Citi Biking and Time Savings

The gendered time penalty of Brooklyn's missing bike lanes

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Problem Statement

New York City's Manhattan-centric subway system creates a transit gap for north-south Brooklyn commuters. With no direct train route, riders are forced to take a roundabout, 50-minute trip into Manhattan just to transfer back out to Brooklyn.

Anecdotally, biking cuts this commute in half. But the routes filling this transit gap lack protected bike lanes, forcing riders to bike in car traffic and making the journey dangerous. Most studies agree this physical risk disproportionately deters women, who currently make up just 25% of Citi Bike riders.

Approach and Data

This research asks: how does women's Citi Bike participation change when massive time savings are on the line?

- Uses 2019 Citi Bike data: the last year gender was included in the public datasets
- Isolate north-south trips with maximum time savings and build meaningful control groups to examine how women's ridership shifts when time savings are present

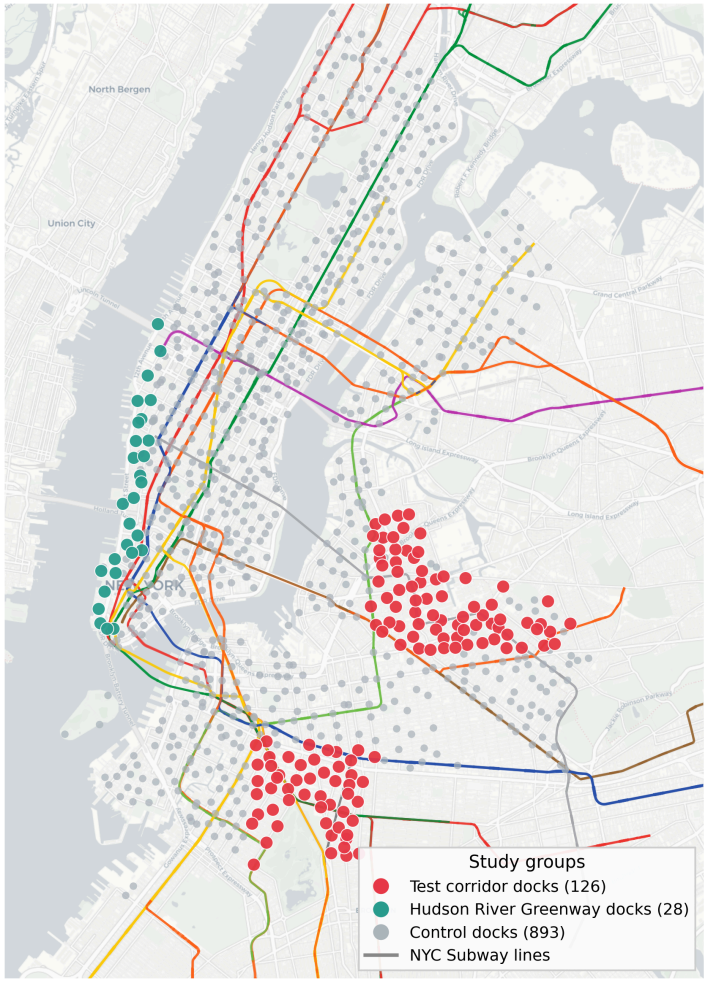
This analysis centers on two core questions:

Research Questions

Q1: Do women riders undertake north-south commutes in Central Brooklyn at a higher rate than on comparable, matched control routes?

Q2: How much time does cycling save compared to the subway on north-south routes in Central Brooklyn versus on matched control routes, and does this time savings differ between men and women riders?

Defining the Experiment



Test: maximum time-saving, dangerous north-south bike rides in Central Brooklyn. Rides must start in the south cluster and end in the north cluster (or vice versa).

Hudson River Greenway: benchmark for a fully protected cycling environment. Rides must both start and end at a dock within this cluster.

Control: all other standard NYC bike trips (unprotected, minimal time savings). Rides exclusive of the other two groups, meeting filter criteria, that do not touch any Citi Bike docks used in the other two groups.

Citi Bike docks: each dot is one dock

Why Statistical Matching?

