Travel, Environmental, and Equity Impacts of Income-Conditioned E-Bike Rebates in British Columbia

Final Report

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Research Team

Polina Polikakhina, Graduate Research Assistant
        Department of Civil Engineering, University of British Columbia

Amir Hassanpour, Graduate Research Assistant
        Department of Civil Engineering, University of British Columbia

Kyla Yu, Undergraduate Research Assistant
        Department of Civil Engineering, University of British Columbia

Meghan Winters, Co-Investigator
        Faculty of Health Sciences, Simon Fraser University

Alexander Bigazzi, Principal Investigator
        Department of Civil Engineering, University of British Columbia

Contact Information

Alexander Bigazzi
2002 – 6250 Applied Science Lane
Vancouver, BC V6T 1Z4
604-822-4426
alex.bigazzi@ubc.ca

https://reactlab.civil.ubc.ca/

Executive Summary

E1. Study Scope and Objectives

Electric-assist bicycles (e-bikes) are an increasingly popular mode of transportation with the potential to advance transportation system goals related to affordability, sustainability, and health. The potential benefits have led to the implementation of e-bike promotion programs by some local, regional and national governments. However, there has been limited empirical investigation of the impacts of e-bike promotion programs on e-bike adoption and use. In addition, many of the expected benefits of e-bike promotion rely on displacement of automobile use, and travel mode substitution from e-bike adoption varies widely. These uncertainties limit the strategic use of e-bike promotion programs to achieve transportation and climate mitigation goals.

In this study we investigate the travel, environmental, and equity impacts of the "BC Electric Bike Rebate Program," which was launched by the British Columbia Ministry of Transportation and Infrastructure in June 2023. The program provided e-bike purchase rebates in three income-conditioned tiers, aiming to support active transportation, make transportation more affordable for lower-income households, and contribute to the Province's greenhouse gas (GHG) reduction goals. Our study objectives were to examine how the rebates changed e-bike purchase decisions, how the incentivized e-bikes were subsequently used, the associated reductions in automobile use and GHG emissions, and how the program benefits varied across dimensions of equity related to the person, household, and geographic context. We surveyed rebate recipients in three waves to collect data on e-bike purchase decisions, use of the purchased e-bikes, and short-term (+3 months) and long-term (+12 months) travel behaviour changes after e-bike purchase.

E2. Study Sample

A 35% response rate from recruited BC e-bike rebate recipients yielded a sample of 1,004 cleaned survey responses at Wave 1, with 60% and 45% of the sample retained at Waves 2 and 3 respectively (Figure E.1). The sample compares well to the study population of BC e-bike rebate recipients, most (86%) of whom received the largest $1,400
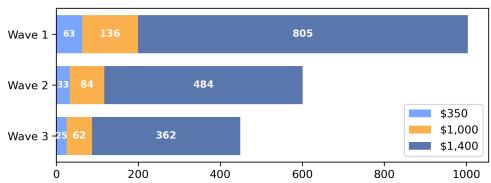

Figure E.1. Number of cleaned responses by rebate value and survey wave

rebates. Survey weights were developed to account for non-representation in recruitment and retention across study waves with respect to gender, age, race, household income, children in household, cycling before purchase, metropolitan region, and rebate value.

E3. Rebate-Driven E-Bike Purchases

Rebate recipients purchased e-bikes with an average price of $3,200, paying an average of $1,900 after the rebate. E-bike price was inversely related to rebate value, showing that the rebates were primarily used to decrease cost rather than to acquire more expensive e-bikes. This inverse relationship also enhanced the effectiveness of higher-value rebates, because they covered a larger share of the e-bike price. Although rebate value generally decreased with higher household income, most recipients in high-income households (even over $150,000 per year) were still able to qualify for the largest $1,400 rebates due to low personal income.

The program was effective in generating new (marginal) e-bike purchases, as the average self-reported likelihood of not purchasing an e-bike without the rebate increased from 21% to 62% with rebate value (Figure E.2).
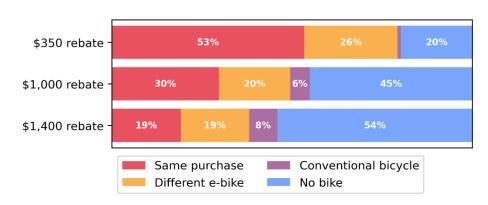

Figure E.2. Likelihood of alternative purchase decisions without rebate

Regression analysis showed that at a given rebate value, rebates were more likely to generate marginal purchases when the e-bike price was lower, and when the rebate recipient was younger, from a lower-income household, living in a milder winter climate, with higher educational attainment, and commuting regularly, but not previously cycling or e-biking. These relationships are positive for mode shift potential because rebates disproportionately induce marginal purchases by people who regularly commute but are not already cycling or e-biking.

