**GENDER AND RAIL TRANSIT USE:**

**THE INFLUENCE OF ENVIRONMENTAL BELIEFS AND SAFETY CONCERNS**

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**ABSTRACT**

Research suggests that gender influences attitudes toward both the environment and safety. While pro-environmental attitudes might encourage transit use, safety concerns might discourage transit use if the transit environment is perceived as unsafe. To quantitatively examine how gender, environmental beliefs, and safety concerns jointly affect transit use, we analyze results from a longitudinal quasi-experimental study which conducted pre- and post-opening travel surveys near a new light rail transit service in Los Angeles. We find that the influence of safety concerns on transit use is more prominent than that of environmental attitudes, particularly for women. Living closer to a new light rail transit station correlates with an increase in train ridership. This effect, however, is significantly lower for women. The results suggest that to foster transit use, reducing personal safety concerns related to transit may be more effective than increasing public awareness of transportation-related environmental issues, especially for attracting female riders.

*Keywords*: gender, transit use, environmental beliefs, safety concerns, quasi-experiment

**INTRODUCTION**

Partly motivated by the threat of global warming, transportation planners have been considering ways to promote public transit and non-motorized travel modes such as walking and bicycling. The transportation sector is the main consumer of oil (64% of global consumption and 71% of U.S. consumption) *(1; 2)* and generates 14% and 28% of greenhouse gas emissions in the global and in the U.S. contexts respectively *(3; 4).* Individual willingness to change travel behavior will play a key role in the success of policies trying to foster sustainable transportation and reduce vehicle-related air pollution.

Women may be more willing to travel by sustainable modes such as walking, bicycling, and public transit given that past research has shown that they express greater environmental concerns and engage more readily in pro-environmental behavior such as recycling and buying eco-products *(e.g., 5; 6).* However, gender differences in attitudes toward sustainable travel and their influence on travel mode choice remain an understudied area. Available evidence is limited and mixed regarding whether men and women equally consider the environment when making mode choices *(e.g., 7; 8).*

In addition, gender differences in safety and security concerns may differentially affect men’s and women’s sustainable travel behavior *(9).* While pro-environmental attitudes might encourage women to reduce driving and increase walking, bicycling, and public transit use, safety and security concerns associated with walking, bicycling, and public transit may offset the influence of environmental motivations. Some studies have examined why women have a higher level of fear of crime in public spaces, including in the transit environment, *(e.g., 10; 11; 12)*, but the effect of safety concerns on sustainable travel behavior has not yet been sufficiently investigated through a quantitative approach.

This paper aims to fill these gaps in the literature by addressing the following questions: (1) Are there gender differences in travel behavior changes when a new light rail transit service is available? (2) Are travel behavior changes (particularly changes in rail transit use) related to attitudes about safety and the environment in ways that vary with gender?

These questions are analyzed in a specific local context – the opening of the Expo Light Rail Line in Los Angeles in April 2012. We used a quasi-experimental research design and conducted before- and after-opening travel surveys in neighborhoods near six Expo Line stations. The surveys were administered to residents who lived within a half-mile of the new stations, a distance that the transportation literature suggests should correspond with an experimental group that would be more likely to change travel behavior *(13)*, and to a control group of residents who lived in the same neighborhood but beyond a half-mile out to approximately three miles from the new stations. The survey included questions about the study subject’s gender, environmental beliefs, safety concerns, and transit use. The results advance our understanding of the link between attitudes and travel behavior, illuminating gender differences that can be important for transit policy. We find that residents within a half-mile of the new light rail increased transit trip-making, but that effect is smaller for females, and safety concerns are an important factor in the lower rail transit effect among females.

**LITERATURE REVIEW**

**The Role of Environmental Beliefs**

In the context of sustainable transportation, researchers have examined whether pro-environmental attitudes trigger pro-environmental travel behavior, guided by the theory of planned behavior (TPB) *(14)*. Most studies are based in Europe and generally show a direct, statistically significant, and positive connection between environmental beliefs and sustainable travel behavior. According to Hunecke *et al*. *(15)* and Kim *et al*. *(16)*, individuals with higher environmental concerns are more likely to use public transit rather than private cars. Moreover, Kahn and Morris *(17)* and Nilsson and Küller *(18)* indicated that those who are more environmentally concerned make a higher percentage of their trips by environmentally friendly travel modes such as walking, bicycling, and public transit. However, Gardner and Abraham *(19)* found that the relationship between environmental concerns and car use is only indirect, and Johansson *et al*. *(20)* reported that environmental concerns only matter for choosing train over bus, but not bus over car.