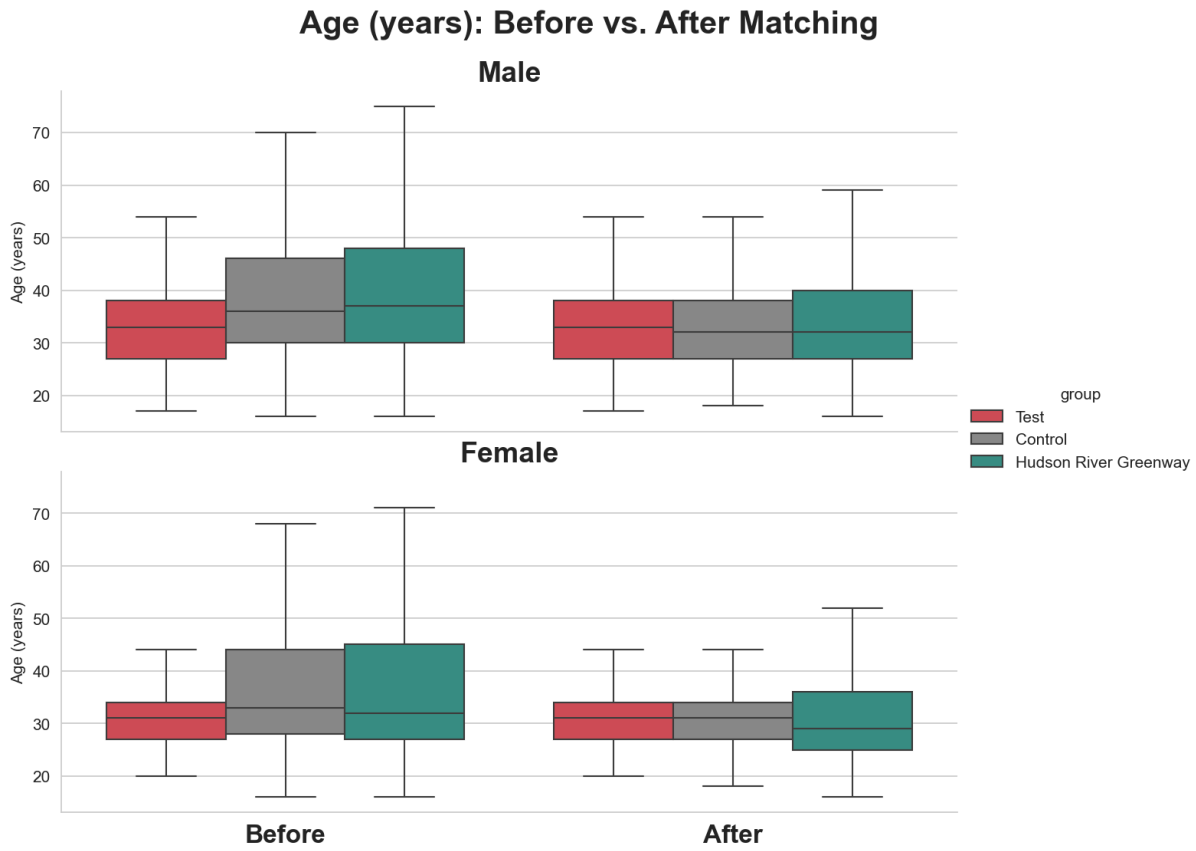
Brooklyn north-south riders are younger and take longer rides than the other experimental groups. Both research questions use the same underlying logit model to fix this, and only the stratification differs:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1\,\mathrm{age} + \beta_2\,\mathrm{duration} + \beta_3\,\sin(\mathrm{hour}) + \beta_4\,\cos(\mathrm{hour})$$

Q1: Ridership: stratified by calendar month

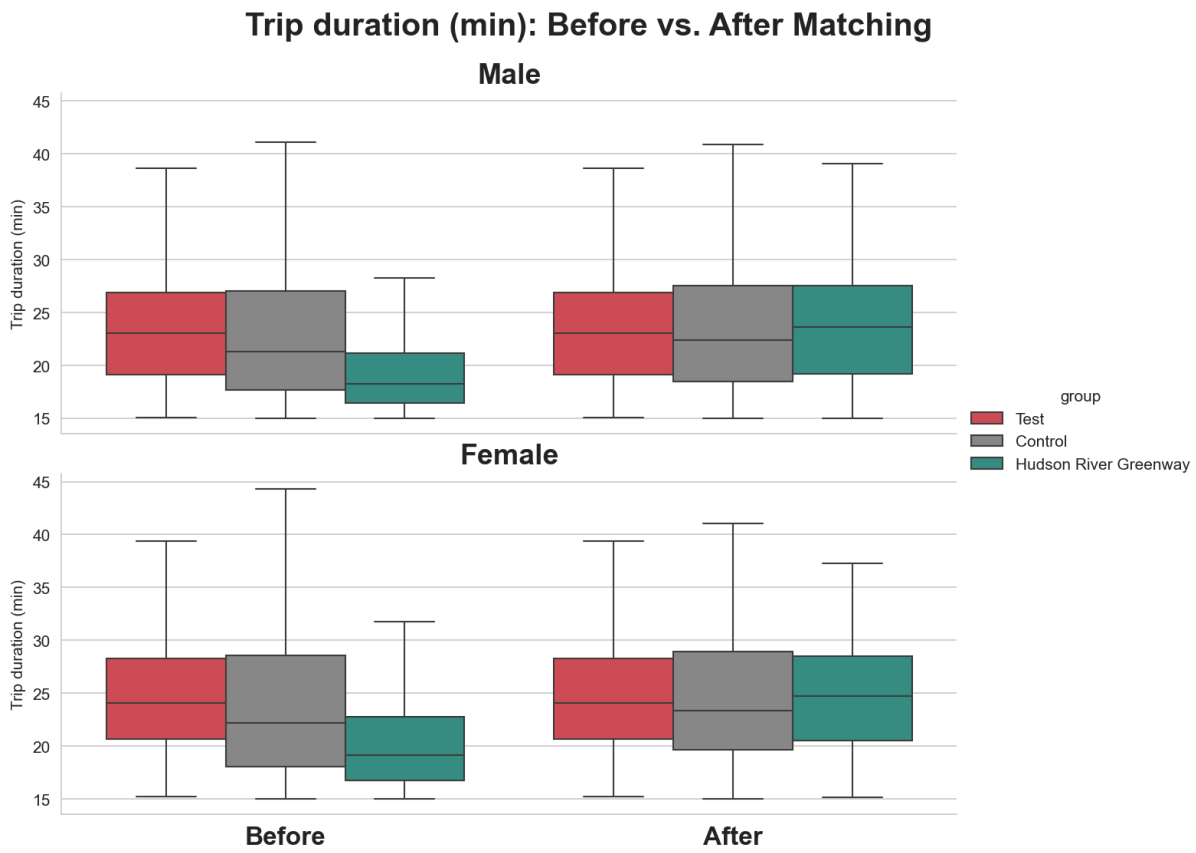
Q2: Time savings: stratified by calendar month × gender, so the matched control's gender mix mirrors Test's by construction