E4. Use of Incentivized E-bikes

The reported combinations of trip purpose and alternative (replaced) travel mode for e-bike trips are illustrated in Figure E.3, showing that the most common types were utilitarian trips (shopping, errands, or commuting) that would have been made by automobile and exercise or leisure trips that would not have been made at all. The share of exercise/leisure trips decreased over time, while the shares of social/recreational/dining and escort/chauffeur trips increased. Recipients of the larger, income-conditioned rebates reported higher shares of utilitarian trips and lower shares of exercise/leisure trips. Utilitarian trips were also more common in the larger

metropolitan areas of Vancouver and Victoria. Participants who cycled pre-purchase reported higher likelihoods of e-bike trips replacing conventional bicycle use, and lower likelihoods of replacing automobile use.
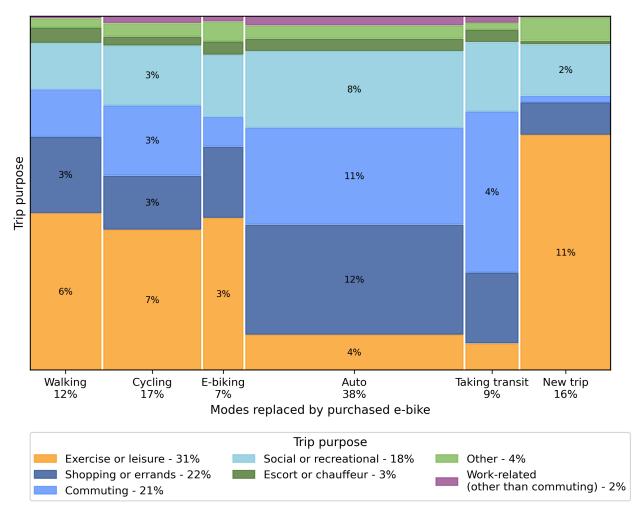
Figure E.3. Trip purpose and modes replaced by trips on the purchased e-bike[1]

The average changes in person-kilometers traveled (PKT) associated with each reported e-bike trip are illustrated in Figure E.4, which combines alternative trip mode and length. On average, each return trip using the purchased e-bike represented 15.2 km of new e-biking, with 3.6 km being net new travel and the rest displacing travel by other modes: 5.9 km of travel by automobile, 2.7 km by conventional bike, 1.6 km by public transit, and the other 1.4 km by walking or other modes.

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[1] Only cells >2% are labelled; "other" alternative mode (<1%) not shown
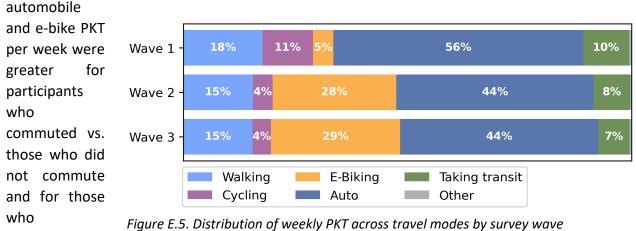
Figure E.4. Illustration of average PKT changes attributable to the reported e-bike (return) trips

E5. Post-Purchase Changes in Weekly Travel by Mode

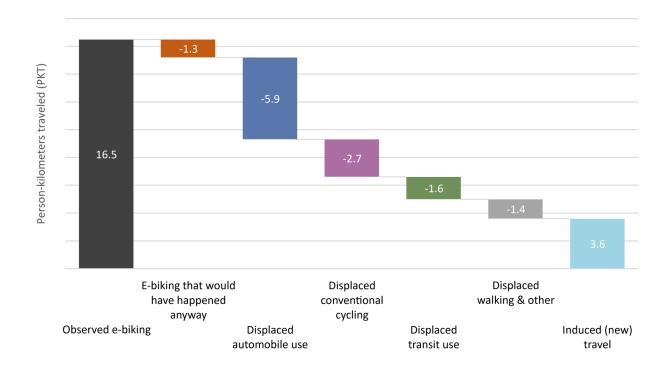Figure E.5 shows the modal distribution of weekly PKT by rebate recipients in each study wave,[2] revealing remarkably similar average mode shares of weekly PKT after 3 and 12 months of e-bike ownership. Most participants (87%) still had access to a private motor vehicle after the e-bike purchase, with an average of 0.75 motor vehicles per adult in the household. Regression analysis revealed that post-purchase automobile use fell by 20% while e-bike use increased by a factor of 16, without a significant difference between short-term and long-term changes. Changes in both automobile and e-bike PKT per week were greater for participants who commuted vs. those who did not commute and for those who