Are women more motivated toward sustainable travel than men? If we use daily activities such as recycling and buying eco-products as an indicator, research indicates that women are consistently more environmentally active than men *(5; 6; 21; 22)*. Does this gender difference hold for sustainable travel? There is only limited evidence from Europe. Both Matthies *et al*. *(23)* and Polk *(8)* found that women are more concerned with environmental impacts of transportation and show greater willingness to reduce car use, but Beirão and Cabral *(7)* reported no difference between men and women in transportation-related environmental concerns. With regard to actual travel mode choice, Matthies *et al*. *(23)* indicated that women are more likely to reduce car use due to environmental concerns, but Beirão and Cabral *(7)* found neither men nor women make travel mode choices in ways that relate to their attitudes about the environment. Gender and environmental beliefs may also influence the adoption of electric vehicles, which is seen as sustainable travel in a broad sense. For instance, Egbue and Long *(24)* suggested that men believe more in the sustainability of electric vehicles and show higher interest. White and Sintov *(25)* found that pro-environmental attitudes are the strongest predictor of the adoption of electric vehicles, and men are more willing to pay.

**The Role of Safety Concerns**

The relationship between women’s fear of crime and their use of public spaces has received worldwide attention. The findings consistently show that women’s higher safety and security concerns limit their mobility. For example, women are more likely to consider not going out after dark, not walking alone, not using public transit, and not choosing specific routes *(26; 27; 28; 29)*. To reduce women’s fear of crime and increase their use of public transit, effective measures suggested by researchers include better lighting, emergency phones, surveillance equipment, police presence, escort programs, staff training, and reliable transit service *(9; 12; 30; 31)*. In countries like Brazil, India, and Japan, women-only transit service was introduced as a practical solution to sexual harassment and assault problems in public transportation settings *(32)*. In the U.S., however, most transit agencies typically do not think specific programs should be implemented despite recognizing this issue *(33)*.

In addition to crime-related safety concerns, gender differences in concerns for traffic-related safety have been examined. While women are more sensitive to driving stress and traffic congestion, men are more likely to relate risky driving to male identity *(7; 34)*. Women also tend to regard motorized traffic as a major constraint on bicycling and walking *(35; 36)*. However, we found only one paper that discusses gender in relation to traffic safety concerns toward public transit, and that result applied to bad weather conditions only. Both men and women consider public transit a safer travel mode during rainy and snowy days *(37).*

Although our research focuses on attitudinal factors, it is pertinent to point out that household structure, social norms, and gender roles affect women’s travel patterns as well. Due to disproportionate domestic obligations, women usually work closer to home, make more grocery shopping trips, and chauffeur children more frequently compared to their male counterparts *(e.g., 38; 39)*. Women also have inferior access to a car, even though traveling by car may better fit their complex trip chains and tight time pressure *(40; 41)*.

Taken as a body of literature, previous research suggests the possibility that safety concerns may moderate or nullify the positive effect of environmental motivations on sustainable travel behavior – particularly for women. However, to our knowledge, no study has considered these two attitudes and the moderating role of gender simultaneously on sustainable travel behavior. Our study contributes to the literature by integrating all three factors to evaluate their combined effects on sustainable travel behavior. Using pre- and post-opening travel surveys for a new light rail transit service with a quasi-experimental research design and a first-differenced modeling approach, we examine how gender affects transit use through environmental beliefs and safety concerns.

**DATA**

The Expo Line is a new light rail transit service connecting Downtown Los Angeles to Culver City that began service in April of 2012. Before its opening, there were 66 bus lines passing through a one-mile area around the Expo Line *(42)*. Adopting a quasi-experimental research design, households located within 1/2 mile of six Expo Line stations (Expo/Western, Expo/Crenshaw, Farmdale, Expo/La Brea, La Cienega/Jefferson, and Culver City) were selected as the experimental group. Households from an area that was similar to the experimental group in neighborhood built environment and socio-demographic composition but who were located more than 1/2 mile from the same six Expo Line stations were selected as the control group. A household travel survey was conducted from September, 2011 through February, 2012 (wave 1, which is before the opening of the Expo Line), and the same households were surveyed again during September, 2012 through November, 2012 (wave 2, which is after the opening of the Expo Line). For more information about the study design and transit service in the study area, see Lee *et al*. *(42)* and Spears *et al*. *(43)*.

The before- and after-opening surveys (wave 1 and wave 2) were administered with the goal of measuring travel during the same season. Data collection for both survey waves began after local primary and secondary schools were in session following the summer break, and no data were collected during major holidays. During the wave 1 data collection, daily average temperatures ranged from 10 to 28 degrees Celsius. During the wave 2 data collection, the daily average temperature range was from 13 to 37 degrees Celsius *(44)*. Rainfall was likely a more important seasonal determinant of travel in southern California’s mild climate. During the five-month period of before-opening (wave 1) data collection, there were five days with more than 0.25 inches of rainfall, and there were two days with more than 0.25 inches of rainfall during the three months of after-opening (wave 2) data collection *(44)*.