Balance Check: Age



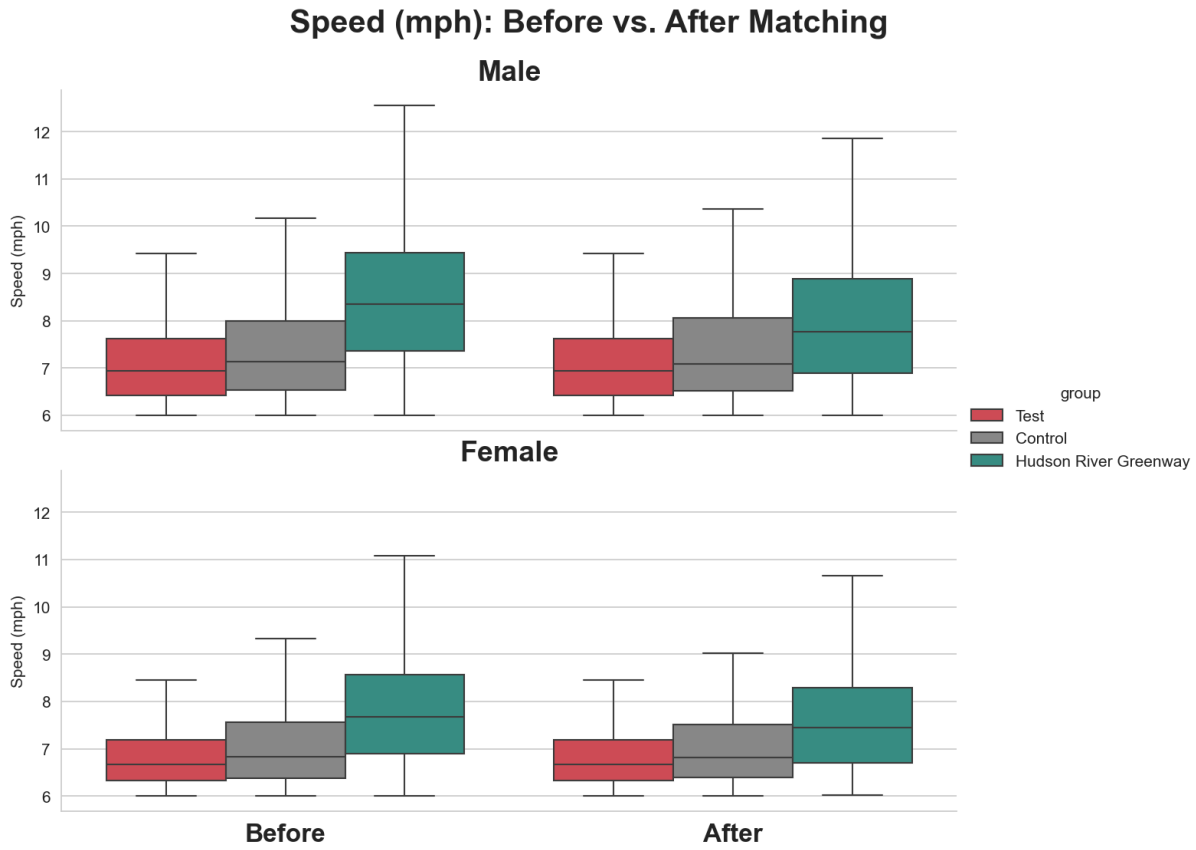
Before matching, north-south Brooklyn riders skew markedly younger than the other experimental groups, in both genders. After matching, that gap closes.

