Undriving Climate Change: The Benefits of An E-Bike Rebate Program

TRB 103rd Annual Meeting, Washington DC, January 2024
Aditi Misra, Anna Henderson, Manish Shirgaokar, and Wesley Marshall

University of Colorado Denver

BACKGROUND

The transportation sector is one of the largest contributors of greenhouse gas emissions in the United States. While climate friendly transportation modes like electric bicycles (e-bikes) continue to gain popularity, the **high initial cost often remains a hurdle**. Some states, cities, and local organizations have started e-bike rebate programs in order to **promote mode shift**.

In 2022, **Denver's Office of Climate Action, Sustainability, and Resiliency (CASR) launched an income-based e-bike incentive pilot program**. Elements of the program included:

-Point-of-sale e-bike vouchers, eligible at trusted brick and mortar bike shops within five miles of Denver.

-Standard e-bike rebates of $300; e-cargo bike qualified for an additional $200.

-Income-qualified rebates of $1200 for residents enrolled in a program meant to support low-income residents, like Medicaid.

By the end of it's first year, the program saw significant success. The City of Denver had:

-Spent **$4.7 million** to provide vouchers to **4,734 residents**.

-Engaged **30 local bike shops** to participate.

-Distributed **49% of vouchers and 67% of funding to income-qualified residents**.

The high demand for Denver's rebate program offers researchers the opportunity to study and **improve the environmental and equitable outcomes** of future programs.

Image: CASR

RESEARCH QUESTIONS

Did the program enable low-income and minority populations in Denver to acquire an e-bike?

Did buying an e-bike lead to mode shift?

If a mode shift occurred, across which modes and for whom did this happen?

DATA AND METHODS

SURVEY DATA

-At the end of 2022, CASR distributed a survey to e-bike rebate redeemers and had 958 respondents.
-The survey asked questions on the following topics, among others:
  -Frequency of trips by mode (e.g., gas-powered vehicles, bicycles, walking, transit) before and after purchasing the e-bike.
  -Estimated reduction in average trip miles by gas powered vehicles.
  -Whether they would have bought an e-bike if the rebate voucher would not have been made available.
  -Household income, age and gender

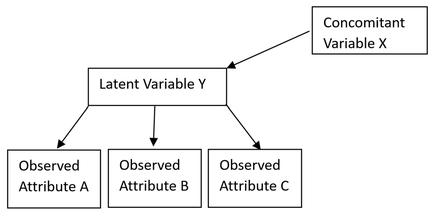
METHODS

1. Exploratory Analysis

We conducted a series of one-way ANOVA tests to identify intergroup variability across **age, gender, and income**. There were significant differences across the following:
-Age and income groups on purchase decision if a rebate was not offered.
-Age, income, and gender in automobile mode replacement frequency.
-Gender and income groups for public transit and bicycling trips respectively.

2. Latent Class Analysis

We used a latent class model (LCM) with covariates to identify which socio-demographic groups were likely to purchase an e-bike without the rebate or replace their automobile trips with an e-bike.
-**Categorical variables:** age, gender, income, and race/ethnicity
-**Covariate for purchase decision:** decision to purchase or not
-**Covariate for mode replacement:** Whether or not the respondent selected "less often" for that specific mode



Schematic representation of latent class modeling with covariates

FINDINGS

SURVEY FINDINGS

Role of the Rebate in Purchase Decisions
-Three percent (3%) would have bought an e-bike without the rebate.

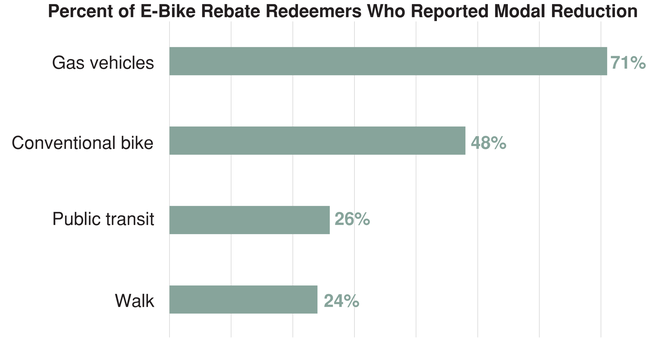
-Forty-three percent (43%) said the rebate acted as a nudge to buy an e-bike.

-Fifty-seven percent (57%) would not have bought an e-bike without the rebate.

Average Trip Replacement
-Respondents replaced 3.4 round car trips and 22 miles of weekly vehicle travel.

-Low-income respondents replaced 4.2 round trips and 30 miles of weekly vehicle travel.

Percent of E-Bike Rebate Redeemers Who Reported Modal Reduction



LATENT CLASS MODEL FINDINGS

Puchase without Rebate
-Members of Class 1 **were more likely to purchase an e-bike without a rebate**.

-**High income, white, 30-41-year-old males** were more likely to be in Class 1 than in any other class.

Mode Replacement for Gas-Powered Vehicle
-Members of Class 1 were **less likely to replace gas-powered vehicle trips** with e-bike trips.

-**High income, white or Asian/Pacific Islander, 30-50 year old males** were more likely to be in Class 1

Mode Replacement for Public Transit
-Members of Class 1 were **less likely to replace public transit trips with e-bike trips**.