In wave 1, survey invitations were sent out to all 27,275 households located within the study area and 651 households expressed an interest in participating. A total of 285 households returned usable responses and received either a $15 or $30 supermarket gift card (depending on participation in additional geographic positioning system and accelerometer tracking), resulting in a response rate of 1.0% from the population or 44% from among the households expressing initial interest. The low response rate may have resulted from the survey’s numerous socio-demographic and attitudinal questions (which took about 30 minutes to finish) and the week-long travel log (which took about 5 minutes each day to complete). However, the response rate was comparable to two recent travel surveys in the same region: the 2010-2012 California Household Travel Survey with a 1.4% response rate *(45)* and the 2012 Neighborhood Travel and Activity Study near rail transit in Los Angeles County with a 0.4% response rate *(46)*. Of the 285 households who took the wave 1 survey, a total of 208 completed the survey again in wave 2 and received either a $50 or $75 supermarket gift card, again depending on participation in the electronic tracking. Of those survey households, the lead responding adult in 202 households (103 in the experimental group and 99 in the control group) provided sufficiently complete data to allow comparison of travel for the same person in wave 1 and wave 2, which comprised the final dataset.

Figure 1 shows the home locations of respondents and their distances from the six Expo Line stations. Compared to 2010 Census estimates in the same study area (Table 1), the survey respondents were in general older, had higher educational attainment, and were more likely to be female and African-American. They also had a smaller household size and a higher home ownership. Hispanics were substantially under-represented even though all survey materials were available both in English and Spanish and extra efforts were made to outreach to the Hispanic community through local organizations. We did not develop a weight to adjust for potential differences because the mailing information used to contact the sample frame did not include sufficient socio-demographic data to compare respondents to non-respondents. Moreover, our research design is based on comparisons of experimental and control subjects (described in detail in the METHODOLOGY section). As shown in Table 3, the travel behavior and attitudinal characteristics of those subjects are the same before the Expo Line opened. For that reason, we did not weight to the study area demographics.

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**FIGURE 1 Study Area and Home Locations of Respondents**

**TABLE 1 Selected Characteristics of Survey Respondents and Study Area Residents**

|  |  |  |
| --- | --- | --- |
| Characteristic | Expo Sample1 | Study Area2 |
| *# of Households*3 | 202 | 66,525 |
| *Gender*3 |  |  |
|  male | 27.4% | 47.2% |
|  female | 72.6% | 52.8% |
| *Age*3 |  |  |
|  20-29 | 10.6% | 20.8% |
|  30-39 | 14.6% | 19.8% |
|  40-49 | 20.7% | 19.7% |
|  50-59 | 26.3% | 17.4% |
|  ≥60 | 27.8% | 22.3% |
| *Ethnicity*3 |  |  |
|  White | 27.2% | 11.4% |
|  African-American | 50.0% | 41.1% |
|  Asian | 11.9% | 4.4% |
|  Hispanic | 6.4% | 37.9% |
|  Other | 4.5% | 5.2% |
| *Education Level*4 |  |  |
|  high school or less | 9.4% | 45.6% |
|  some college | 35.9% | 29.0% |
|  bachelor’s degree | 31.8% | 16.0% |
|  graduate degree | 22.9% | 9.4% |
| *Household Income*4 |  |  |
|  <$15K | 16.4% | 18.0% |
|  $15K-$35K | 23.6% | 24.1% |
|  $35K-$55K | 20.0% | 18.5% |
|  $55K-$75K | 14.9% | 13.5% |
|  $75K-$100K | 11.8% | 10.1% |
|  >$100K | 13.3% | 15.9% |
| *Household Size*3 |  |  |
|  average | 2.1 persons | 2.8 persons |
| *Home Ownership*3 |  |  |
|  own | 44.4% | 40.0% |
|  rent | 55.6% | 60.0% |

Notes:

1. Includes 202 respondents who completed surveys for both wave 1 and wave 2.
2. Includes 44 census tracts which cover the Expo study area (shown in Figure 1).
3. Based on 2010 Census tract data.
4. Based on 2006-2010 American Community Survey (ACS) tract data.

