. In the AMAI index, it is operationalized by the possession of 12 assets (Light, Color TV, Car, Floor, DVD, Microwave, Bathroom, Computer, Sprinkler, Stove, Domestic service, Room)
- The social dimension represents the stock of knowledge, contacts and social networks. In the AMAI index, it is operationalized by the level of study of the head of the family

The socioeconomic level represents the ability to access a set of goods and lifestyles. The AMAI model has six levels, the lowest being E (low socioeconomic status) and the highest, A/B (high socioeconomic status). Points are awarded based on a criteria consisting of the thirteen variables, as stated above. Each variable is weighted according to its importance. Assigned points for each variable are based on the coefficient of each one the values in a regression on the family income (see Appendix D for further details).

Figure 3 details the demographics of the respondents.



Figure 3: Demographic profile of all respondents

3.2.2. Descriptive Analysis

Our results show that 91% of customers of the Company are satisfied with the current delivery time. The number of delivery days range from one day to over four days (average of 2.2 days vs. the one day promised by Company). 50% of customers show a willingness to wait longer with no incentive or additional information, and this number increases to 70% with economic incentive provided and to 71% with environmental impact information provided. Figure 4 provides information on the entire dataset. The

left bar graph in Figure 4 shows that 50% of the customers answer that they are willing to wait a little longer with no incentive or information, suggesting that even with an average delivery time of 2.2 days and without additional incentives, the Company could justifiably increase its delivery time.

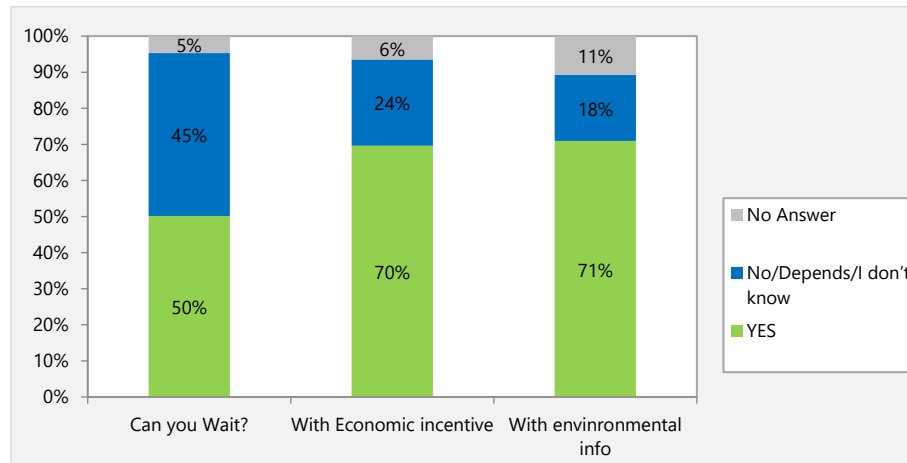


Figure 4: Customer response to Q3 (Sample size: all response 961)

The middle bar graph in Figure 4 shows the number of customers who respond “Yes” increases to 70% when an economic incentive is offered, and the right bar graph shows an increase to 71% when environmental impact is provided. The number of customers who respond “No/ Depends/I don’t know” decrease from 45% to 24% when the economic incentive is offered and from 45% to 18% when environmental impact is provided.

Among the respondents who answered “No/ Depends/I don’t know” to economic incentives, 53% changed their minds to “Yes” when shown the environmental impact of waiting an additional day for delivery.

Figure 5 also presents willingness to wait, but sorts according to socioeconomic status. We grouped the households according to The AMAI index, which uses data from INEGI. The AMAI model has six levels, the lowest is E (lowest socioeconomic status) and the highest is A/B (highest socioeconomic status). Please see the appendix D for further details on the AMAI index and INEGI. As shown in the left bar graph, a total of 62% of customers who responded “No/Depends/I don’t know” to the question of whether they can wait a little longer - with no incentive or additional information - changed their mind to “Yes” when given environmental information (yellow bars).

The right bar graphs in Figure 5 shows how responses changed from “No/ Depends/ I don’t know” when different **information on environmental impact** is communicated (i.e. CO₂ emission, Electricity, Trash

or Tree). As show in the bottom right bar graph, providing customers environmental information (waiting an additional day for delivery results in the saving of 45 tree seedlings grown for 10 years) resulted in the largest percentage of customers changing their response from “No/ Depends/ I don’t know” to “Yes” (78%). Separately, environmental savings equivalent one home’s electricity use for two months shows the largest number of people who consistently said “No” to the initial question and “No answer” given environmental incentives, when compared with other environmental information.

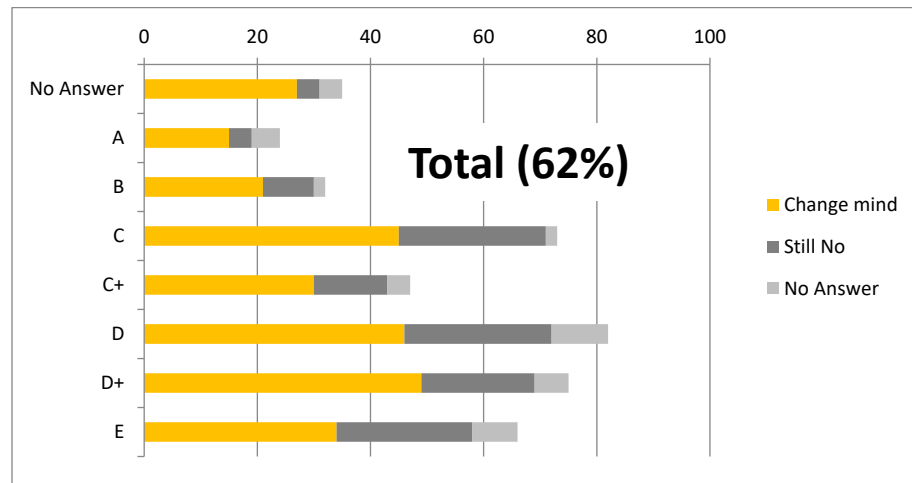


Figure 5: Customer response changes to “Yes” from question three to question five (sample size: 434)

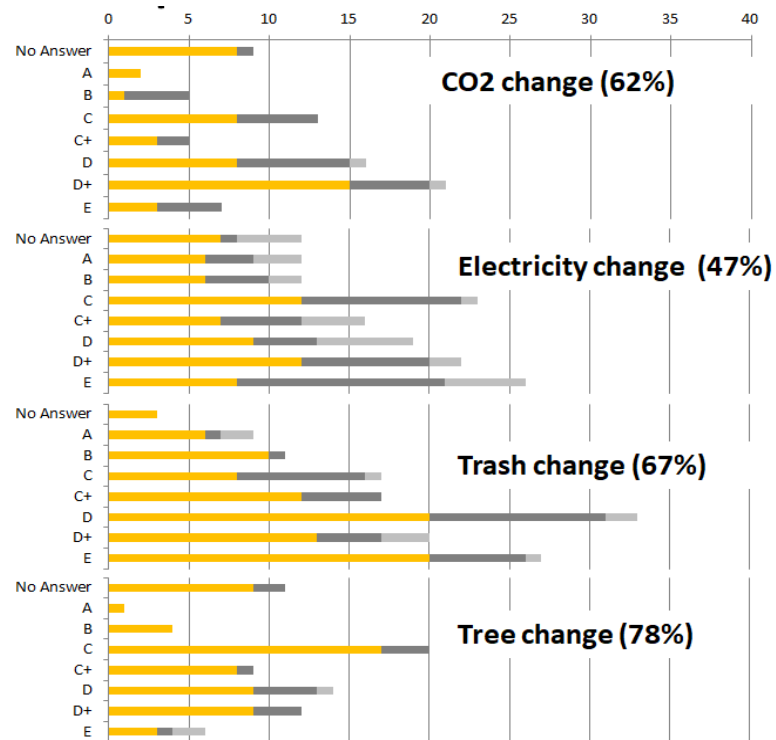


Figure 6: Customer response changes per environment impact information

3.2.3. Consumer Tolerance for Longer Delivery Times

The questionnaire also revealed that customers are willing to wait 4.3 days on average to receive their purchase. This number increases to 5.5 days with economic incentives and to 4.7 days when environmental impact information was given (See Figure 7⁶). Figure 8 presents a range free delivery times ranging from two to fifteen days for various American retailers (Beyer, 2011). Based on these results, we conclude that a consumer tolerance level of four days for deliveries is reasonable.

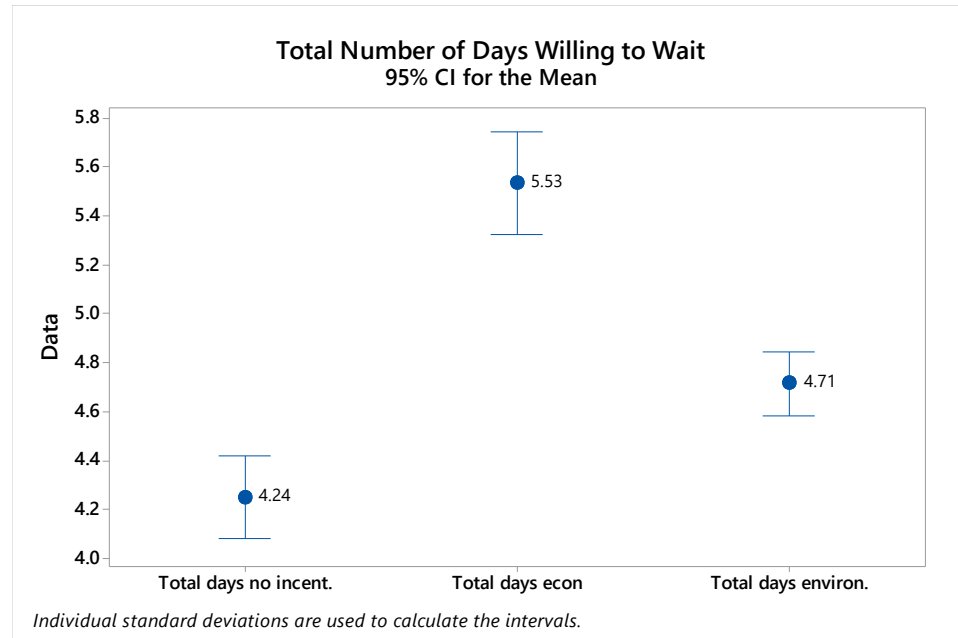


Figure 7: Consumer's willingness to wait (Number of days)