Balance Check: Trip Duration



A smaller pre-match imbalance than age, but matching tightens it further: north-south Brooklyn, control, and Greenway durations converge. Hudson River Greenway riders make shorter rides than either other experimental group.

Balance Check: Speed



Speed (≥6 mph) was only an eligibility filter, not a matching covariate: before/after barely differ, as expected. Probably worth adding to the PSM model in a future iteration: facing fewer traffic stops on a fully protected path, Hudson River Greenway riders bike at a higher speed than either other experimental group.

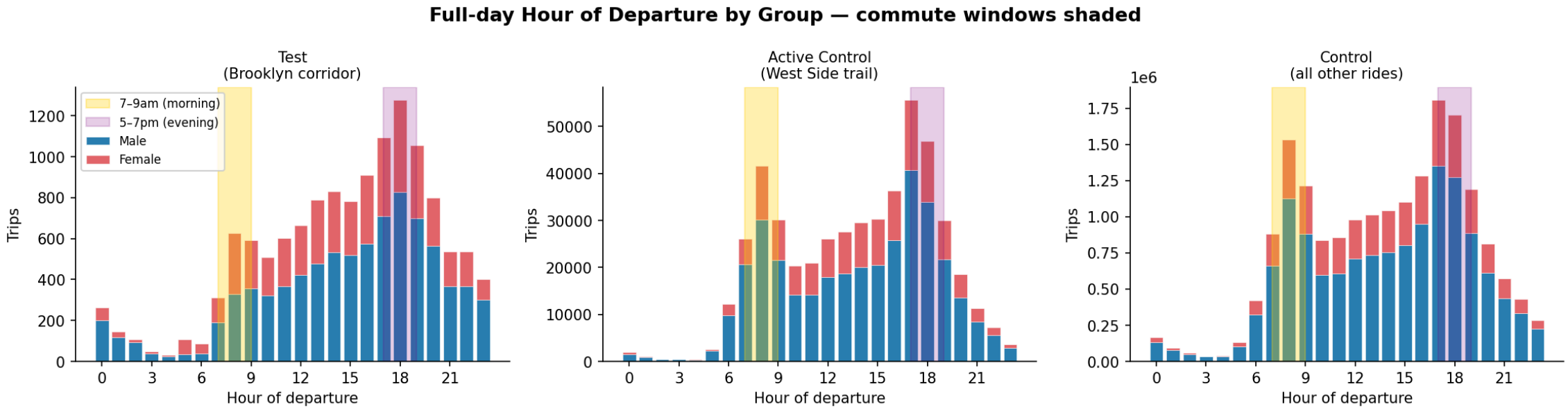
The Gender Commuting Gap

A persistent gender commuting gap shows up across the literature:

- Dual-earning mothers make shorter commutes than fathers, on average (Kwan & Akar, 2022)
- Children in the household reduce leisure time for married women, not married men (Mattingly & Bianchi, 2003)
- Household responsibilities push women toward jobs close to home: the Household Responsibility Hypothesis (Gimenez-Nadal & Molina, 2016)

As the connection between home and work, commutes are heavily studied and tie directly into the Household Responsibility Hypothesis. Specifically, the double burden of professional and household responsibilities creates "leisure poverty" for women. To explore this dynamic, this analysis focuses on weekday commute-window trips (7-9 AM and 5-7 PM) instead of all-day, all-purpose riding.

Choosing the Commute Windows



All three groups show the same bimodal pattern: a morning peak and a larger evening peak. The shaded 7-9am / 5-7pm windows show how commutes were selected: simply by trip start time (a trip only needs to begin or end in the commuting window).

Data Filtering, by Group

Stage	Test	Control	Hudson River Greenway
Raw (full year)	14,894	19,987,831	548,972
+ Duration (15-45 min)	13,913	6,060,974	171,763
+ Speed (≥6 mph)	6,969	1,841,880	74,922
+ Commute window	1,956	890,095	28,277
After matching	1,956	1,956	1,956

- **Commute window:** trip begins or ends 7-9am or 5-7pm, weekdays only

Note: Morning + evening combined.