In addition to providing socio-demographic information, respondents were asked to answer attitudinal questions regarding their environmental beliefs and safety concerns on a 7-point Likert scale and to record their total daily trip counts by each travel mode (car, bus, train, walking, and bicycling) for a 7-day period. Questions about environmental beliefs inquired into personal values and norms toward resource conservation, environmental protection, and environmental benefits of public transit. Questions about safety concerns related to transit use were developed based on past research *(e.g. 12; 29; 47; 48)*. Traveling by each mode was counted as a separate trip, excluding walking and bicycling trips that were less than 5 minutes. For example, a walk of 10 minutes to take a bus and then transfer to rail transit counts as 3 trips, and a walk of 2 minutes in a parking lot to drive a car was considered 1 trip. Survey subjects were advised of these protocols at the beginning of the 7-day survey and via follow up phone calls from research staff during the survey period.

Table 2 summarizes the descriptive statistics for socio-demographic characteristics, attitudes and intentions, and transit use for the 141 respondents included in the regression analyses, since 61 out of the 202 respondents did not answer all of the questions on both the wave 1 and wave 2 surveys. Because our analysis compares persons in the treatment area with persons in the control group, this attrition does not compromise our results. We compared characteristics of the respondents that did and did not complete all questions and results are available upon request.

**TABLE 2 Descriptive Statistics for Variables Considered**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Meaning | (n=141) | Wave 1 |  | Wave 2 |
| Mean | S.D. | Min | Max |  | Mean | S.D. | Min | Max |
| ***Transit Use and Expo Line Exposure*** |
| ptransit | Percentage of total trips by transit (bus and train combined) | 0.08 | 0.18 | 0.00 | 0.90 |  | 0.08 | 0.16 | 0.00 | 1.00 |
| ptrain | Percentage of total trips by train | 0.01 | 0.04 | 0.00 | 0.33 |  | 0.02 | 0.05 | 0.00 | 0.25 |
| pbus | Percentage of total trips by bus | 0.07 | 0.17 | 0.00 | 0.90 |  | 0.06 | 0.14 | 0.00 | 1.00 |
| ntransit | Average daily number of trips by transit (bus and train combined) | 0.42 | 0.99 | 0.00 | 4.29 |  | 0.45 | 1.04 | 0.00 | 4.57 |
| ntrain | Average daily number of trips by train | 0.04 | 0.21 | 0.00 | 2.00 |  | 0.14 | 0.41 | 0.00 | 2.71 |
| nbus | Average daily number of trips by bus | 0.38 | 0.89 | 0.00 | 4.29 |  | 0.31 | 0.76 | 0.00 | 3.71 |
| expo | Residence within ½ mile of Expo Line stations (yes=1) | -- | -- | -- | -- |  | 0.52 | 0.50 | 0 | 1 |
| ***Attitudes and Intentions*** |
| Unsafe-C | Safety and security concerns (1-7 Likert scale. 1: completely unafraid; 7: extremely afraid) |
|  walkunsf | Question about neighborhood walking safety: | 4.40 | 1.94 | 1 | 7 |  | 4.12 | 1.85 | 1 | 7 |
|  | “How safe do you feel when walking in your neighborhood at night?” |  |  |  |  |  |  |  |  |  |
|  stopunsf | Question about transit stop safety: | 4.35 | 1.70 | 1 | 7 |  | 4.19 | 1.69 | 1 | 7 |
|  | “How safe do you feel where you get on and off of the train/bus at night?” |  |  |  |  |  |  |  |  |  |
|  rideunsf | Question about transit riding safety: | 4.26 | 1.72 | 1 | 7 |  | 4.20 | 1.66 | 1 | 7 |
|  | “How safe do you feel while riding on the train/bus at night?” |  |  |  |  |  |  |  |  |  |
| Envir-C | Environmental concerns (1-7 Likert scale. 1: strongly disagree; 7: strongly agree) |
|  resoucon | Question about resource conservation: | 6.14 | 1.28 | 1 | 7 |  | 6.11 | 1.13 | 1 | 7 |
|  | “I don’t like to waste natural resources or energy.” |  |  |  |  |  |  |  |  |  |
|  envirpro | Question about environmental protection: | 6.28 | 1.16 | 1 | 7 |  | 6.30 | 1.03 | 2 | 7 |
|  | “Protecting the environment is important to me.” |  |  |  |  |  |  |  |  |  |
|  transben | Question about transit benefits: | 6.35 | 1.21 | 1 | 7 |  | 6.20 | 1.29 | 1 | 7 |
|  | “Increasing use of public transit is beneficial to the environment.” |  |  |  |  |  |  |  |  |  |
| Unsafe-I | Safety and security intentions (1-7 Likert scale. 1: very unlikely; 7: very likely) |
|  | Question: “How likely are you to reduce or avoid using public transit because of safety and security concerns?” | 3.76 | 2.06 | 1 | 7 |  | 3.87 | 2.02 | 1 | 7 |
| Envir-I | Environmental intentions (1-7 Likert scale. 1: strongly disagree; 7: strongly agree) |
|  | Question: “I try to minimize my impact on the environment by taking the bus/train whenever I can.” | 3.84 | 2.10 | 1 | 7 |  | 3.89 | 2.04 | 1 | 7 |
| ***Socio-Demographic Characteristics*** |
| female | Being a female (yes=1) | 0.70 | 0.46 | 0 | 1 |  | 0.70 | 0.46 | 0 | 1 |
| age1835 | Age is 18 to 35 years (yes=1) | 0.25 | 0.43 | 0 | 1 |  | 0.23 | 0.42 | 0 | 1 |
| age3655 | Age is 36 to 55 years (yes=1) | 0.40 | 0.49 | 0 | 1 |  | 0.39 | 0.49 | 0 | 1 |
| age56p | Age is 56 years or older (yes=1) | 0.35 | 0.48 | 0 | 1 |  | 0.38 | 0.49 | 0 | 1 |
| racewh | Race is White (yes=1) | 0.29 | 0.46 | 0 | 1 |  | 0.30 | 0.46 | 0 | 1 |
| raceaf | Race is African-American (yes=1) | 0.46 | 0.50 | 0 | 1 |  | 0.46 | 0.50 | 0 | 1 |
| raceot | Race is other (yes=1) | 0.25 | 0.43 | 0 | 1 |  | 0.24 | 0.43 | 0 | 1 |
| edulb | Education level is less than a bachelor’s degree (yes=1) | 0.42 | 0.50 | 0 | 1 |  | 0.42 | 0.50 | 0 | 1 |
| eduba | Education level is a bachelor’s degree (yes=1) | 0.36 | 0.48 | 0 | 1 |  | 0.33 | 0.47 | 0 | 1 |
| edugr | Education level is a post-graduate degree (yes=1) | 0.22 | 0.42 | 0 | 1 |  | 0.25 | 0.44 | 0 | 1 |
| hhinc35 | Household income is less than $35K (yes=1) | 0.38 | 0.49 | 0 | 1 |  | 0.35 | 0.48 | 0 | 1 |
| hhinc75 | Household income is between $35Kand $75K (yes=1)  | 0.36 | 0.48 | 0 | 1 |  | 0.36 | 0.48 | 0 | 1 |
| hhinc75p | Household income is greater than $75K (yes=1) | 0.26 | 0.44 | 0 | 1 |  | 0.29 | 0.46 | 0 | 1 |
| child12 | Having child(ren) under 12 years in the household (yes=1) | 0.14 | 0.35 | 0 | 1 |  | 0.14 | 0.35 | 0 | 1 |