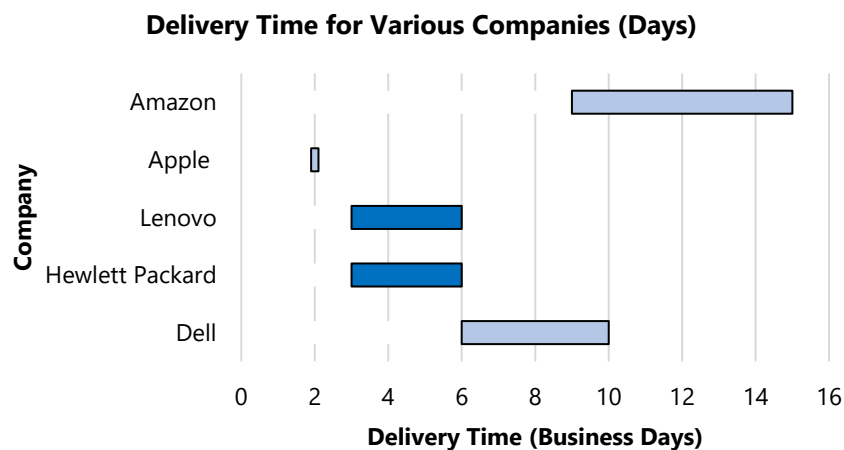


Figure 8. Free delivery time for various companies (Beyer, 2011)

⁶ This graph excludes consumers who responded as willing to wait 15 days or more and blank values

3.2.4. Inferential Analysis⁷

Differences among demographic groups

We conduct statistical analyses (measures of central tendency, Difference of Means, Chi-Square Goodness-of-Fit, ANOVA, and Binary Logistic Regression) to calculate the effects of various factors (economic incentives, environmental incentives, age group, education level, occupation, socioeconomic status, and region) on willingness to wait and number of additional days willing to wait.

Using the Difference of Means test (two-sample t-test), results show that there is a statistically significant difference in mean willingness to wait vs. a baseline of no willingness to wait (willing to wait = 1, not willing to wait = 0). There is 95% confidence that the respondents are between 47.0% and 53.3% more likely to say they are willing to wait than they are to say they are not willing to wait.

Next, the effect of economic and environmental incentives is assessed. Figure 9 shows the willingness to wait (Yes/No) depending on the information provided (no incentive, economic incentive, environmental incentive). Using the Difference of Means test (two-sample t-test), the results show that there is a statistically significant difference in willingness to wait between environmental incentive vs. no incentive (respondents given environmental incentives are 21% more likely to wait), and between economic incentives vs. no incentive (respondents given economic incentives are 19% more likely to wait, see Table 2). For the number of additional days willing to wait, there is a statistically significant difference between economic incentive vs. environmental incentive (respondents given economic incentives are willing to wait an additional 0.8 days), between environmental incentive vs. no incentive (respondents given environmental incentives are willing to wait an additional 0.5 days), and between economic incentive vs. no incentive (respondents given economic incentives willing to wait an additional 1.3 days, see Table 2).

⁷ Note: throughout the paper, we denote statistical significance as having a p-value < 0.05

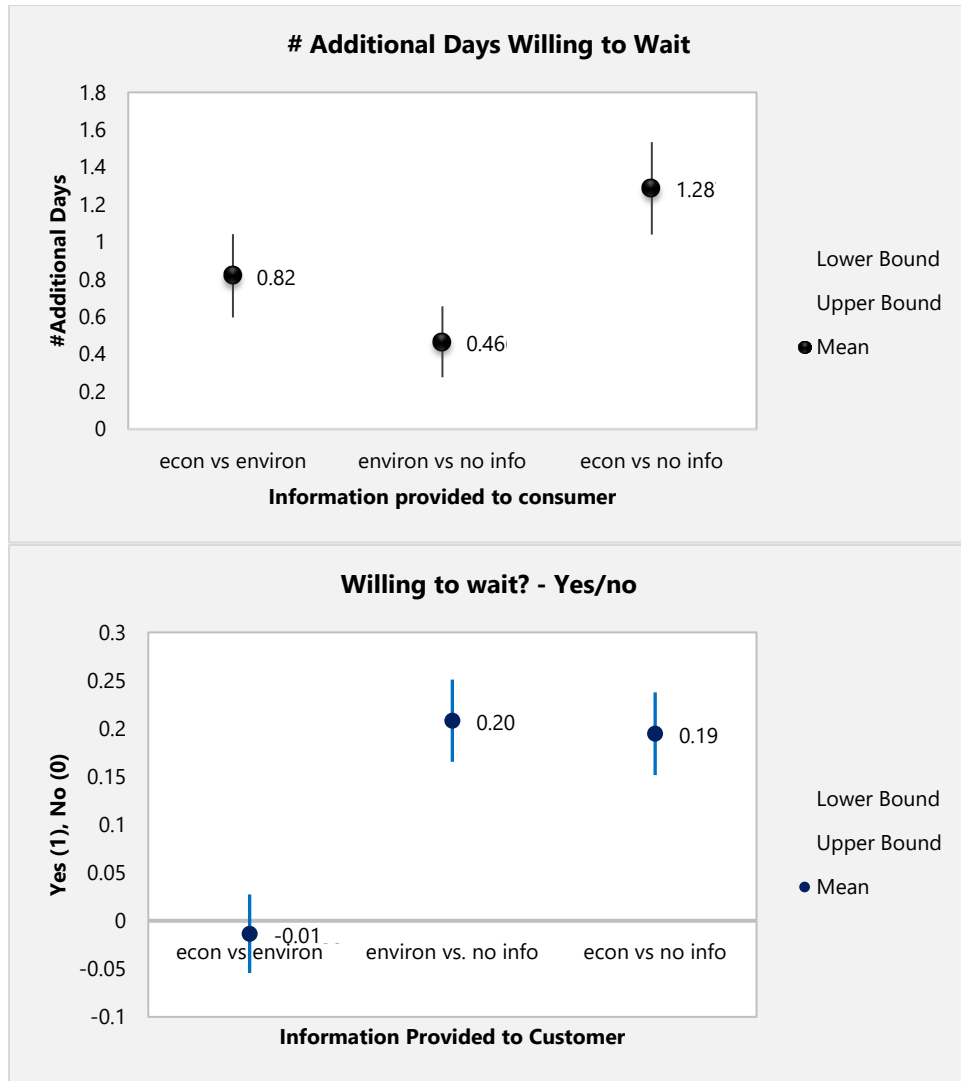


Figure 9 Willingness to wait (Yes/No and Number of Additional Days)

Table 2: Comparison of willingness to wait: Difference of Means (Two-Sample T-Test)

Question	Comparison	Difference of Means	Confidence Interval		Statistically Significant at 0.05?
			CI 95% LHS	CI 95% RHS	
Willing to Wait? (Y/N)	econ vs environ	-0.01	-0.05	0.03	
	environ vs. no info	0.21	0.17	0.25	Yes
	econ vs no info	0.19	0.15	0.24	Yes
Additional # of Days Wait	econ vs environ	0.82	0.60	1.04	Yes
	environ vs no info	0.47	0.28	0.66	Yes
	econ vs no info	1.29	1.04	1.53	Yes

To compare the differences among types of environmental information provided (CO₂, Electricity, Trash, and Trees), we performed an F-test in the ANOVA table and a Tukey HSD (Honestly Significant Difference) test to determine whether any significant differences exist amongst the means.

Figure 10 shows the willingness to wait (Yes/No) depending on the environmental incentive provided. The F-test results show a statistically significant difference in the means and the Tukey test (see Table 3) show that there is a statistically significant difference of mean willingness to wait between environmental information on trash vs. electricity, and between trees vs. electricity. The results suggest respondents are more willing to wait when given information on trash recycled instead of land-filled (14.3% more likely) compared to information on electricity savings. Respondents are also more willing to wait given information on trees saved (16.7 % more likely) compared to information on electricity savings.

Table 3: Willingness to wait - comparison between environmental incentives

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Electricity - CO ₂	-0.09	0.05	(-0.21, 0.02)	-2.05	0.170
Trash - CO ₂	0.05	0.04	(-0.07, 0.17)	1.02	0.740
Trees - CO ₂	0.07	0.05	(-0.06, 0.20)	1.39	0.507
Trash – Electricity	0.14	0.04	(0.05, 0.23)	4.03	0.000
Trees – Electricity	0.17	0.04	(0.06, 0.27)	4.05	0.000
Trees – Trash	0.02	0.04	(-0.08, 0.13)	0.56	0.944

Individual confidence level = 98.96%

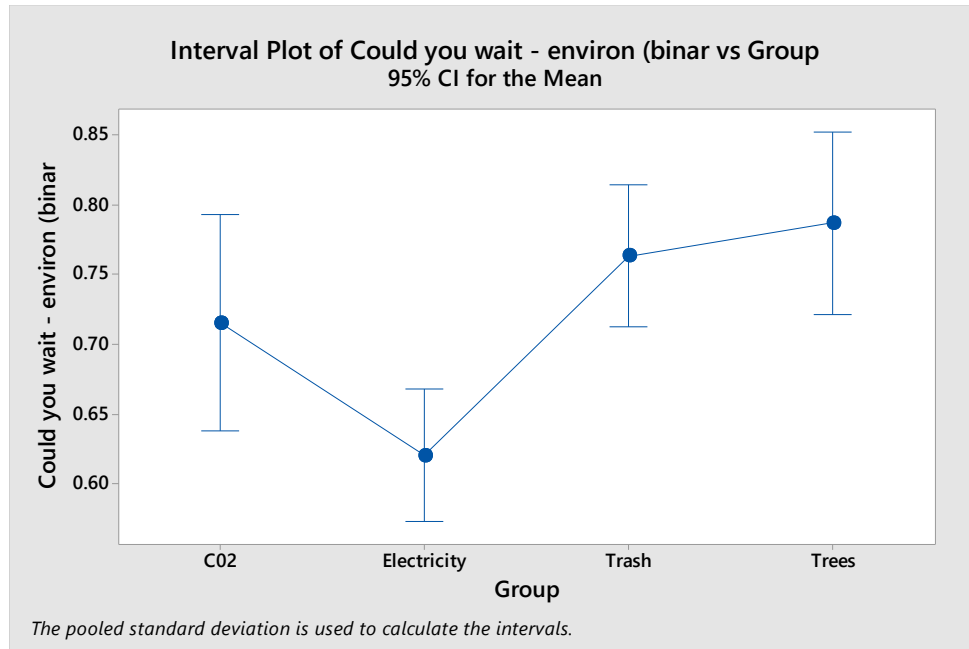


Figure 10 Willingness to wait (Yes = 1, No = 0)

Figure 11 shows the number of additional days willing to wait depending on the environmental incentive provided. The F-test results show a statistically significant difference in the means and the Tukey test (see Table 4) shows that there is a statistically significant difference between environmental information on trees vs electricity. The results suggest respondents are willing to wait approximately 0.7 additional days when given information on trees saved compared to information on electricity savings.