Figure E.5. Distribution of weekly PKT across travel modes by survey wave

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[2] Only for those who took all three survey waves and owned an incentivized e-bike at Waves 2 & 3

conventional cycled before the e-bike purchase. Reductions in automobile use were also greater for those with higher household income and those living in suburban areas that are relatively dense but with poorer access to destinations by walking, cycling, or public transit. Increases in e-bike use were also greater for those with lower household income and those living in hillier areas.

The weekly travel data and trip-level e-bike mode substitution data align in indicating that most travel on the purchased e-bikes is new e-biking, and most of that new e-biking is displacing travel by other modes: roughly half replacing automobile use and a quarter replacing conventional cycling. Applying modal greenhouse gas (GHG) emission rates, we estimate that over 95% of GHG from personal travel by the participants is generated by automobile use. Overall weekly GHG fell by 22% between Wave 1 and Wave 2, and then partially rebounded to a net 17% reduction in Wave 3 (from 35.2 to 29.2 kg CO2eq/wk).

E6. Total Program Costs and Impacts on Auto Use and Greenhouse Gas Emissions

Figure E.6 illustrates the aggregate cost of e-bikes purchased using rebates from the BC Program, for which $6.5 million in rebates generated $8.7 million in new retailer revenue. In addition to the $4.0 million in rebates that induced marginal purchases, the remaining rebates reduced $2.5 million of costs for non-marginal purchasers, almost all (98%) for people who met the program's low-income criteria (including 88% for the lowest-income recipients). Each $1000 in rebates generated $720 in new spending on e-bikes by marginal purchasers and $390 in reduced costs for non-marginal purchasers. The BC Program provided approximately $2,200 in rebates for each marginal e-bike purchased.
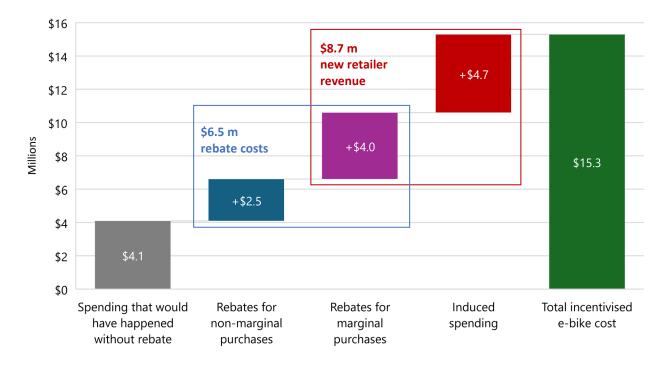

Figure E.6. Illustration of aggregate e-bike costs and spending for the BC Rebate Program

One year after their e-bike purchase, BC rebate recipients had increased their e-bike use by 40 km/wk and decreased their automobile use by 17 km/wk on average, which reduced their weekly GHG from travel by 5.4 kg CO_2eq. Restricting the impacts to marginal (rebate-induced) e-bike purchases, the average rebate generated 20 km/wk of new e-bike use, and reductions of 12 km/wk in automobile use and 3.9 kg CO_2eq/wk in GHG from travel. Extrapolating these 1-year changes out to an assumed 5-year e-bike use life, the rebate program induced new e-bike purchases that will be used for 25 million km of travel and result in 15 million fewer person-km travelled by automobile and 5,000 tonnes less CO_2eq emissions. We also estimate a reduction of approximately $1.3 million annually in travel-related externalities for all rebate recipients. The implied GHG abatement costs are $1,300 or $900 per tonne CO_2eq using marginal or non-marginal accounting methods (lower for the $350 rebate tier than for the $1,000 or $1,400 rebates). The BC e-bike rebates were cost-competitive for GHG reduction with electric vehicle incentives, but not with general carbon markets.[3]