Note: The sample consisted of 141 respondents whose information was used in the regression analyses.

**METHODOLOGY**

We used the quasi-experiment of the Expo Line opening, and the attitudinal and travel data collected in the survey, to examine how gender and attitudes toward safety and the environment were associated with changes in transit travel among survey respondents. The analysis proceeded in two steps. We first examined bivariate correlations between survey respondents’ attitudes about safety, attitudes about the environment, and transit use. We then used a longitudinal model to examine how changes in transit use, in the experimental versus control groups, were associated with gender and attitudes toward safety and the environment.

We tested two measures of transit use: (1) the survey respondent’s percentage of total trips made by transit during the 7-day tracking period (which is a fractional variable ranging from 0 to 1) and (2) the respondent’s average daily number of trips made by transit during the 7-day survey (which is a non-negative rational number). The results using both measures were similar, therefore we only report results using the percentage of total trips by transit.

Our key independent variables were measures of concerns about safety and the environment. The survey questions allowed us to construct measures of attitudes, which reflect concerns about neighborhood safety (Unsafe-C) and environmental issues (Envir\_C), and intentions, which reflect how the survey respondents would intend to act based on their attitudes toward safety (Unsafe-I) and the environment (Envir-I). The survey questions that were used to construct these measures are shown in Table 2. Because larger values of the safety measures indicate a higher concern about safety and security, we labeled the safety measures “Unsafe-C” and “Unsafe-I” to indicate concerns and intentions, respectively, about a lack of safety. Note that only Unsafe-I and Envir-I (each based on one survey question) were included in the following first-differenced modeling analysis. Unsafe-C and Envir-C (each based on three survey questions) were used in the structural equation modeling analysis, which is not shown here (since the main results agree with that from the first-differenced modeling) but available upon request.

**RESULTS**

**Bivariate Analysis**

Table 3 shows the responses (on a 7-point Likert scale) to the constituent survey questions that were used later to construct the attitude and intention measures, and the sample average values for responses to those questions for men and women and for experimental and control groups, in each survey wave. Table 3 also shows measures of transit travel, including bus, train, and any transit (bus and train combined), again for men and women and for experimental and control groups, in each survey wave.