Table 4: Number of additional days willing to wait - comparison between environmental incentives

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Electricity - CO ₂	-0.15	0.25	(-0.80, 0.49)	-0.61	0.928
Trash - CO ₂	0.29	0.26	(-0.38, 0.95)	1.11	0.683
Trees - CO ₂	0.58	0.28	(-0.15, 1.30)	2.05	0.171
Trash - Electricity	0.44	0.19	(-0.06, 0.93)	2.28	0.103
Trees - Electricity	0.73	0.22	(0.16, 1.31)	3.26	0.006
Trees - Trash	0.29	0.23	(-0.30, 0.89)	1.26	0.589

Using Tukey Simultaneous Tests for Differences of Means - Individual confidence level = 98.96%

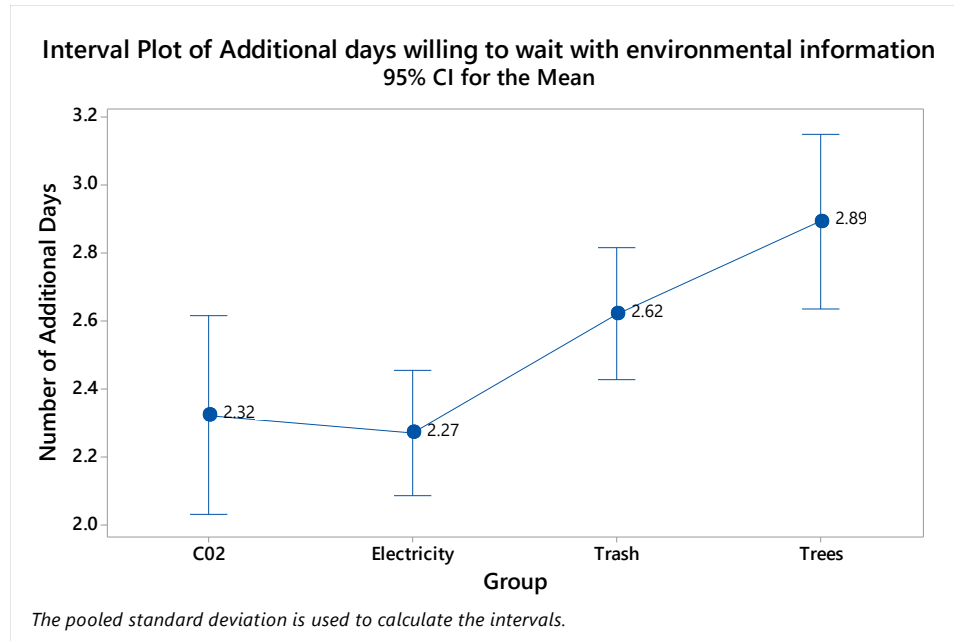


Figure 11 Number of additional days willing to wait given environmental incentives

Willingness to wait according to demographic group – Chi-Square Goodness-of-Fit

Next, the Chi-Square Goodness-of-Fit test was used to assess all groups within a category, such as age group 18-24 year olds against all other age groups. The result shows that the age group of 55-64 year olds is less likely to say that they are willing to wait than other generations when an economic incentive or environmental information is provided (Results can be found in Appendix E). Surprisingly, there is no statistical significance in any other age group saying that they are willing to wait longer. In the next section, we run a binary logistic regression on willingness to wait, but with normalized values for age groups. Similarly, there is no major statistical significance in the demographic categories of education, occupation, and socioeconomic status. The region in Mexico did show statistical significance, with several regions containing respondents saying that they are willing to wait longer. Specifically, Culiacan and Iztapalapa are less likely to say that they are willing to wait in most conditions while León, Monterrey and Toluca are more likely to say that they are willing to wait longer. Detailed results can be found in Appendix E.

A Tukey test compared different regional pairings of the nine regions to see which regions were more likely to wait, here willingness to wait longer is expressed as 1 and lack of willingness to wait is expressed as 0. Results show that Culiacan in particular demonstrates a strong difference of mean

between -0.23 to -0.17, meaning respondents in Culiacan were 17%-23% less willing to wait than those of other regions. Respondents in Toluca, on the other hand, were more willing to wait than those of other regions. Toluca had a difference of means between 0.13 to 0.23 in three different regional pairings. More details can be found in Appendix F.

Next, we conducted a One-way ANOVA on mean willingness to wait and number of additional days willing to wait, among levels of a demographic group. Table 5 provides a summary of the statistically significant groups.

Table 5: Summary of groups that led to statistically different mean willingness to wait and number of additional days willing to wait

Category	ANOVA: Difference of Means					
	Statistically Significant?					
	Willing to Wait (no incentive)	# Days Willing to Wait	Willing to Wait (econ. incentive)	# Days Willing to Wait	Willing to Wait (environ. incentive)	# Days Willing to Wait
Age	-	-	YES (N=891)	YES (N=838)	-	YES (N=838)
Education	-	-	-	-	-	-
Socioeconomic Level (INEGI)	-	-	-	-	-	-
Occupation	-	-	-	-	-	-
Region	YES (N=960)	YES (N=838)	Yes (N=960)	Yes (N=838)	Yes (N=960)	YES (N=838)

Note: N = Number of Responses

1) Age

The age group of respondents resulted in a statistically significant difference in the mean willingness to wait (see Appendix G for analysis), specifically willingness to wait given economic incentives and number of additional days willing to wait given environmental incentives.

For willingness to wait given economic incentives, 55-64 year olds are less likely to say they are willing to wait for their delivery than are 25-34, 34-44, and 45-54 year olds.

For additional days willing to wait given environmental incentives, 55-64 year olds are willing to wait approximately 1 day less than Gen Z (ages 18-24) and Millennials (ages 25-34) for their deliveries.

2) Region

The regional location of respondents' results in a statistically significant difference in the mean willingness to wait (see Appendix G for analysis) regardless of the incentive provided.

In particular, the regions of Toluca, León, and Monterrey show a higher willingness to wait and higher number of additional days willing to wait. Toluca respondents in particular showed a strong willingness, representing 12 of the 36 statistically significant regional differences (see Appendix G). For instance, Toluca respondents are willing to wait between 0.5-3 days longer than Puebla residents when given no incentive. In contrast, Culiacan, Iztapalapa and Azcapotzalco respondents were less willing to wait additional days than respondents in several other regions.

3) Socioeconomic status

Different socioeconomic statuses do not result in a statistically significant difference in the mean willingness to wait (see Appendix G for analysis).

4) Education

Level of education does not result in a statistically significant difference in the mean willingness to wait (see Appendix G for analysis).

5) Occupation

Type of occupation does not result in a statistically significant difference in the mean willingness to wait (see Appendix G for analysis).

Willingness to wait according to demographic group – Binary Logistic Regression Analysis

To determine the correlation between various demographic factors and willingness to wait (Yes/No), we ran a Binary Logit Regression. Our predictor variables were age, campus, education, occupation and socioeconomic status. We normalized three of the demographic groups, age group, education level, and socioeconomic level to run binary logistics regression analysis.

In the earlier goodness of fit analysis, the above three variables were categorical and we found no statistical significance in the level of willingness to wait. In this analysis, we normalized the three variables. The results of the regression (see Table 6) showed that age is negatively correlated with willingness to wait; in other words, younger consumers are more attracted to the green delivery option.

The regression analysis also shows that region is a statistically significant predictor of willingness to wait; however, education, occupation, and socioeconomic level were not statistically significant. Appendix H provides the detailed results.

Table 6: Binary Logistic Regression - willingness to wait (Yes = 1, No = 0)

N = 650	Dependent Variable Willingness to Wait			Dependent Variable Willingness to Wait		
Independent Variable	Full Model	Odds Ratio	p-Value	Reduced Model	Ratio	p-value
Age	-0.1719	0.842	0.019	-0.1573		0.013
Campus			0.038			0.022
Azcapotzalco	Reference level					
Culiacan	-0.913	0.4012	x	-0.467	0.6266	x
Iztapalapa	-0.502	0.6054	x	-0.247	0.7813	x
León	0.223	1.2496	x	0.391	1.4782	x
Monterrey	-0.58	0.5599	x	-0.508	0.6016	x
Puebla	-0.173	0.8414	x	-0.094	0.9107	x
Queretaro	-0.281	0.7549	x	-0.125	0.8822	x
Toluca	1.078	2.9389	x	0.941	2.5617	x
Veracruz	-0.218	0.8042	x	-0.16	0.8521	x
Education	0.213	1.238	0.090	a -	a -	a -
Occupation	categorical variable	categorical variable	0.399	a -	a -	a -
Socioeconomic Level	-0.0504	0.951	0.342	a -	a -	a -

Note: 'a' indicates a p-value greater than 0.15.

3.2.5. Results of Hypothesis Testing

Null Hypothesis: no difference exists between levels of a demographic grouping vs. the rest of the demographic grouping.