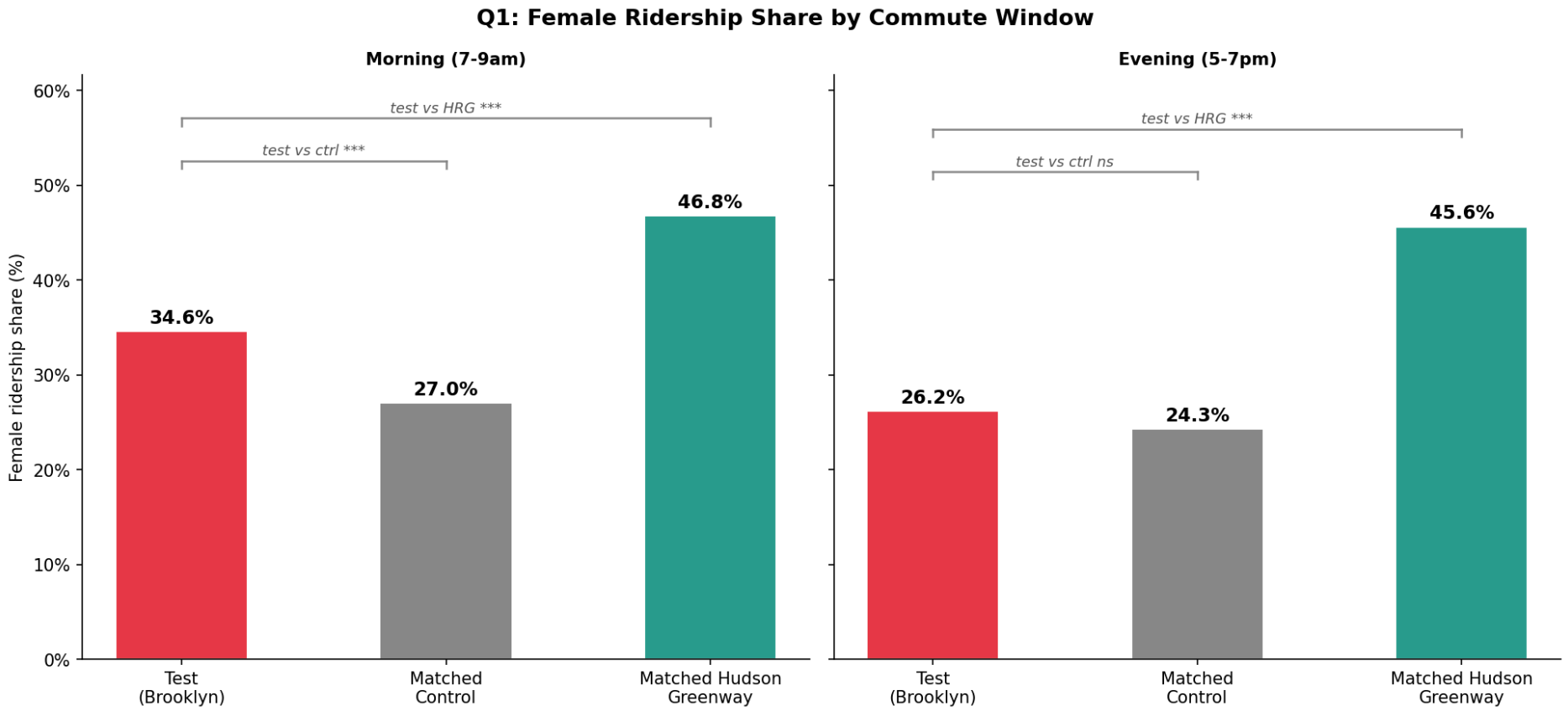
Sample Sizes: Q1 Matching

Stratified by month only

Group	AM Men	AM Women	PM Men	PM Women
Test	537	284	838	297
Matched Control	599	222	859	276
Hudson River Greenway	437	384	617	518

Note: Q1's matched groups don't mirror Test's gender split by design: gender is the outcome, not a matching covariate.

Q1 Results: Commutes Only



Morning: north-south Brooklyn riders are +7.6 pp higher in women's share than matched control (34.6% vs 27.0%, p<0.001). Evening: gap narrows to +1.9 pp, not significant (p=0.31).