Table E.1. Summary of factors affecting three key determinants of e-bike rebate program outcomes

Influencing factor	More marginal e-bike purchases	Potential for new e-biking	Potential for displaced automobile use
Being a marginal purchaser	▲	▼	▲
Higher rebate value	▲[1]	•	•
Higher e-bike price	▼	•	•
Men	•	▲	▲*
Older age	▼	▲	▲
Educational attainment	▲	•	▲
Higher household income	▼	▼	▲
Larger households (with children)	•	•	▲
More motor vehicles per person	•	•	▲
Cycling pre-purchase	▼	▲	▲
Regular commuting	▲	▲	▲
Bike parking inside home	•	▲	▲
Higher population density	•	•	▲
Better non-auto access to destinations	•	•	▼
Higher annual precipitation	•	▼*	•
More moderate winter temperatures	▲	▲*	▲*
More cycling infrastructure near home	•	▼*	•
Hillier areas	•	▲	▲*

▲ indicates greater effects and ▼ indicates smaller effects for these participants than for others; • indicates no significant difference in effects between these participants and others

* Effects observed at a 90% (rather than 95%) confidence level

[1] Larger effect per rebate, but not per rebate-dollar

[3] The GHG mitigation cost of electric car rebates in BC is around $1,000 per tonne CO_2eq, while the carbon market price in Canada is less than $300 per tonne CO_2eq.

Table E.1 summarizes some of the factors shown to influence the key determinants of program outcomes. Beneficial factors include rebates distributed to commuters, in more moderate winter climates, in hillier areas, and to those who can park an e-bike inside their home. Other factors have trade-offs, such as marginal purchasers using their new e-bikes less, but reducing their automobile use more. Rebate recipients living in lower-income households are more likely to make marginal purchases and subsequently use their e-bike more, but have less automobile use to displace with e-biking. In addition, rebate recipients who are older or already conventional cycling are less likely to make marginal purchases, but use the purchased e-bikes more, and displace more automobile use. We find that the twin objectives of increased e-bike use and decreased automobile use were most realized by those in households with moderately low income (1x to 2x the low-income cut-offs or LICO) and by those with moderate or low satisfaction with household income.

E7. Personal and Equity-Related Impacts

Table E2 illustrates key program benefits for rebate recipients and how they varied across population subgroups. The rebates made e-bike purchases more affordable, reducing purchase costs by an average of 43%. E-bike ownership enabled net new mobility for both exercise and utilitarian purposes, helped to reduce total weekly travel costs by 12% (approximately $2.3 million in annual travel cost savings for all 4,943 rebate recipients), and increased travel-related physical activity by 13%. To varying extents, these benefits were disproportionately gained by

Table E2. Benefits for rebate recipients and variation across population subgroups

	Rebate amount	E-bike purchase cost[1]	Net new mobility	Net change in weekly travel costs	Net change in physical activity
Average for all recipients	$1,320	$1,771	+5.8 km/week	-$9.07 (-12%)	+153 MMM[2] (+13%)
Low household income	▲	▲	▲	•	•
Low satisfaction with household income	▲	▲	•	▲	▲
Non-man	•	•	▼*	•	▼*
Non-white	▲	▲	▼	•	•
Disability	•	•	▲	•	•
No college	▲*	▲	•	•	•
Senior	▼	▼	▲	•	•
Rural	•	▼	▲	•	•

▲ indicates greater benefits (larger rebate, lower cost, more mobility, greater reduction in travel cost, more physical activity) and ▼ indicates smaller benefits for these participants as compared to others; • indicates no significant difference in benefits between these participants and others
* Effects observed at a 90% (rather than 95%) confidence level
[1] Price paid by participants after rebate applied
[2] Marginal MET minutes (from weekly travel alone)

those in low-income households, with less educational attainment, or with a disability, while women and non-binary folks benefitted less than men in new mobility and physical activity. Non-white rebate recipients benefitted more than others in regard to purchase costs but gained less new mobility. This pattern was reversed for seniors and rural residents who reduced their purchase costs less than others but gained more new mobility.