Table 7: Hypothesis and analysis results

No.	Alternative Hypothesis	Reject Null Hypothesis?	Implication
H1. (a)	Millennials are more likely to choose green delivery compared to other age groups	Cannot reject null hypothesis	Millennials' responses are not statistically different from other age groups.
H1. (b)	High educated group (university or higher) is more likely to choose green delivery compared to other educated groups	Cannot reject null hypothesis	Highly educated groups' responses are not statistically different from other education groups.
H1. (c)	Higher socioeconomic level groups are more likely to choose green delivery compared to other socioeconomic groups	Cannot reject null hypothesis	High socioeconomic groups' responses are not statistically different from other socioeconomic groups.
H1. (d)	Residents in Mexico city are more likely to choose green delivery compared to others	Cannot reject null hypothesis	Mexico city's response is not statistically different from other regions.
H2.	Providing environmental information drives more consumers to choose green delivery	Reject null hypothesis	Consumers' responses are statistically different with environmental information vs. without.
H3.	Different environmental impact information influences consumer preference toward green delivery	Reject null hypothesis	Consumers' responses are statistically different between different words used to express environmental impact.

Chapter 4. Carbon Emissions Calculation

4.1. Methodology

As discussed in Section 3.2.3, we find that customers can tolerate a four-day delivery time based on our field study data and industry comparisons. This research provides a high level estimate of the environmental impact of green delivery (four-day delivery) for the Company in the sample region (Culiacan, Mexico).

First, we collect past vehicle and delivery data from the Company and selected a sample region, Culiacan. Second, we establish three scenarios in order to determine the most restrictive constraints (maximum weight per vehicle, maximum number of stops per vehicle, and maximum distance per trip per vehicle) for the Company's delivery trucks. Last, we calculate the carbon emissions savings by applying NTM method (Bäckström et al., 2010) for both baseline and each of the three scenarios.

We set the average one-way distance from the Culiacan distribution center (DC) to its allocated stores as 27.40km. When calculating average daily trip distance, some vehicle and delivery data showed multiple days between odometer readings. In these instances, trip distance estimates for the trucks were calculated based on total distance divided by the number of days. For each delivery vehicle, we set a gas mileage of 5.49 km per liter and a tank capacity of 80 liters, resulting in a maximum distance of 439.2 km per day. Any records over this distance threshold are omitted. The distance between home deliveries is set to 2km, representing the approximately sixtieth percentile according to field study data. (See Appendix I). Truck capacity is 1,246kg based on the Company data. Fuel consumption values are the same for all road conditions.

4.1.1. Sample Region

We have identified Culiacan to be the most suitable region within the Company's operating regions. Culiacan is where The Company is headquartered and holds a strong presence. There are many loyal consumers in the region because of the Company's strong brand as well as their support for the community. Culiacan is also a mid-sized city with lower population density and less traffic compared to other urban cities in Mexico. While delivery trucks are underutilized in most of the regions due to a one-day delivery policy, truck utilization in Culiacan appeared to be lower than average in both volume and

weight. More details can be found in Figure 12. Total distance travelled includes each truck's store delivery in the morning and home delivery in the afternoon.

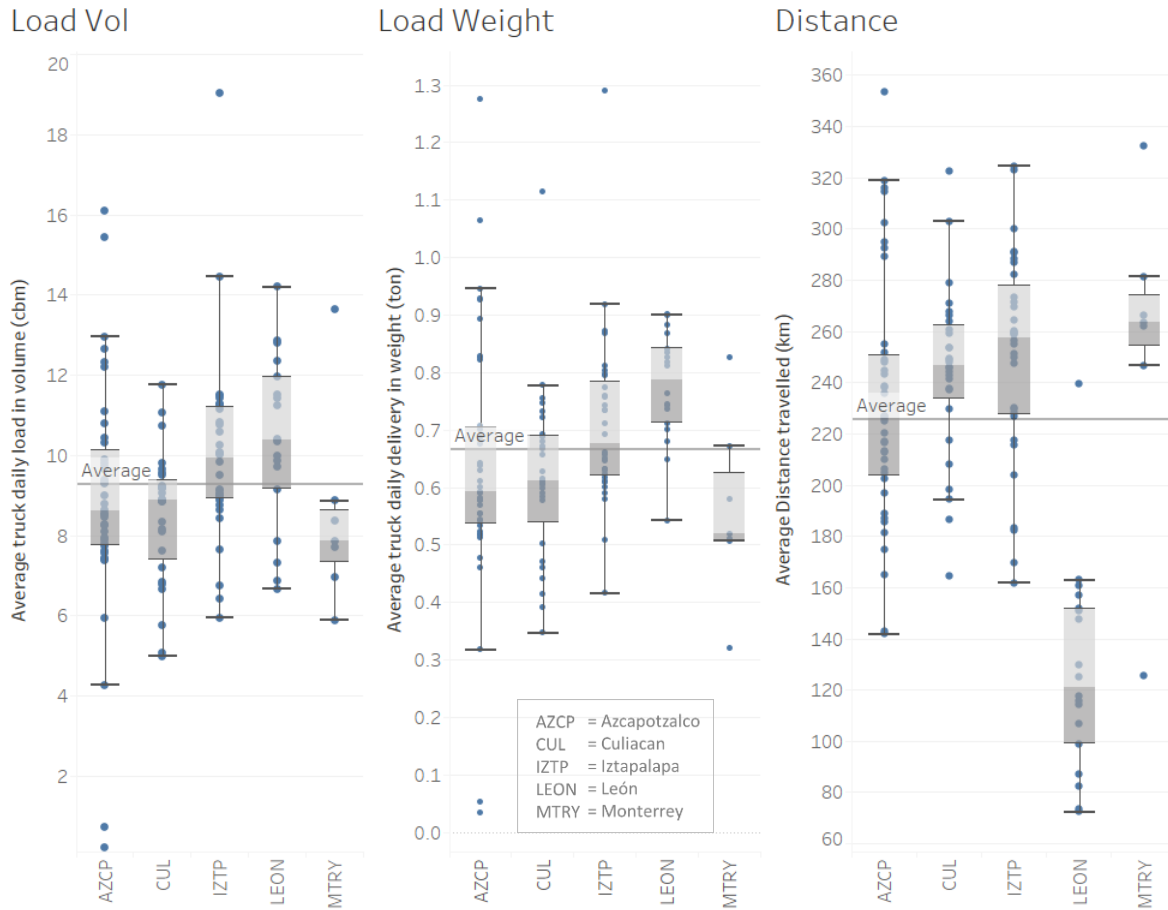


Figure 12: Delivery truck regional comparison

Given a strong customer base, room to improve truck utilization, and limited risk of heavy traffic, we concluded Culiacan would significantly benefit from a longer delivery lead time. Based on the seven months of delivery data, average truck utilization in Culiacan is 49% (by cargo weight) under the current one-day delivery policy. By introducing four-day delivery, the Company can consolidate more deliveries into a single truck, resulting in a decrease in overall fuel consumption.

4.1.2. A Deterministic Scenario Approach to Reduce Carbon Emissions

To determine the level of utilization achievable by introducing green delivery and extending the delivery time, we identified three major constraints on utilization: weight, number of stops (time) and distance.

For each of these constraints, we have made assumptions on the maximum level allowed.

1) Cargo weight per truck

The Company uses a Nissan NP300 chassis with tailored trailer with a load capacity of 1,246kg. We defined theoretical maximum capacity to be 85% ($1,246 \times 85\% = 1,182$ kg) considering the many products tend to be high volume cargo (furniture).

2) Number of stops per truck per day (time)

We assumed that the optimized number of stops per truck is 16 stops vs. a baseline average of 13 according to historical data. Based on the steady period between 2017 week 33 to 36 (see Figure 11 below) in Culiacan, most trucks have a driving range between 14 to 18 (see Figure 13 below). 25% of the time, trucks made more than 16 stop per day. We set a maximum number of deliveries per day to 16 to ensure our estimate would be achievable by The Company Operations.

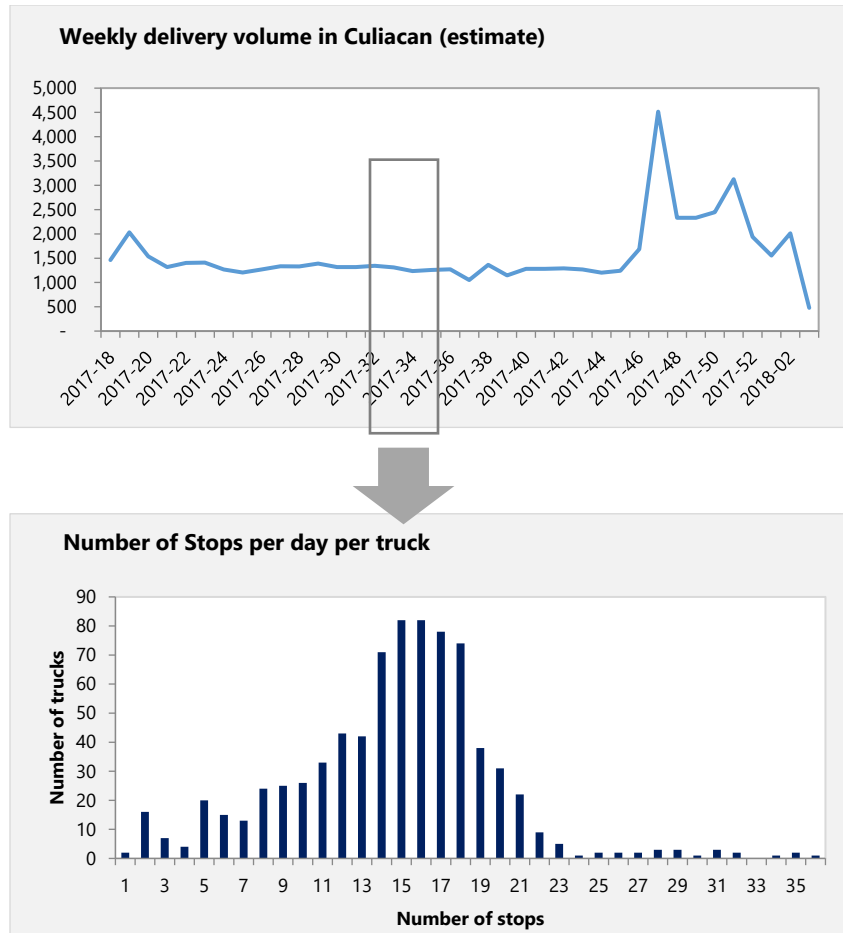


Figure 13: Number off stops observation in Culiacan

3) Distance travelled per truck per day

We assume the maximum distance each truck can travel for home delivery in the afternoon to be 210.95km. The Company deploys trucks to deliver goods from Culiacan DC to stores in the morning and deliver goods from the DC to consumers in the afternoon. To calculate the distance traveled for home deliveries, we took the total distance travelled within a day, and subtracted the average roundtrip distance from the DC to its allocated stores based on a provided store list. For home delivery, the Company's trucks are currently driving 161.81km per day on average. Based on the frequency distribution of daily distances travelled, we have set the maximum distance at 75th percentile, representing 210.95km per truck per day.