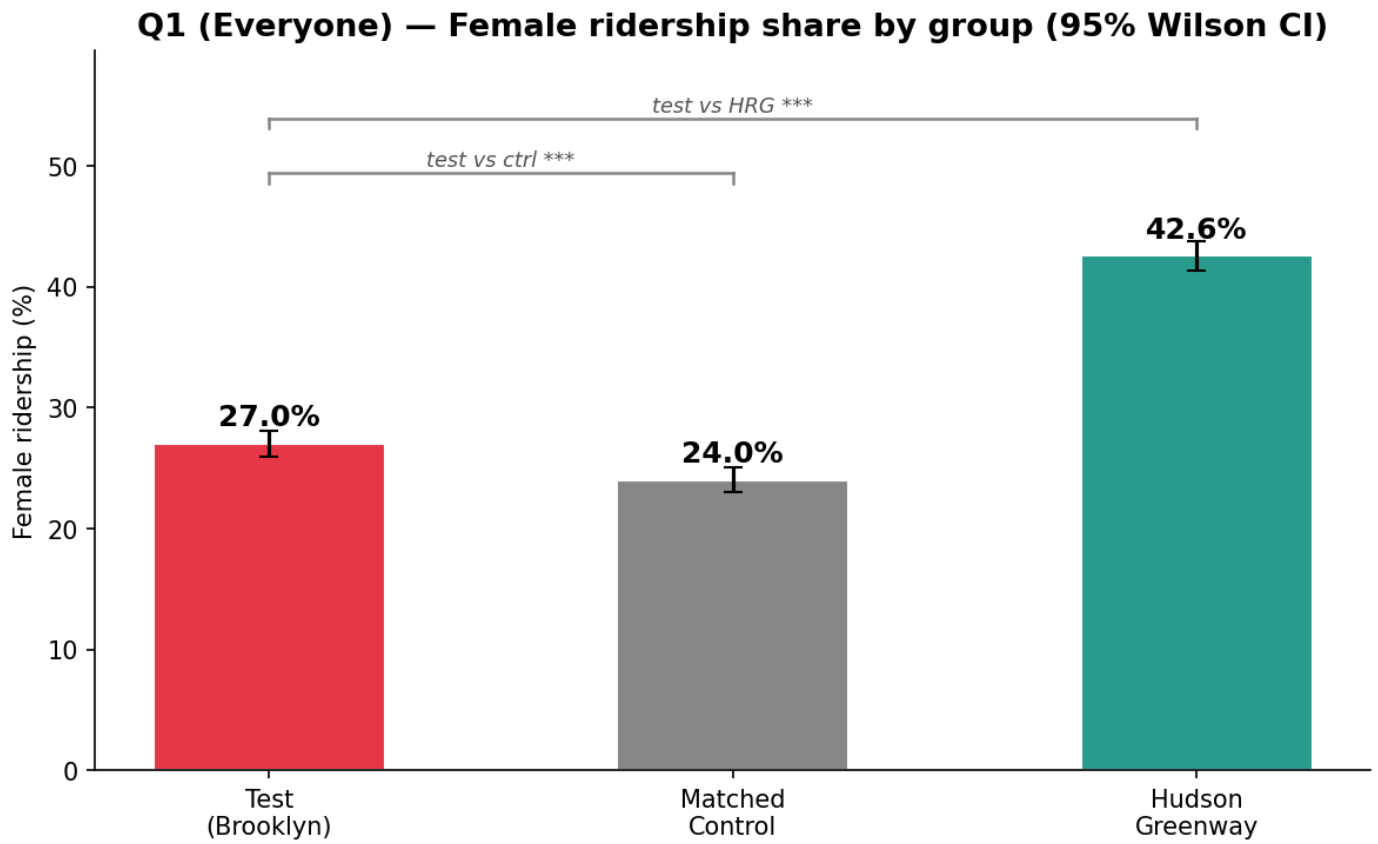
Stat test: two-proportion z-test (test vs. matched control women's share)

Sample Sizes: Q1 Everyone Matching

Duration + speed filtered, no commute-window restriction

Group	Men	Women
Test	4,684	1,733
Matched Control	5,097	1,609
Hudson River Greenway	3,641	2,700

Q1 Results: Everyone



All-day, all-year, same duration/speed filter as the commute analysis (no time-of-day restriction): 27.0% women vs. 24.0% matched control (+3.0 pp, p<0.001): the gap holds outside the commute window, though it's smaller than the +7.6 pp morning-commute gap.

Stat test: two-proportion z-test (test vs. matched control women's share)

Sample Sizes: Q2 Matching

Stratified by month × gender

Group	AM Men	AM Women	PM Men	PM Women
Test	537	284	838	297
Matched Control	537	284	838	297
Hudson River Greenway	537	284	838	297

Note: Q2's matched groups mirror Test's gender split exactly, by construction.