**TABLE 3 Average Attitudes, Intentions, and Transit Use**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Wave 1 |  | Wave 2 |  | Wave 1 |  | Wave 2 |
|  | Men | Women |  | Men | Women |  | Experi. | Control |  | Experi. | Control |
|  | (n=42) | (n=99) |  | (n=42) | (n=99) |  | (n=74) | (n=67) |  | (n=74) | (n=67) |
| ***Attitudes*** |  |  |  |  |  |  |  |  |  |  |  |
| Unsafe-C |  |  |  |  |  |  |  |  |  |  |  |
|  walkunsf | **3.24** | **4.90** |  | **2.86** | **4.66** |  | 4.55 | 4.24 |  | 4.32 | 3.90 |
|  stopunsf | **3.38** | **4.77** |  | **2.98** | **4.71** |  | 4.43 | 4.27 |  | 4.43 | 3.93 |
|  rideunsf | **3.14** | **4.73** |  | **2.93** | **4.74** |  | 4.34 | 4.16 |  | 4.42 | 3.96 |
| Envir-C |  |  |  |  |  |  |  |  |  |  |  |
|  resoucon | **6.55** | **5.97** |  | 6.21 | 6.06 |  | 6.04 | 6.25 |  | 6.05 | 6.16 |
|  envirpro | 6.43 | 6.22 |  | 6.21 | 6.34 |  | 6.30 | 6.27 |  | 6.28 | 6.33 |
|  transben | 6.36 | 6.35 |  | 6.40 | 6.11 |  | 6.46† | 6.24 |  | **5.99**† | **6.43** |
| ***Intentions*** |  |  |  |  |  |  |  |  |  |  |  |
| Unsafe-I | **2.74** | **4.19** |  | **2.52** | **4.43** |  | 3.99 | 3.51 |  | 4.00 | 3.72 |
| Envir-I | **4.50** | **3.56** |  | **4.48** | **3.65** |  | 3.92 | 3.75 |  | 3.89 | 3.90 |
| ***Transit Us*e** |  |  |  |  |  |  |  |  |  |  |  |
| ptransit | 0.125 | 0.061 |  | **0.124** | **0.056** |  | 0.080 | 0.081 |  | 0.078 | 0.074 |
| ptrain | 0.012 | 0.006 |  | 0.029 | 0.017 |  | 0.008† | 0.008 |  | **0.031**† | **0.009** |
| pbus | 0.114 | 0.055 |  | **0.095** | **0.039** |  | 0.072 | 0.073 |  | 0.047 | 0.066 |
| ntransit | **0.697** | **0.304** |  | **0.824** | **0.290** |  | 0.430 | 0.412 |  | 0.532 | 0.357 |
| ntrain | 0.060 | 0.037 |  | 0.221 | 0.100 |  | 0.047† | 0.041 |  | 0.195† | 0.070 |
| nbus | **0.645** | **0.264** |  | **0.603** | **0.190** |  | 0.383 | 0.371 |  | 0.337 | 0.287 |

Notes:

1. Numbers in bold indicate that the results of the two-sample t-tests between men and women or between experimental and control groups within the same wave are significant at the 95% level.
2. † denotes that the results of the two-sample t-tests for the same group across waves are significant at the 95% level.
3. Variables walkunsf, stopunsf, and rideunsf denote concerns about neighborhood walking safety, transit stop safety, and transit riding safety respectively. Variables resoucon, envirpro, and transben denote attitudes toward resource conservation, environmental protection, and transit benefits respectively. Variables ptransit, ptrain, and pbus denote percentages of total trips by transit, train, and bus respectively. Variables ntransit, ntrain, and nbus denote average daily number of trips by transit, train, and bus respectively.

Note that before the Expo Line opened (wave 1), there were no statistically significant differences in the attitude or intention questions or in transit travel across the experimental and control groups. By design, we sought control subjects who lived in areas that were otherwise comparable to the locations within a half-mile of the new light rail stations, and it is reassuring that there were no before-opening differences in the sample average values across experimental and control groups in Table 3. After the Expo Line opened, the experimental group had a statistically significant increase in the percentage and average daily number of train trips (variable names are “ptrain” and “ntrain” respectively), and there was a statistically significant experimental versus control difference in the percentage of train trips across the two groups in wave 2 (average ptrain = 0.031 for experimental and 0.009 for control groups).