We first established the Baseline according the seven months of historical delivery data from the Company. Then we ran three scenarios that utilized the delivery trucks with one of the constraints at the

maximum level enforced (See Table 7). The resulting scenario analysis omits potential saving of reduction in total number of stops because the same homes may be receiving multiple deliveries within three days.

Table 8: Scenario description

Scenarios	Constraints enforced		
	Weight	Number of stops	Distance
Baseline	-	-	-
TOBE 1	Enforced at 1,182kg	-	-
TOBE 2	-	Enforced at 16	-
TOBE 3	-	-	Enforced at 210.95km

4.1.3. Carbon emissions calculation

In each of the three scenarios (weight, number of stops, distance traveled), we calculate the environmental performance, measured as emissions to air (kg of CO₂), as follows:

$$Em_{i,x,y}^{Tot} = EF_{i,x,y} * FC_{x,y_x} * Dist$$

The equation calculates the total emissions *Em* of a substance *i* (CO₂) for driving on road *x* (Culiacan) with vehicle *y* (Nissan NP300). *EF* represents the emissions factor. *FC* represents the fuel consumption, and *Dist* represents the distance traveled.

The main steps in this calculation are CO₂ calculation assumptions presented in Table 8 (See Appendix J for calculations).

Table 9: CO₂ calculation assumptions

No.	Description (keyword in bold)	Comment
1	Collect information about the shipment	The shipments weight, volume and cargo holders
2	Selection of relevant vehicle type and load capacity utilization	Nissan NP300 chassis outfitted with a trailer. Note: while the majority of vehicles are Nissan make, some are other makes. The analysis assumes all vehicles are Nissan make (see Appendix K)
3	Vehicle operation distance and road types ⁸	Daily travel distance per vehicle across different road types
4	Set fuel type and fuel consumption (FC)	Use manufacturer values, adjusted according to Euro IV gasoline guidelines on content of carbon, sulphur and aromatic hydrocarbons. The exhaust emissions are calculated from the fuel consumption of the selected vehicle (Nissan NP300). Average default values [l/km] are given for full and empty vehicles, See Appendix K)
5	Set emission factors of the fuel	Use activity-based calculation (direct readings from the vehicle, see Appendix K).
6	Calculate vehicle environmental performance data (emissions to air) for the operation of the vehicle	Emissions value taken from fuel consumption data records of The Company's vehicle fleet.
7	Compensate for the effect of applicable exhaust gas abatement techniques	No reduction for filters and catalyst are applied.
8	Allocation to investigated cargo	Calculate the share of the environmental performance data (emissions to air) that is related to the investigated cargo. Data for load capacity was set to 57% because of the restriction of 16 stops per vehicle per day (see Table 12).

⁸ Note: one road type is assumed for all driving conditions.

4.2. Results and Discussion

4.2.1. Analysis Output

Based on a total of approximately 1,250 tons of cargo to be delivered, and 27,928 delivery stops (see Table 9), the results of our analysis suggest that the number of stops (time) is the most restrictive constraint for the Company's home delivery trucks in the selected region (see scenario "To Be 2" in Table 10). To Be 2 results in the lowest utilization which indicates the associated constraint (number of stops) being the most restrictive compared to Be 1 and To Be 3. One reason for the time constraint being most restrictive is that one of the Company's major products is furniture, and the Company offers not only delivery but also assembly upon delivery. The longer each stop takes, the fewer stops a vehicle can make in a day.

Table 10: Baseline and assumptions

Baseline		
Total cargo delivered (kg)		1,250,339
Total truck cap used (kg)		2,545,578
Total Distance travelled (km)		273,477
Number of trips		2,043
Average truck Utilization		49%
Average number of stops per truck		13.67
Average distance per truck (km)		133.86
To Be Scenarios		
Assumptions	Total cargo delivered (kg)	1,250,339
	Total Number of stops	27,928
	Average additional distance per stop (km)	2

Table 11: Scenario output

Scenarios	Total #of trips	Average Utilization	Results per truck (average)		
			Weight	Number of stops	Distance
Baseline	2,043	49%	612.01 kg	13.67	133.86 km
To Be 1 (weight)	1,182	85%	Enforced at 1,182.00kg	23.63	153.78 km
To Be 2 (stops)	1,746	57%	716.12 kg	Enforced at 16	138.52 km
To Be 3 (distance)	537	187%	2,328.05 kg	52.21	Enforced at 210.95km

Using the above result (average cargo load, number of stops and distance), we calculate the environmental performance, measured as emissions to air (kg of CO₂), as follows:

$$Em_{i,x,y}^{Tot} = EF_{i,x,y} * FC_{x,y_x} * Dist$$

The equation calculates the total emissions Em of a substance i (CO₂) for driving on road x (Culiacan) with vehicle y (Nissan NP300). EF represents the emissions factor. FC represents the fuel consumption, and $Dist$ represents the distance traveled.

Table 11 provides a summary of the carbon emissions calculation for one trip and Table 12 applies the carbon emissions to the total cargo over the seven month period. Using 16 stops as our constraint (scenario To Be 2), the estimated carbon emission savings of changing from one-day delivery to four-day delivery was 10,631 kg of CO₂ over a time period of seven months in Culiacan, Mexico (1,518 kg CO₂ per month). Total fuel savings was 5,361 liters diesel and 31,621 km in distance. Finally, the average truck utilization increased from 49% to 57% and the number of trips dropped by 298.

Table 12: Carbon emissions calculation

LCU	EF (g/l)	FC (l/km)	Dist. (km)	EM_vehicle total (kg CO ₂ equiv.)
49% LCU	1982.36	0.182	133.86 km	$1982.36 * 0.182 * 133.86 = 48.33 \text{ kg}$
57% LCU	1982.36	0.184	138.52 km	$1982.36 * 0.184 * 138.52 = 50.48 \text{ kg}$

Table 13: Allocation of carbon emissions

CO ₂	Total Weight (kg)	Cargo weight per truck (kg)	Number of trips in sample space (trips)	Emissions (kg CO ₂ equiv. per trip)	Cumulative CO ₂ emissions for all trucks [kg]
49%	1,250,339	612.01	2043	48.33	98,737
57%	1,250,339	716.40	1745	50.48	88,106
Savings					10,631

4.2.2. Recommendations

We recommend the Company offer consumers four-day delivery (new delivery option). With four-day delivery service, the Company can reduce its carbon emissions by 10,631 kg compared to the current emissions with one-day delivery.

Internal Managerial Implications

- **Variable cost reduction**

By switching all deliveries from one-day delivery to four-day delivery, we estimate a reduction of 5,361 liters of fuel consumption, resulting in direct cost savings to the Company.

At the current rate of Diesel MXN 18.42 per liter⁹, the savings in fuel consumptions would be equivalent to MXN 98,748 over the seven month period of this study.

- **Fixed cost reduction**

The reduction in number of trips will reduce the required number of delivery vehicles to satisfy the consumer delivery demand, freeing up fleet capacity and reducing fixed costs. In our analysis over a period of 7 months, 298 trips were reduced. Such savings could reduce vehicle purchases, maintenance costs, and depreciation.

- **Operational implications**

If the Company chooses to continue the one-day delivery to cater to customers preferences, the Company could offer two delivery options (one-day delivery and four-day delivery). However, providing two delivery options would add complexity in delivery planning at each distribution center.

4.2.3. External Managerial Implications

Translating the results of carbon emissions reduction into a digestible, consumer-friendly format can incentivize consumers to switch from one-day to four-day delivery. We present a mockup of an online shopping checkout screen in Figure 14. The figure shows a “GREEN BUTTON” for four-day shipping for Culiacan deliveries, and visualizes the 10,631 kg of carbon emissions reduction using three equivalent scenarios:

⁹ www.globalpetrolprices.com/Mexico/diesel_prices/

- a. Reduction in carbon emissions from 4 tons of waste recycled instead of landfilled (trash bag)
- b. Carbon emissions from a single home's electricity use for 1.3 years (light bulb)
- c. Carbon sequestered from 300 tree seedlings grown for 10 years (tree)

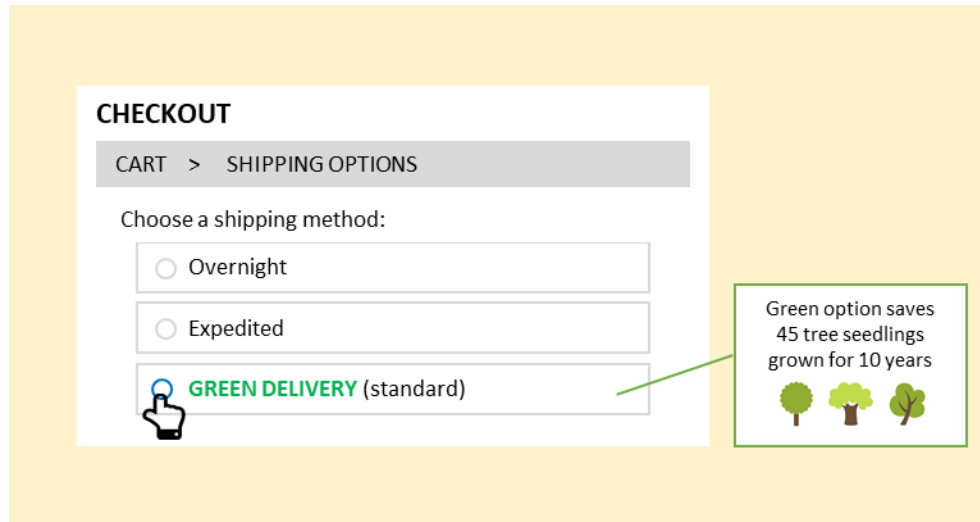


Figure 14. Screen mockup of online shopping portal for four-day delivery

Furthermore, providing a sustainable delivery option would attract new customers interested in sustainability to the Company's stores or webpage. Estimates are based on transportation data provided by the Company and feedback from the logistics division of the Company with assumptions previously discussed.