Google Maps API Call

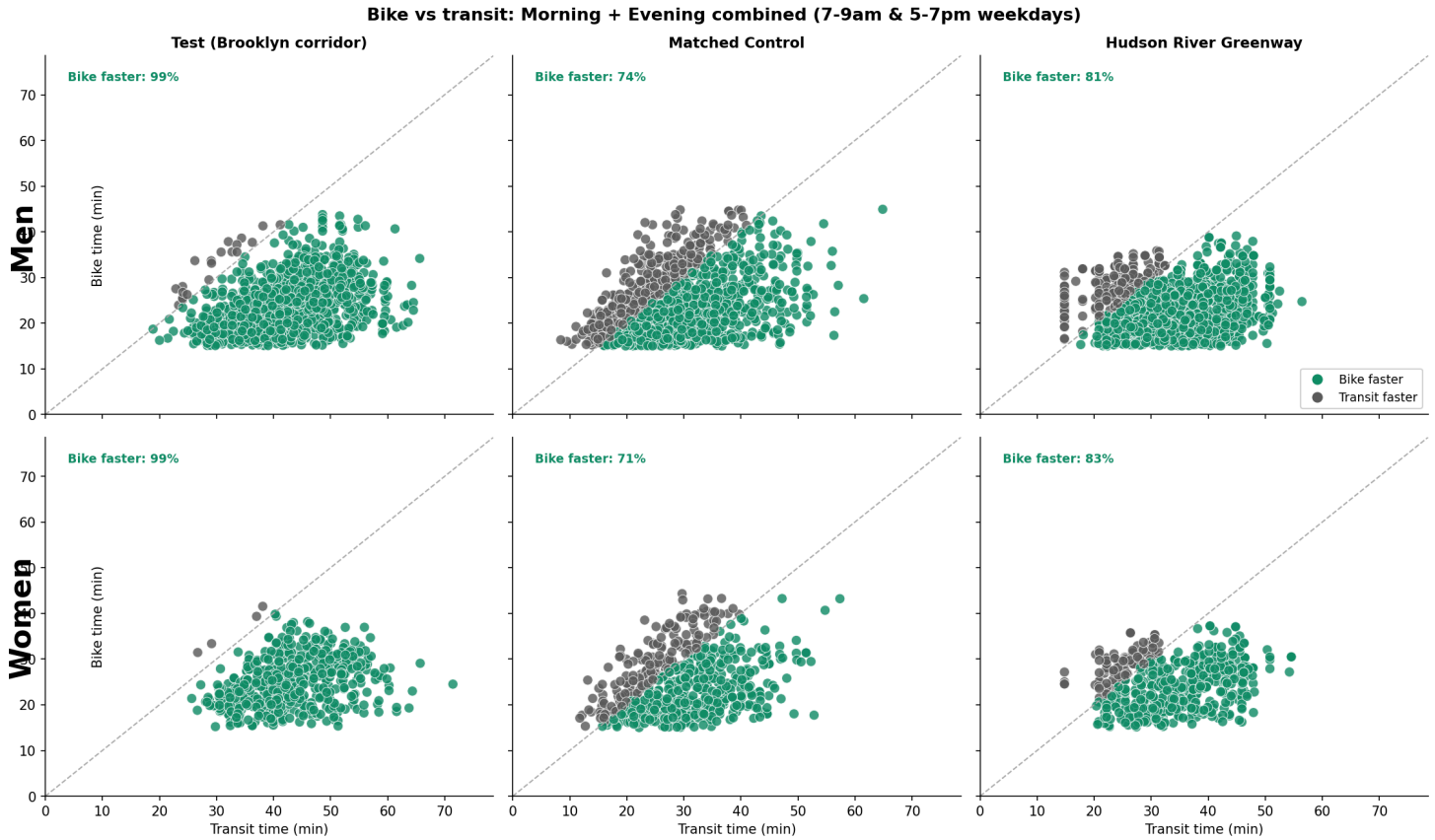
Transit times come from the Google Maps Directions API, one call per trip:

```
params = {
    'origin':         f"{origin_lat},{origin_lng}",
    'destination':    f"{dest_lat},{dest_lng}",
    'mode':           'transit',
    'transit_mode':   'subway|train',
    'departure_time': int(departure_dt.timestamp()),
    'key':            API_KEY,
}
```

Only ~10,000 calls are free per month; the matched commute sample alone took 5,868.