-Similar to the gas-powered vehicle model, **high-income, white** people were more likely to be in Class 1.

	Class 1	Class 2	Class 3
Age			
Below 30	0.0815	0.5599	0
30-41	0.4834	0.265	0.1988
41-50	0.194	0.1196	0.0956
Above 50	0.2411	0.0555	0.7056
Gender			
Male	0.5978	0.4894	0.5697
Female	0.3892	0.4013	0.3986
Other	0.013	0.1093	0.0316
Race			
White	0.8288	0.7056	0.5829
Hispanic	0.0416	0.167	0.1864
Multiracial	0.0431	0.0598	0.0203
Asian/Pacific Islander	0.0349	0.0083	0.025
African American/Black	0.0104	0.0414	0.0377
Other	0.0411	0.0179	0.1477
Income			
Income below $25,000	0	0.2778	0.5805
$25,001-50,000	0.0726	0.3194	0.326
$50,001-75,000	0.135	0.2667	0.0071
$75,001-100,000	0.1221	0.1361	0.0864
$100,000+	0.6703	0	0
Estimated class population shares	0.5276	0.3802	0.0922

Fit for 3 Latent Classes

Class 2/1

	Coefficient	Std. error	t value	Pr(>|t|)
(Intercept)	0.0778	0.1675	0.464	0.643
No Purchase without rebate	-0.93516	0.19278	-4.851	0.000

Class 3/1

	Coefficient	Std. error	t value	Pr(>|t|)
(Intercept)	-1.44354	0.38587	-3.744	0.000
No purchase without rebate	-0.64291	0.40943	-1.57	0.117

Model diagnostics
Number of observations: 877
Number of estimated parameters: 46
Residual degrees of freedom: 313
Maximum log-likelihood: -3860.296
AIC(3): 7812.593
BIC(3): 8032.312
X^2(3): 317.8894 (Chi-square goodness of fit)

	Class 1	Class 2
Age		
Below 30	0.083	0.319
30-41	0.504	0.215
41-50	0.201	0.101
Above 50	0.21	0.3643
Gender		
Male	0.61	0.56
Female	0.378	0.4167
Other	0.0117	0.0774
Race		
White	0.832	0.67
Hispanic	0.0427	0.1687
Multiracial	0.0494	0.0341
Asian/Pacific Islander	0.0326	0.0193
African American/Black	0.0107	0.0386
Other	0.0414	0.0694
Income		
Income below $25,000	0.0118	0.3693
$25,001-50,000	0.0919	0.2839
$50,001-75,000	0.0934	0.2238
$75,001-100,000	0.1177	0.1229
$100,000+	0.6852	0
Estimated class population shares	0.6057	0.3943

Fit for 2 latent classes:

Class2/1

	Coefficient	Std. error	t value	Pr(>|t|)
(Intercept)	-0.01463	0.23909	-0.061	0.951
Use gas-powered vehicles less often	-0.58758	0.19999	-2.938	0.004

Model diagnostics
Number of observations: 877
Number of estimated parameters: 30
Residual degrees of freedom: 329
Maximum log-likelihood: -3889.026
AIC(2): 7838.051
BIC(2): 7981.347
X^2(2): 421.1804 (Chi-square goodness of fit)

	Class 1	Class 2
Age		
Below 30	0.0843	0.3128
30-41	0.5011	0.2263
41-50	0.2025	0.1021
Above 50	0.212	0.3588
Gender		
Male	0.6065	0.5137
Female	0.3819	0.4103
Other	0.0116	0.076
Race		
White	0.8233	0.6758
Hispanic	0.0431	0.1649
Multiracial	0.0487	0.0355
Asian/Pacific Islander	0.034	0.0176
African American/Black	0.0106	0.038
Other	0.0404	0.0702
Income		
Income below $25,000	0	0.3777
$25,001-50,000	0.0859	0.2879
$50,001-75,000	0.1018	0.2081
$75,001-100,000	0.1153	0.1263
$100,000+	0.697	0
Estimated class population shares	0.5955	0.4045

Fit for 2 latent classes:

Class2/1

	Coefficient	Std. error	t value	Pr(>|t|)
(Intercept)	-0.46366	0.18756	-2.472	0.014
Use public transit less often	0.11503	0.18364	0.626	0.532

Model diagnostics
Number of observations: 877
Number of estimated parameters: 30
Residual degrees of freedom: 329
Maximum log-likelihood: -3893.254
AIC(2): 7846.508
BIC(2): 7989.803
X^2(2): 420.5279 (Chi-square goodness of fit)

CONCLUSIONS

-Low-income and marginalized people, who would otherwise have difficulty purchasing an e-bike, benefitted from this rebate program.

-The **return on investment** for the e-bike rebate program was likely **higher for low-income, marginalized groups**.

-Marginalized people, whether financially, racially or by gender, more often **used e-bikes as a replacement for their automobile** compared to their high-income, White compatriots.

ACKNOWLEDGEMENTS

This work was supported by the University of Colorado Denver and the Mountain Plains Consortium, a University Transportation Center funded by the U.S. Department of Transportation.

We sincerely thank the Office of Climate Action, Sustainability, and Resiliency, City & County of Denver and Michael Salisbury for sharing the data for this research.