4.2.4. Limitations to the Study

Although considerable precaution has been taken to insure the quality of the data, several risks may negatively influence the results of our study.

We cannot be certain that we have captured all the variables that influence willingness to wait and additional days willing to wait. For example, while certain regions, such as Toluca, show a higher willingness to wait, we cannot be certain that other confounding variables, such interviewer bias or seasonal factors did not influence the respondent replies.

Our sample size may not be sufficient. In some instances, the sample sizes of different levels are less than ten. For example, the number of 75+ year-old respondents in our field study of 961 respondents was eight. Thus, results from this group may not be statistically significant.

Our questionnaire design may have biased the respondents by presenting questions in a specific order. For example, a respondent that answers four days when asked how many additional days they would be willing to wait given economic incentives might create an anchoring bias, which affected the respondent's answer to the subsequent question of how many additional days they would be willing to wait given environmental incentives. The wording and delivery method of the questionnaire (in-person using an app) could also have influenced respondents' results.

Because of a lack of accurate information, we were unable to calculate utilization according to volume. Thus, a possibility exists that volume constraints would trump weight constraints.

CO₂ emissions from delivery vehicles are influenced by cargo weight. A truck typically starts the day loaded with cargo, makes its deliveries, and ends the day empty. Our model assumes a constant fixed cargo weight throughout each trip. This assumption inflates the CO₂ emissions estimate of each trip because the truck remains loaded with cargo all day. Further refinements on cargo weights would improve accuracy.

Purchase variability. This analysis is based on historical consumer purchase patterns during the period of May-November 2017. Any significant change in consumer purchasing patterns or environmental condition (gasoline price, road conditions etc.) in the current environment may change the carbon emissions results.

The vehicle data provided may be inaccurate and thus would impact the carbon emissions calculations. Our assumptions on emissions factor, fuel consumption, load utilization, distance traveled, weight utilization and others may not reflect actual values.

Chapter 5. Conclusion

Our primary finding for green last mile home delivery is that customers are willing to wait on average 4-6 days depending on the incentives provided (no incentive – 4.2 days, economic incentive – 5.5 days, and environmental incentive – 4.7 days). Furthermore, regarding the specific type of environmental incentives (CO₂ equivalent, electricity, trash, trees), information on number of trees saved has the greatest impact on a customer's willingness to wait.

In general, education, occupation, and socioeconomic status have little impact on willingness to wait and the number of additional days willing to wait. Regarding age, although we could not conclude that millennials are more willing to wait when given environmental incentives, using binary logistic regression, we showed, in general, that a respondent's willingness to wait increases with decreasing age. For example, millennials are more likely to be willing to wait than are baby boomers. These results suggest that a respondent's age should be further studied to determine the correlation between age and willingness to wait. Region does have a significant impact, however, as evidenced by responses in regions of Mexico City (Atzapalsalco and Iztapala), which showed less willingness to wait than those responses in other less urban regions.

We determine customer tolerance for delivery time to be four days. Based on this four-day lead time, we increased utilization by weight on existing vehicles (from 49% to 57%), resulting in more cargo on fewer delivery vehicles and a savings of 10,631kg of CO₂ equivalent. Our utilization improvement was constrained by the number of stops a delivery vehicle could make in a day.

Based on our analysis, we recommend the Company increase its free delivery from one-day to four-day delivery. According to feedback from interviewers and truck drivers, customers receive free delivery on almost all purchases, and are not subject to minimum price or quantity constraints. Not only does this one-day policy result in less cargo on more delivery vehicles, this policy also invites customers to abuse free delivery. For example, in some cases, the Company trucks drove several kilometers to deliver small items, such as hair curlers or candles. Increasing delivery to four days could drive efficiencies in truck utilization without sacrificing customer service.

The level of consumer demand for four-day delivery and interest in sustainable products should be further investigated. A U.S. based field study could be conducted to assess differences in consumer preferences between U.S. and Mexican consumers. Knowing the appropriate consumer group would allow the

Company to target its marketing campaigns to maximize adoption and minimize carbon emissions. Finally, a pilot study in one store of one region could be conducted to test the results of the findings.

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Appendices

A. Questionnaire methodology comparison

Table A-1: Primary Communication Methods of Data Collection: Advantage (+) and Disadvantage (-). Source: Churchill, 2003)

Interview method	Sampling control	Information Control	Administrative Control
Personal interview	+ high response rate; best for getting response from specific person - narrow distribution, difficult to identify sampling frame	+ any type of question; allows probing via open ended question; clarification of ambiguous questions; easy use of visual and other sensory stimuli interview - interviewer bias	+ generally most expensive method, relatively slow -
Written Formats (Mail, Fax, Web, E-mail)	+ Only method to reach certain people; sampling frame easy via mailing lists - low response rates; little control in wo completes survey; cannot control speed of survey completion	+ not subject to interviewer bias; respondents work at their own pace; ensures anonymity; best for personal, sensitive questions - researcher cannot explain ambiguous questions; no probing	+ generally least expensive; very short response time for e-mail - longer response time for mail
Telephone	+ relatively strong response rates; wide distribution possible - difficult to establish sampling frame due to unlisted numbers	+ less interviewer bias than in person, interviewer supervision in stranger - cannot use visual aids; more difficult to establish rapport over the hone than in person	+ relatively low cost; quick turnaround; little difficulty and cost in handling call backs; allows easy use of computer support - must be brief

B. Questionnaire

Table B-1

No.	Question	Answer Choices
1.	How long did this delivery take?	1 day, 2 day, 3 day, several days, I prefer not to answer
2.	How did you find this delivery? Fast, Normal or Slow?	Slow, Normal, Fast
3.	Would you be willing to wait longer?	Yes, No, I don't know, Depends
4.	If so, how many additional days?	Numeric
5.	Would you be willing to wait longer if an economic incentive was offered?	Yes, No, I don't know, Depends
6.	If so, how many additional days?	Numeric
7.	<p>If we told you that the impact made of waiting for additional day would be [environmental impact information], would you be willing to wait longer?</p> <p>➤ One of the following pieces of environmental impact information was given:</p> <ol style="list-style-type: none"> 1. 10 tons of CO₂ emission 2. 1 Homes' electricity use for 2 months 3. 500kg of waste recycled instead of landfilled 4. 45 tree seedlings grown for 10 years 	Yes, No, I don't know
8.	If so, how many additional days?	1 day, 2 days, 3 days, 4 days, More than 4 days
9.	What is your gender?	Female, Male
10.	What is your age?	18-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75+
11.	What is your highest education level attained?	Elementary – High School, Undergraduate, Graduate, Post-graduate, I prefer not to answer
12.	What is your occupation?	Housewife, Employee, Business owner, Student, Other
13.	Product Delivered	Open-ended
14.	Comments	Open-ended

C. Interview Script Guidelines

The Council for Marketing and Opinion Research (CMOR)¹⁰ conducted a study of phone questionnaire participation. The key ingredients in a telephone interviewer's introduction that help provide the perception of a professionally conducted marketing research questionnaire, which in turn enhanced participant cooperation, included (Iacobucci and Churchill, 2010):

- Stating the sponsoring company's name
- Giving a brief overview about the general topic of the Questionnaire
- Providing the participant with the interviewer's first name
- Assuring the interviewee that there will be no attempt to sell anything
- Assuring the interviewee that their responses will be held confidential
- Providing an accurate estimate as to the approximate length of the interview

Based on guidelines from CMOR, we developed a script that each interviewer followed when conducting a questionnaire. The script is reposted below:

"I am a college student working on a class project for Coppel. My name is [insert interviewer's name] and I would like to ask you a few questions related to sustainable delivery solutions. Green delivery solutions include waiting longer for your package to be shipped, so that more cargo can be put on fewer trucks. There will be no attempt to sell you anything and your responses will be strictly confidential. The questionnaire will take approximately five minutes. Could I begin the survey?"

¹⁰ <https://www.cmoresearch.com/>

D. AMAI Method¹¹

The Mexican Association of Marketing Research and Public Opinion Agencies (AMAI) socioeconomic level is a hierarchical structure based on the accumulation of economic and social capital in the Mexican population:

- The economic dimension represents the possession of material goods. In the AMAI index, it is operationalized by the possession of 12 assets (variables 1-12)
- The social dimension represents the stock of knowledge, contacts and social networks. In the AMAI index, it is operationalized by the level of study of the head of the family (13th variable)

The socioeconomic level represents the ability to access a set of goods and lifestyles. The AMAI model has six levels, the lowest being E (low socioeconomic status) and the highest, A/B (high socioeconomic status). Points are awarded based on a criteria consisting of the thirteen variables, as stated above. Each variable is weighted according to its importance. Assigned points for each variable are based on the coefficient of each one the values in a regression on the family income.

¹¹ <http://www.inegi.org.mx/rne/docs/Pdfs/Mesa4/20/HeribertoLopez.pdf>

Variables and points are as follows:

Table D-1: AMAI possession of property and assigned points

	Quantity of possession (unless otherwise specified)				
Possession of property	0	1	2	3	4
Light	0 (0-5)	14 (6-10)	23 (11-15)	30 (16-20)	44 (21+)
Color TV	0	2.3	3.6	4.6	4.6
Education level of the head of family	0 No education	11 Primary, Secondary	23 High school	37 University	53 Post graduate
Car	0	21	40	56	56
Floor	0 (cement or earth)	10	10	10	10
DVD	0	17	29	29	29
Microwave	0	10	10	10	10
Bathroom	0	12	12	29	42
Computer	0	16	24	24	24
Sprinkler	0	11	11	11	11
Stove	0	20	20	20	20
Domestic service	0	34	34	34	34
Room	0	0 (1-2)	0 (3-4)	9 (5-6)	14 (7+)

Socioeconomic levels, in order from lowest socioeconomic status to highest:

Table D-2: AMAI socioeconomic levels

Points	Level
0-51	E
52-76	D
77-133	D+
134-170	C
171-222	C+
223+	A/B

Further information can be found at www.amai.org.

Note: AMAI uses data compiled by the National Institute of Statistics, Geography and Informatics (INEGI). INEGI is an autonomous public body responsible for regulating and coordinating the National System of Statistical and Geographic Information, as well as capturing and disseminating information about Mexico in terms of territory, resources, population and economy, which allows the public to know the characteristics of the country and help decision making. Further information can be found at www.inegi.org.mx.