Compared to men, women had higher safety and security concerns and intentions related to transit use (Unsafe-C and Unsafe-I) in both wave 1 and wave 2, consistent with earlier research that suggested that women have higher safety concerns related to transit use than do men *(e.g., 28; 29)*. Although men and women in general did not differ in their environmental concerns (Envir-C, the only exception was the “not to waste natural resources or energy” component in wave 1, where men expressed a stronger attitude), women had lower intentions to increase transit use out of environmental concerns (Envir-I). In wave 2, the experimental group showed a lower level of agreement that increasing transit use was beneficial to the environment compared to wave 1.

To summarize, after the Expo Line opened, the experimental subjects (who lived within a half-mile of new stations) increased their rail transit travel, and women consistently reported higher on both safety concerns (Unsafe-C) and intentions to reduce transit travel out of concerns about safety (Unsafe-I). In the next section, we examine whether gender was associated with travel behavior changes after the Expo Line opened, and if so how attitudes and intentions toward safety and the environment played a role in gender differences.

**Longitudinal Analysis**

We collected panel data that enables us to examine how respondents’ transit travel changed across the two waves. We used a first-differenced model (FDM) to examine how the change in the percentage of transit trips for a respondent from wave 1 to wave 2 (Δptransit) or the change in the percentage of train trips (Δptrain) is a function of (1) experimental group status (expo, a dummy variable that takes a value of 1 for households that live within a half-mile of an Expo Line station after rail service began) and (2) changes in the respondent’s safety and environmental intentions from wave 1 to wave 2 (ΔUnsafe-I and ΔEnvir-I). FDM is commonly employed to deal with two-period panel data *(49)*. This model differences out time-invariant variables, and only time-varying explanatory variables stay in the model. The advantage of the FDM is that time-constant unobserved factors are controlled via a time-constant effect for each subject being cancelled out of the model *(50)*. Exposure to the Expo Line is a time-varying explanatory variable because there was no Expo Line transit service in wave 1 and only respondents in the experimental group (located within 1/2 mile of the Expo Line stations) were exposed to this transit service in wave 2. More accurately, we assumed that the experimental group was more exposed to the new transit service than the control group. Although time-invariant variables such as gender cannot stay in the FDM, we can and do include the interaction of time-invariant variables (e.g. gender) and time-varying variables (e.g. Expo Line exposure) in the model to estimate the effects of time-invariant variables *(see, e.g., 50)*. The equation form is as follows:

Δptransit*i* or Δptrain*i* = *β1*ΔUnsafe-I*i* + *β2*ΔEnvir-I*i* + *β3*expo*i* + *β4*(female\*expo)*i* + Δε*i*,

where Δ denotes change from wave 1 to wave 2, *i* denotes individuals, *β1* to *β4* denote coefficients to be estimated, and *ε* denotes an i.i.d. error term.

The results of the FDM models (estimated with the OLS methods) are shown in Table 4. In Model 1, the dependent variable is the respondent’s change in the percentage of transit trips (Δptransit; denoted as Δ(% Transit Trips) in Table 4). Living within a half-mile of the Expo Line stations was not associated with a change in total (bus plus rail) transit trip making. In Models 2, 3, and 4, the dependent variable is the respondent’s change in their percentage of rail transit trips (Δptrain; denoted as Δ(% Train Trips) in Table 4). We estimated models for changes in rail transit trips since it was most closely related to the intervention. Living within a half-mile of the new stations was statistically significantly associated with an increase in the percentage of rail transit trips – an effect that was the same when we used the change of the average daily number of rail trips (Δntrain) as the dependent variable (results available upon request). The magnitude of the coefficient on the “expo” variable indicates that living within a half-mile of a new light rail station was associated with from a 2.4 percentage point increase in rail transit as a share of all daily individual trips (Model 2) to a 4.3 percentage point increase (Model 3). In Model 3, we added an interaction between gender (variable name is “female”, = 1 if being a female) and exposure to the Expo Line (variable name is “expo”, = 1 if residence within 1/2 mile of Expo Line stations), which was statistically significant and negative. This suggests the Expo Line “treatment effect” on rail ridership was attenuated for women, and that for women the Expo Line treatment effect was less than half the full sample average (the Expo Line treatment effect was a 4.3 percentage point increase in rail ridership for the full sample but there was a 2.7 percentage point decrease for women). In Model 4, we interacted the female dummy variable and the respondent’s measure of safety intentions in wave 2 (Unsafe-I2) with the Expo Line treatment effect, similarly obtaining a statistically significant negative effect. These results suggest that the effect of living near the new light rail transit service on increased rail transit ridership was lower for women, due in part to female concerns about safety and security related to transit. Also see Figure 2 which graphically displays how the Expo Line exposure effect was reduced for women using results of Model 3.