Quantitative and qualitative data revealed overall positive experiences with e-bike adoption. Fun and enjoyment stood out as important aspects of owning and using an e-bike, which many participants connected to mental and physical health improvements. Participants also highlighted the "freedom, flexibility, and independence" of new mobility options gained with e-bike adoption and the opportunity for travel mode shift. Conversely, participants expressed concerns about limited availability of safe places to ride and secure bike parking. Weather emerged as another primary consideration that increased in importance, possibly due to negative experiences e-biking in inclement weather.

E8. Conclusions and Recommendations

Overall, the BC Program was successful in achieving its aims of supporting active transportation, making transportation more affordable for lower-income households, and reducing GHG emissions. Approximately 3 out 5 rebates induced a new (marginal) purchase that would not have happened without the rebate. The incentivized e-bikes were used regularly for a variety of purposes; a large portion of the e-bike use displaced automobile travel, which led to net reductions in travel costs and GHG emissions and a net increase in physical activity during travel. Most of the program benefits were equitably distributed, with people in lower-income households receiving larger rebates and greater mobility and cost benefits, although most e-bike purchasers in high-income households also received the largest rebates. Generally, larger rebate values had greater impact per rebate but smaller impact per rebate-dollar. The changes in travel patterns were similar at the +3 and +12 month survey waves, which is promising for longer-term impacts. In addition to practical considerations such as travel time, "fun" was a key factor motivating sustained e-bike use.

The study results are largely consistent with past research and pre-program modelling. One major difference from the Saanich E-bike Incentive Program (which preceded the BC program) is that Saanich rebate values were strongly differentiated by household income, as a consequence of applying household income criteria (rather than personal income criteria, as in the BC program). BC rebates were slightly less cost efficient in inducing marginal purchases, likely due to higher e-bike prices, higher household income, more pre-purchase e-bike use, and more recipients living in areas with colder winters. Although post-purchase e-bike use was similar for recipients of the Saanich and BC rebates, changes in automobile use 12 months after purchase were smaller for the BC program due to particularly high pre-purchase automobile use by recipients of the income-conditioned Saanich rebates. We are more confident generalizing from the BC study

results, given the larger sample, more diverse contexts, and greater consistency with other studies on e-bike use and automobile mode substitution.

The results of this study support the core assumptions of e-bike rebate programs and provide insights to inform future rebate program design. Rebate program designers should consider the potential trade-offs in program impacts when selecting program criteria to prioritize rebate cost efficiency, new e-bike use, or automobile mode substitution. We recommend continuing the BC Electric Bicycle Rebate Program but changing from a personal to a household income criterion. Our findings indicate this change would likely increase the program's effectiveness in generating marginal e-bike purchases and use. It would also shift the rebate demand of high-income households to the more cost-efficient lower-value rebates. We also recommend setting LICO-based income thresholds (which account for household size and geographic context) for future e-bike rebates at around 2x LICO, which would prioritize income-constrained households while still capturing households with the potential for substantial automobile mode substitution.

Additionally, there are other factors beyond income that can influence program effectiveness. Given the strong positive impact of providing rebates to regular commuters, designing a rebate program that prioritizes this group (possibly in partnership with employers) may be a promising strategy to enhance program outcomes. Geographic prioritization is another option, based on contextual factors associated with greater rebate impacts such as milder winters, hillier terrain, and suburban settings with limited public transit. E-bike rebates need not be constrained to areas with high "bikeability". Other strategies to increase rebate availability and cost efficiency are to restrict the total number of rebates available at the high-value tiers, or to reduce the value of rebates at the upper tiers.

While e-bike rebates are effective in generating new e-bike use, there are persistent perceived barriers limiting use, particularly concerns about poor riding facilities (especially in rural areas) and theft (especially in urban areas). Thus, in addition to rebates, continued effort is required to improve cycling networks and mitigate bike theft, as these issues are particularly salient for those who are seniors, non-white, or have a disability.

We find that e-bike rebates are cost-competitive with electric vehicle rebates for GHG mitigation. They also generate a range of other important benefits through automobile mode substitution and increased physical activity. Thus, although GHG mitigation is an important and significant benefit of e-bike rebates, these programs need not (and likely should not) be justified solely through climate action. Considering mobility and physical activity co-benefits will be increasingly important if declining automobile emission rates diminish the effectiveness of e-bike rebates for GHG reduction. As interest in e-bike incentive programs continues to expand, we look forward to further investigations on their effectiveness in various scales and settings, and their comprehensive impacts on public health, traffic safety, and transportation system costs.