E. Chi-Square test and ANOVA results per demographic group

Table E-1: Chi Sq. and ANOVA test results

Category	Group	Sample Size	Chi Sq test - P value			ANOVA		
			With no info	Economic Incentive	Environmental Impact	With no info	Economic Incentive	Environmental Impact
Age	18-24	104	0.1683	0.9572	0.4260	-	-	-
	25-34	239	0.5871	0.0125	0.0622	-	0.0290	-
	35-44	224	0.2086	0.7231	0.7617	-	-	-
	45-54	179	0.6153	0.3408	0.8722	-	-	-
	55-64	98	0.1997	0.0000	0.0278	-	0.0000	0.0400
	65-74	40	0.3325	0.4225	0.0842	-	-	-
	75+	8	0.1133	0.5052	0.3769	-	-	-
Education	Primary - Secondary	299	0.5039	0.5039	0.0429	-	-	0.6090
	High school	243	0.4701	0.4701	0.5943	-	-	-
	University	186	0.8962	0.8962	0.2191	-	-	-
	Posgraduate	11	0.5161	0.5161	0.5437	-	-	-
Occupation	Student	39	0.0324	0.0770	0.5850	0.0360	-	-
	Housewife	366	0.9605	0.7778	0.5264	-	-	-
	Employee	289	0.7182	0.3646	0.8973	-	-	-
	Own business	40	0.0846	0.0243	0.1048	-	0.0290	-
	Other	84	0.8962	0.6048	0.8933	-	-	-
Socioeconomic	A	62	0.2367	0.8396	0.9578	-	-	-
	B	77	0.6341	0.8267	0.2211	-	-	-
	C+	109	0.2663	0.4991	0.0330	-	-	0.0440
	C	154	0.3080	0.8972	0.4996	-	-	-
	D+	160	0.9743	0.1930	0.9840	-	-	-
	D	174	0.9860	0.7434	0.4025	-	-	-
	E	127	0.2244	0.1231	0.3866	-	-	-
Region	Azacapotzalco	156	0.1381	0.4525	0.3184	-	-	-
	Culiacan	45	0.0073	0.0121	0.0005	0.0090	0.0150	0.0010
	Iztapalapa	136	0.0146	0.3072	0.0340	0.0240	-	0.0520
	LEON	74	0.0470	0.2215	0.0197	0.0560	-	0.0240
	Monterrey	123	0.0031	0.0060	0.3258	0.0060	0.0090	0.3620
	Puebla	144	0.1068	0.3632	0.4133	-	-	-
	Queretaro	77	0.0003	0.4819	0.5215	-	-	-
	Toluca	85	0.0000	0.0056	0.0000	0.0000	0.0070	0.0000
	Veracruz	121	0.3293	0.2338	0.5092	-	-	-

F. Tukey Test Result – One Group vs. Everyone Else

The table below compares the willingness to wait of one group to the rest of its group. For example, 25-34 year olds' willingness to wait was higher than the rest of the other age groups.

Table F-1

Category	Group	Type of Question	Tukey Test			
			Difference of Means	Lower Confidence Interval (95%)	Higher Confidence Interval (95%)	P-Value
Age	25-34	Economic incentive	0.0734	0.0075	0.1393	0.029
	55-64	Economic incentive	-0.1881	-0.2809	-0.0954	0.000
		Environmental impact	-0.0963	-0.1885	-0.0041	0.040
Occupation	Student	With no info	0.1711	0.0106	0.3317	0.036
	Own business	Economic incentive	-0.1576	-0.2995	-0.0158	0.029
Socioeconomic	C+	Environmental impact	0.094	0.0026	0.1855	0.044
Region	Culiacan	With no info	-0.1998	-0.3492	-0.0504	0.009
		Economic incentive	-0.1708	-0.3083	-0.0333	0.015
		Environmental impact	-0.2316	-0.367	-0.0963	0.001
	Iztapalapa	With no info	-0.1046	-0.1953	-0.0139	0.024
		Environmental impact	-0.0815	-0.1639	0.0009	0.052
	León	With no info	0.1154	-0.0032	0.2341	0.056
		Environmental impact	0.1242	0.0166	0.2318	0.024
	Monterrey	With no info	0.1334	0.0389	0.2279	0.006
		Economic incentive	0.1154	0.0284	0.2023	0.009
		Environmental impact	-0.04	-0.1261	0.0461	0.362
	Toluca	With no info	0.2371	0.1265	0.3476	0.000
		Economic incentive	0.1397	0.0375	0.242	0.007
		Environmental impact	0.2152	0.1149	0.3156	0.000

G. Tukey Test – Multiple Groups

Table G-1

Outcome Variable		Comparison	Difference of Means	Confidence Interval		Statistically Significant at 0.05?
				CI 95% LHS	CI 95% RHS	
NO INCENTIVE	Willing to Wait	Region				
		Queretaro - Azcapotzalco	-0.2396	-0.4508	-0.0284	Yes
		León - Culiacan	0.297	0.0103	0.5837	Yes
		Monterrey - Culiacan	0.3068	0.0426	0.571	Yes
		Toluca - Culiacan	0.4065	0.1269	0.6861	Yes
		Monterrey - Iztapalapa	0.2061	0.0174	0.3948	Yes
		Toluca - Iztapalapa	0.3059	0.0962	0.5156	Yes
		Queretaro - León	-0.2964	-0.5433	-0.0495	Yes
		Queretaro - Monterrey	-0.3062	-0.5266	-0.0858	Yes
		Toluca - Puebla	0.2732	0.0658	0.4806	Yes
		Toluca - Queretaro	0.406	0.1674	0.6446	Yes
		Veracruz - Toluca	-0.2548	-0.4695	-0.0402	Yes
	Additional days willing to wait	Region				
		Toluca - Azcapotzalco	1.178	0.125	2.231	Yes
		Monterrey - Iztapalapa	0.964	0.035	1.894	Yes
		Toluca - Iztapalapa	1.674	0.626	2.722	Yes
		Queretaro - León	-1.345	-2.529	-0.162	Yes
		Queretaro - Monterrey	-1.342	-2.417	-0.267	Yes
		Toluca - Puebla	1.286	0.251	2.32	Yes
		Toluca - Queretaro	2.051	0.872	3.23	Yes
ECONOMIC INCENTIVE	Willing to Wait	Age				
		55-64 vs. 25-34	-0.2212	-0.3774	-0.065	Yes
		55-64 vs. 35-44	-0.1754	-0.3331	-0.0177	Yes
		55-64 vs. 45-54	-0.193	-0.3566	-0.0293	Yes
		Region				
		Monterrey - Culiacan	0.2634	0.0165	0.5104	Yes
		Toluca - Culiacan	0.2902	0.0289	0.5515	Yes
	Additional days willing to wait	Region				
		Toluca - Azcapotzalco	0.429	0.211	2.875	Yes
		Toluca - Iztapalapa	1.513	0.188	2.839	Yes
		Toluca - Queretaro	1.511	0.02	3.002	Yes

Table G-2

Outcome Variable		Comparison	Difference of Means	Confidence Interval		Statistically Significant at 0.05?
				CI 95% LHS	CI 95% RHS	
ENVIRONMENTAL INCENTIVE	Willing to Wait	Region				
		León - Culiacan	0.3354	0.073	0.5978	Yes
		Puebla - Culiacan	0.2472	0.0102	0.4843	Yes
		Queretaro - Culiacan	0.2514	-0.0091	0.5118	Yes
		Toluca - Culiacan	0.417	0.1611	0.6729	Yes
		Toluca - Iztapalapa	0.2662	0.0742	0.4581	Yes
		Toluca - Monterrey	0.2311	0.0353	0.4269	Yes
		Veracruz - Toluca	-0.2199	-0.4164	0.0235	Yes
	Additional days willing to wait	Region				
		Toluca - Azcapotzalco	0.089	1.597	0.015	Yes
		León - Iztapalapa	1.174	0.42	1.927	Yes
		Puebla - Iztapalapa	0.74	0.1	1.379	Yes
		Toluca - Iztapalapa	1.365	0.615	2.115	Yes
		Veracruz - Iztapalapa	0.855	0.173	1.537	Yes
		Toluca - Queretaro	0.867	0.023	1.711	Yes
	Willing to Wait	Age				
		55-64 vs. 25-34	-0.2212	-0.3774	-0.065	Yes
		55-64 vs. 35-44	-0.1754	-0.3331	-0.0177	Yes
		55-64 vs. 45-54	-0.193	-0.3566	-0.0293	Yes
	Additional days willing to wait	Age				
		55-64 vs. 18-24	-0.705	-1.385	-0.025	Yes
		55-64 vs. 25-34	-0.599	-1.18	-0.017	Yes

H. Binary Logistic Regression – Willingness to Wait

Response: Willingness to wait (Yes = 1, No = 1)

Response event: Yes = 1

Predictors: age, education, occupation, campus, socioeconomic level

Sample Size: 650

Table H-1: Response Information

Variable	Value	Count
Could you wait - environ (binary)	1	473 (Event)
	0	177
	Total	650

Table H-2: Deviance Table

Source	DF	Adj. Dev	Adj. Mean	Chi-Square	P-Value
Regression	15	31.879	2.1253	31.88	0.007
Age-normalized	1	5.482	5.4822	5.48	0.019
Occupation	4	4.049	1.0124	4.05	0.399
Campus	8	16.359	2.0449	16.36	0.038
Socioeconomic Level (INEGI)	1	0.901	0.9014	0.90	0.342
Education - normalized	1	2.881	2.8812	2.88	0.090
Error	634	729.324	1.1504		
Total	649	761.203			

Table H-3: Model Summary

Deviance R-Sq	Deviance R-Sq(adj)	AIC
4.19%	2.22%	761.32

Table H-4: Coefficients

Term	Coef	SE Coef	VIF
Constant	1.496	.537	
Age (normalized)	-0.1719	0.0735	1.23
Occupation (reference: employee)			
Housewife	0.267	0.223	1.50
Other	0.132	0.341	1.16
Own business	-0.461	0.389	1.13
Student	-0.131	0.454	1.20
Campus (reference: Astalpozalco)			
Culiacan	-0.9130	0.470	1.40
Iztapalapa	-0.502	-0.353	1.91
León	0.223	0.429	1.57