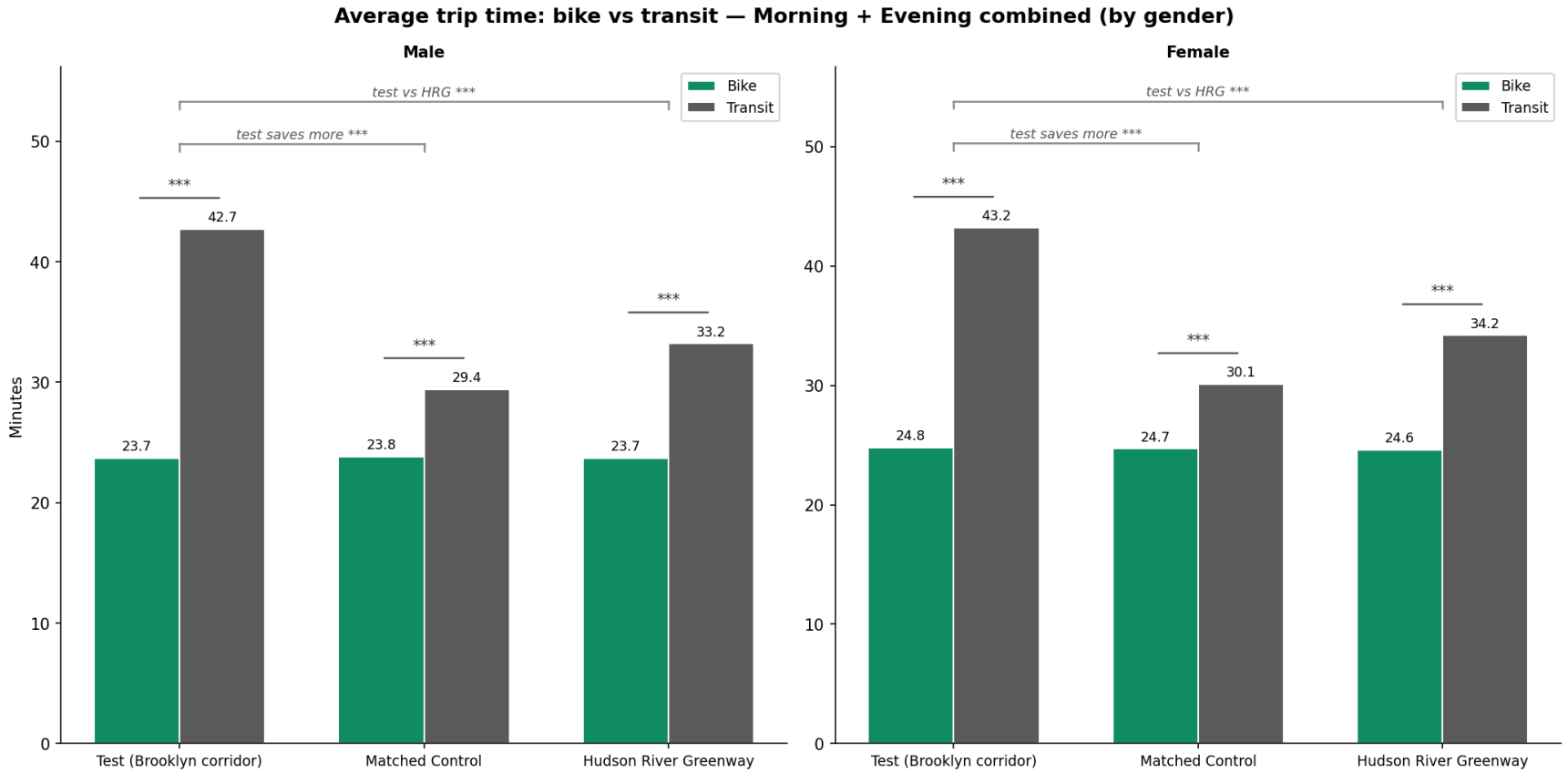
That's why Q2 sticks to commutes only: a full-year, all-trips run isn't feasible.

Q2 Results: Trip-by-Trip



Every dot below the diagonal is a trip where biking beat transit. Men and women see nearly identical bike-faster rates within each group: 99% on the north-south Brooklyn corridor, ~73-74% for matched control, ~81-83% for Hudson River Greenway.

Q2 Results: Commutes Only



North-south Brooklyn riders save **~21 minutes** over transit regardless of gender (men 22.0 min, women 20.6 min, AM).

Stat tests: paired t-test (bike vs. transit, $p<0.001$); Welch's t-test (vs. comparators, $p<0.001$)

Q1 Findings

- The share of female riders spikes in the morning but drops in the evening. This happens because men's ridership surges in the evening (+56%, jumping from 537 to 838 trips), while women's trip volume stays almost entirely flat (+4.6%, shifting from 284 to 297 trips)
- Across the entire dataset, the Test group still maintains a higher female ridership share than the matched control. However, the overall gap narrows to +3.0 percentage points: less than half the size of the +7.6 percentage point gap isolated during the morning commute
- Female ridership nearly reaches parity on the Hudson River Greenway (42.6%). While protected infrastructure clearly matters, this high share may also be impacted by the Greenway's popularity as a recreational route

Q2 Findings

- The Test corridor saves the most time of the three groups, and the savings are large (~21 minutes) and practically meaningful
- Biking beats transit in all three groups (73-99% of trips)
- No meaningful gender difference in time saved, within any of the three groups

Discussion

- Biking is faster than transit, across every group studied (within the 15-45 min duration, ≥6 mph speed filter used throughout). Biking's time savings are rarely part of the conversation in biking infrastructure discussions, which tend to focus on safety alone
- Time savings increase women's Citi Bike ridership. The size of that increase may also depend on the morning commute specifically
- Protected bike routes should be used to fill transit gaps and maximize time savings. This is even more paramount in light of climate change: if policy goals are to increase biking, new routes should be designed so that time savings match or beat alternative forms of transportation (subway, car) in trip or commute time