**TABLE 4 First-Differenced Models (FDMs) Estimated with OLS for Changes in the Percentage of Transit and Train Trips from Wave 1 to Wave 2**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Model 1** |  | **Model 2** |  | **Model 3** |  | **Model 4** |
|  | Δ(% Transit Trips) |  | Δ(% Train Trips) |  | Δ(% Train Trips) |  | Δ(% Train Trips) |
|  | Coef. | S.E. |  | Coef. | S.E. |  | Coef. | S.E. |  | Coef. | S.E. |
| ΔUnsafe-I → | 0.002 | 0.008 |  | 0.001 | 0.004 |  | 0.001 | 0.003 |  | 0.002 | 0.004 |
| ΔEnvir-I → | 0.018\*\*\* | 0.007 |  | 0.005\*\* | 0.003 |  | 0.005\*\* | 0.003 |  | 0.005\*\* | 0.003 |
| expo → | 0.008 | 0.021 |  | 0.024\*\*\* | 0.009 |  | 0.043\*\*\* | 0.016 |  | 0.041\*\*\* | 0.013 |
| female·expo → | -- | -- |  | -- | -- |  | -0.027\* | 0.016 |  | -- | -- |
| female·expo·Unsafe-I2 → | -- | -- |  | -- | -- |  | -- | -- |  | -0.005\*\* | 0.002 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| ***Overall Model Fit Indices*** |  |  |  |  |  |  |  |  |  |
| *F*-test | 2.53 |  |  | 2.97 |  |  | 2.73 |  |  | 3.07 |  |
|  df | (3, 137) |  |  | (3, 137) |  |  | (4, 136) |  |  | (4, 136) |  |
|  p-value | 0.060 |  |  | 0.034 |  |  | 0.032 |  |  | 0.019 |  |
| R2 | 0.067 |  |  | 0.072 |  |  | 0.096 |  |  | 0.101 |  |
| n | 141 |  |  | 141 |  |  | 141 |  |  | 141 |  |

Notes: Transit trips are bus and train trips combined. Δ denotes change from wave 1 to wave 2; Coef. denotes coefficient; S.E. denotes robust standard error; -- denotes not included in the model; \*, \*\*, \*\*\* denote statistical significance respectively at the 10%, 5%, and 1% level; “female·expo” denotes the interaction of female and expo; “female·expo·Unsafe-I2” denotes the interaction of female, expo, and Unsafe-I in wave 2.



**FIGURE 2 Interaction of Gender and Expo Line Exposure Effect for the Percentage of Train Trips**

Notes: CI denotes confidence interval. Wave 1 values are group means from the observed data. Wave 2 values are wave 1 values plus across-wave changes predicted from Model 3.

**CONCLUSIONS**

In this paper, we used the opening of a new light rail transit service to conduct a quasi-experimental study to examine the relationships among gender, environmental beliefs, safety concerns, and transit use. With a rather small sample (n=141), we got the following main results from the longitudinal analysis. We find that living within a half-mile of a new light rail transit station is associated with an increase in the percentage of train trips, as would be expected. This effect, however, is statistically significantly lower for women in ways that are linked to safety and security concerns toward transit use.

These findings have important implications for policies that aim to stimulate sustainable transportation. First, to improve transit ridership, reducing personal concerns over safety and security related to transit use may be more effective than increasing public awareness of the environmental impacts of transportation. A reduction in safety and security concerns could also help enhance individual intentions to use public transit for environmental reasons. This is particularly important to attract potential female riders, since fear of crime is a crucial restrictor on women’s use of public transit. Moreover, it suggests the difficulties in translating pro-environmental attitudes into pro-environmental travel behavior. Unlike other types of pro-environmental behavior such as recycling and buying eco-products, transportation is a derived demand to fulfill other needs (e.g., work, recreation, shopping, chauffeuring) and the level of inconvenience to perform pro-environmental travel behavior such as riding transit might be higher, especially in transit unfriendly environments. As a consequence, while information and education campaigns are a common strategy to increase environmentally friendly behavior, they may not be as successful in promoting sustainable travel behavior.

A small sample size is the main limitation of our work. With such a small sample size, we might not have enough statistical power to detect nuanced differences that would have been significant if the sample size had been larger. In addition, the small sample size and low response rate were in part due to the lack of Hispanic participation, possibly related to worries over status of residence. Although there are a few studies discussing travel mode choice of Hispanic or immigrant groups *(e.g., 51; 52)*, their travel-related attitudes are still largely unknown. As the Hispanic population is growing in the U.S., under-representation of this group could limit the generalizability and the predictive power of our research. Moreover, we did not consider the possible bias due to cognitive dissonance. Women may justify their non-use of a newly available transit service by expressing greater concerns toward transit safety than before. Future research into those issues could help craft more elaborate policies for encouraging sustainable transportation.

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