Monterrey	-0.580	0.340	2.17
Puebla	-0.173	0.357	2.11
Queretaro	-0.281	0.391	1.69
Toluca	1.078	0.661	1.16
Veracruz	-.218	0.364	1.87
Socioeconomical Level (NEGI)	-0.0504	0.0533	1.09
Education (normalized)	0.213	0.126	1.36

Table H-5: Odds Ratio for Continuous Predictors

	Odds Ratio	95% CI
Age-normalized	0.8421	(0.7291, 0.9726)
Socioeconomic Level (INEGI)	0.9508	(0.8565, 1.0555)
Education - normalized	1.2376	(0.9662, 1.5851)

Table H-6: Odds Ratio for Categorical Predictors

Level A	Level B	Odds Ratio	95% CI
Occupation			
Housewife	Employee	1.3060	(0.8435, 2.0222)
Other	Employee	1.1416	(0.5854, 2.2261)
Own business	Employee	0.6307	(0.2943, 1.3514)
Student	Employee	0.8770	(0.3604, 2.1339)
Other	Housewife	0.8741	(0.4481, 1.7052)
Own business	Housewife	0.4829	(0.2237, 1.0423)
Student	Housewife	0.6715	(0.2690, 1.6766)
Own business	Other	0.5524	(0.2202, 1.3861)
Student	Other	0.7682	(0.2687, 2.1968)
Student	Own business	1.3906	(0.4596, 4.2074)
Campus			
Culiacan	Azcapotzalco	0.4012	(0.1597, 1.0079)
Iztapalapa	Azcapotzalco	0.6054	(0.3029, 1.2102)
León	Azcapotzalco	1.2496	(0.5395, 2.8947)
Monterrey	Azcapotzalco	0.5599	(0.2878, 1.0891)
Puebla	Azcapotzalco	0.8414	(0.4176, 1.6951)
Queretaro	Azcapotzalco	0.7549	(0.3510, 1.6237)
Toluca	Azcapotzalco	2.9389	(0.8039, 10.7431)
Veracruz	Azcapotzalco	0.8042	(0.3942, 1.6406)
Iztapalapa	Culiacan	1.5091	(0.6170, 3.6910)
León	Culiacan	3.1148	(1.1348, 8.5495)
Monterrey	Culiacan	1.3956	(0.5832, 3.3394)
Puebla	Culiacan	2.0973	(0.8444, 5.2090)
Queretaro	Culiacan	1.8816	(0.7261, 4.8760)
Toluca	Culiacan	7.3254	(1.7772, 30.1952)
Veracruz	Culiacan	2.0046	(0.8075, 4.9761)

León	Iztapalapa	2.0641	(0.9192, 4.6346)
Monterrey	Iztapalapa	0.9248	(0.4941, 1.7310)
Puebla	Iztapalapa	1.3898	(0.7137, 2.7063)
Queretaro	Iztapalapa	1.2469	(0.6014, 2.5850)
Toluca	Iztapalapa	4.8542	(1.3520, 17.4284)
Veracruz	Iztapalapa	1.3284	(0.6718, 2.6265)
Monterrey	León	0.4480	(0.2080, 0.9651)
Puebla	León	0.6733	(0.3048, 1.4874)
Queretaro	León	0.6041	(0.2522, 1.4472)
Toluca	León	2.3518	(0.6036, 9.1628)
Veracruz	León	0.6436	(0.2856, 1.4502)
Puebla	Monterrey	1.5028	(0.8094, 2.7903)
Queretaro	Monterrey	1.3483	(0.6675, 2.7233)
Toluca	Monterrey	5.2491	(1.4908, 18.4814)
Veracruz	Monterrey	1.4364	(0.7575, 2.7239)
Queretaro	Puebla	0.8972	(0.4267, 1.8866)
Toluca	Puebla	3.4928	(0.9727, 12.5428)
Veracruz	Puebla	0.9558	(0.4879, 1.8724)
Toluca	Queretaro	3.8931	(1.0436, 14.5235)
Veracruz	Queretaro	1.0653	(0.4984, 2.2774)
Veracruz	Toluca	0.2736	(0.0754, 0.9927)

Odds ratio for level A relative to level B

Table H-7: Regression Equation

$$P(1) = \exp(Y') / (1 + \exp(Y'))$$

$$Y' = 1.496 - 0.1719 \text{ Age-normalized} + 0.0 \text{ Occupation_Employee} + 0.267 \text{ Occupation_Housewife} \\ + 0.132 \text{ Occupation_Other} - 0.461 \text{ Occupation_Own business} - 0.131 \text{ Occupation_Student} \\ + 0.0 \text{ Campus_Azcapotzalco} - 0.913 \text{ Campus_Culiacan} - 0.502 \text{ Campus_Iztapalapa} \\ + 0.223 \text{ Campus_León} - 0.580 \text{ Campus_Monterrey} - 0.173 \text{ Campus_Puebla} \\ - 0.281 \text{ Campus_Queretaro} + 1.078 \text{ Campus_Toluca} - 0.218 \text{ Campus_Veracruz} \\ - 0.0504 \text{ Socioeconomic Level (INEGI)} + 0.213 \text{ Education - normalized}$$

Table H-8: Goodness-of-Fit Tests

Test	DF	Chi-Square	P-Value
Deviance	634	729.32	0.005
Pearson	634	642.24	0.402
Hosmer-Lemeshow	8	11.12	0.195

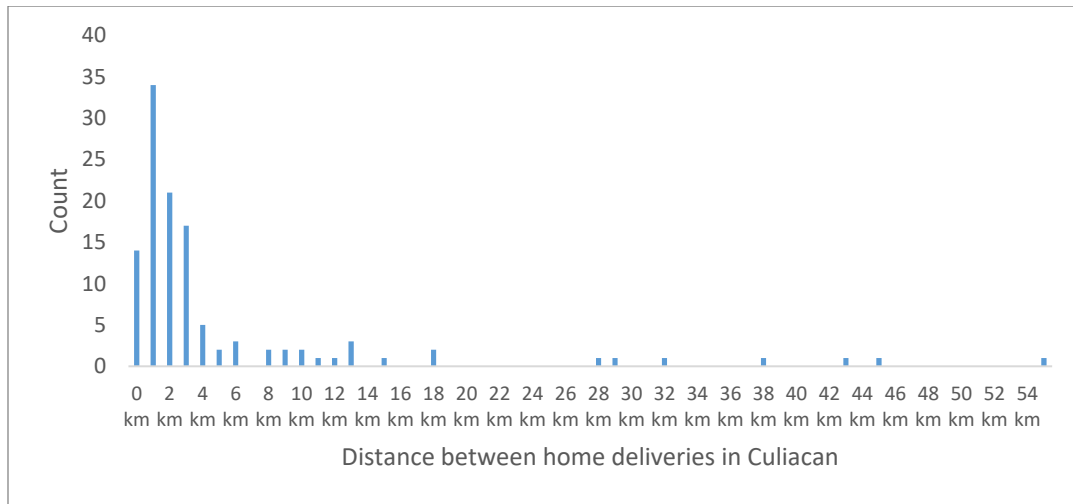
Table H-9: Fits and Diagnostics for Unusual Observations

Obs	Observed Probability	Fit	Resid	Std Resid	
380	0.0000	0.9295	-2.3032	-2.34	R
382	0.0000	0.9069	-2.1792	-2.22	R
588	0.0000	0.9031	-2.1606	-2.20	R

R Large residual

I. Distance between homes in Culiacan (km)

Table I-1: Distance between homes



Source: Fulcrum Data collection

J. Carbon Emissions Calculation

Vehicle Description

Vehicle type: Nissan NP300 (some other trucks are used but we assume all are NP300)

Vehicle size: Max weight 1.246 tons (The Company data)

Emission concept: Diesel - Euro IV

Fuel Parameters

Fuel type: Gasoline

Fuel Consumption at 49%: 5.49 km/l or 0.182 l/km (Copped data)

Cargo/Load Description

Cargo Type: Bulk

Weight: 1.246 tons

Loading units: tons

Load capacity utilization: 49-57 %-w

Route Description

133.86km (avg 13 stops at 49% utilization)

138.52km (avg 16 stops at 57% utilization)

Assume fuel consumption is the same for all road types

Fuel consumption

Table J-1:

Road Type	FC LCU 0% (l/km)	FC LCU 100% (l/km)	FC LCU 49% (l/km)	FCU LCU 57.3% (l/km)
All types	0.172	=0.172 * 0.132/0.118 = 0.193	0.172 + (0.193-0.172)*0.49 = 0.182	0.172 + (0.193-0.172)*0.573 = 0.184

Source: NTM: Heavy Good Vehicle urban and the Company's fuel consumption data.

Emissions Factors at 49% and 57% LCU

0.59 kg CO₂ eq/ ton-km * .612201 tons * 152 km/ trip = 1982.36 kg CO₂/ trip

(Source: Company fuel consumption data)

Emissions calculations

$$Em_{i,x,y}^{Tot} = EF_{i,x,y} * FC_{x,y_x} * Dist$$

Equation for calculating total emission of substance *i* (CO₂) for driving on road *x* (Culiacan) with vehicle *y* (Nissan NP300).

Note: Motorway/Urban/Rural assumed to have same EF (Emissions Factors)

Table J-2

LCU	EF (g/l)	FC (l/km)	Dist. (km)	EM_vehicle total (kg CO ₂ equiv.)
49% LCU	1982.36	0.182	133.86 km	1982.36 * 0.182 * 133.86 = 48.33 kg
57% LCU	1982.36	0.184	138.52 km	1982.36 * 0.184 * 138.52 = 50.48 kg

Allocation of emissions to goods

Table J-3

CO ₂	Total Weight (kg)	Cargo weight per truck (kg)	Number of trips in sample space (trips)	Emissions (kg CO ₂ equiv. per trip)	Cumulative CO ₂ emissions for all trucks [kg]
49%	1,250,339	612.01	2043	48.33	98,737
57%	1,250,339	716.40	1745	50.48	88,106
Savings					10,631

K. Vehicle Type

Table K-1

Make: Nissan	Model: NP300 chassis	Modifications: trailer added to chassis frame
