Synthetic Control Analysis: Chicago PPLTT on ChatGPT Subscriptions

January 2026

1 Method

We estimate the effect of Chicago's 9% Personal Property Lease Transaction Tax (PPLTT) on ChatGPT subscriptions using synthetic control. The method constructs a weighted average of untreated ZIP3s to match Chicago on pre-treatment characteristics, then compares actual vs. synthetic outcomes post-treatment.

Matching variables:

- **Demographics (7 covariates):**
  - `pct_college`: % with bachelor's degree or higher
  - `pct_hh_100k`: % households earning $100k+
  - `pct_young`: % aged 18–34
  - `median_age`: median age
  - `median_income`: median household income
  - `pct_stem`: % in STEM occupations
  - `pct_broadband`: % with broadband internet
- **Pre-treatment outcomes (3 scalars):**
  - `pre_mean_early`: mean log(outcome) Mar–Jun 2023
  - `pre_mean_late`: mean log(outcome) Jul–Sep 2023
  - `pre_median_price`: mean of monthly median transaction price Mar–Sep 2023

Using pre-period means captures the outcome trend without overfitting to month-by-month noise. Pre-period price matching helps select donors with similar existing tax exposure.

Outcome: log(transactions in $15–$25 range) per ZIP3-month.

Implementation: Stata `synth` package (Abadie et al.).

2 Sample

- **Treated unit:** ZIP3 606 (Chicago)
- **Treatment date:** October 2023

- **Donor pool:** ∼740 ZIP3s with complete panel and demographic data
- **Panel:** Constant individual panel (cardlinkids active in all 70-day windows)
- **Transaction filter:** $15–$25 (ChatGPT Plus subscription range)
- **Sample period:** March 2023 – November 2024

The $15–$25 filter captures ChatGPT Plus subscriptions ($20 + tax). Conditional on having at least one transaction in this range, the average user has 1.02 transactions per active month (1.03 in Chicago), consistent with monthly billing. However, from a user's first transaction to the end of the sample, only 0.59 of potential months have a transaction (0.57 in Chicago)—not everyone renews each period.

3 Results

Table 1 reports the main synthetic control results.

Metric	**Value**
Pre-treatment RMSPE (Mar–Sep 2023)	0.014
Post-treatment RMSPE (Oct 2023–Nov 2024)	0.125
RMSPE ratio (post/pre)	8.96
Average post-treatment gap	-0.102
Implied effect	−10%

Table 1: Synthetic control results for Chicago (ZIP3 606).

Pre-treatment RMSPE (0.014) indicates good fit. The average post-treatment gap is -0.102 (≈10% reduction); the higher post-treatment RMSPE (0.125) reflects the widening gap over time visible in Figure 1.

4 Covariate Balance

Table 2 shows the covariate balance between Chicago and synthetic Chicago.

5 Donor Weights

Table 3 shows the ZIP3s receiving positive weight in the synthetic control.

Figure 2 compares Chicago to the top donors over time.

6 Interpretation

The Chicago PPLTT reduced the number of unique ChatGPT Plus subscribers by approximately 10% relative to the synthetic counterfactual. This is the extensive margin effect—fewer distinct cardholders making subscription-priced transactions.

At a $20 subscription price, a 9% tax is $1.80/month. A 10% reduction in subscribers implies a demand elasticity on the order of −1, though this is rough given the level shift rather than continuous price variation.

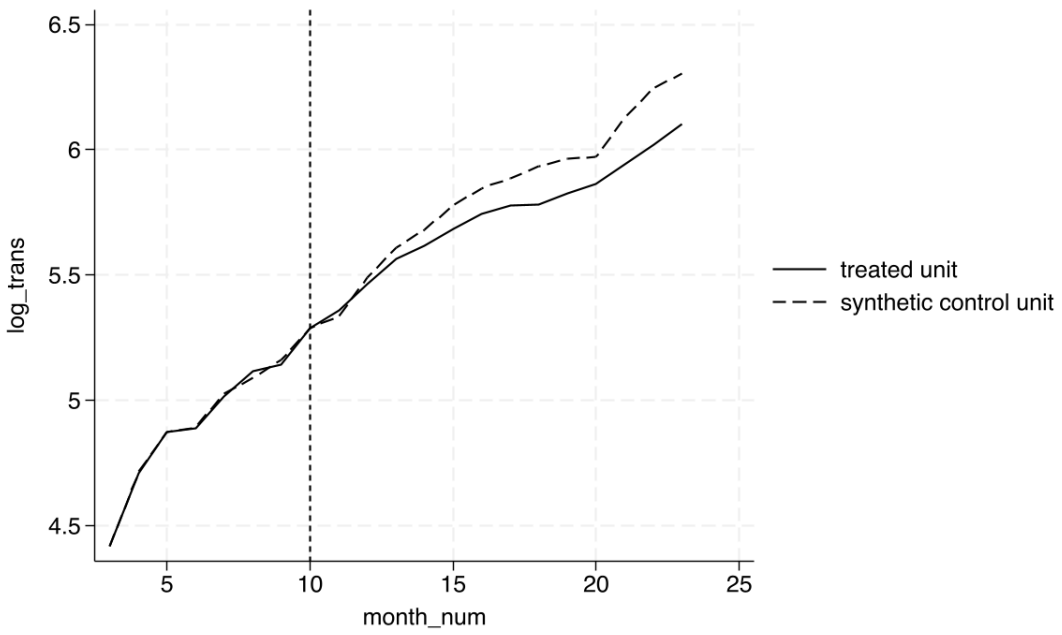

Figure 1: Chicago vs. synthetic control. Vertical line marks October 2023 (tax implementation). Output from Stata `synth` command.

6.1 Identification Caveat: Manhattan Placebo

Running the synthetic control procedure on ZIP3 100 (Manhattan) as a placebo reveals a similar pattern: treated unit falls below its synthetic control post-treatment. New York State has taxed SaaS at approximately 8.5% continuously—there was no new tax in October 2023. Yet Manhattan exhibits a similar divergence pattern, placing it toward the high end of the placebo distribution.

Update (Jan 2026): A systematic scan of median transaction prices across all ZIP3s (March 2023 vs. November 2024) reveals Manhattan shows a +2.6% price increase—second only to Chicago's +5.7%(Figure 5). This may indicate OpenAI began collecting New York sales tax during the sample period. If so, Manhattan experienced a (smaller) tax treatment of its own, which would justify excluding it from the donor pool. We have not yet made this exclusion.

Three implications follow:

1. **Big-city saturation**: Large cities may have adopted ChatGPT earlier and faster, saturating by late 2023.

2. **ChatGPT Enterprise**: OpenAI launched ChatGPT Enterprise in August 2023. If big-city employers began paying for employee subscriptions, those users would stop appearing in Consumer Edge data (personal credit card transactions).

3. **Synthetic construction**: No weighted combination of smaller areas can replicate big-city dynamics. Chicago tracks Manhattan because both face the same urban-specific shocks.

6.2 Price Pass-Through Evidence

While quantity effects face identification challenges, price pass-through is cleaner. Chicago's median transaction price jumps from $20.11 to $21.03 exactly at October 2023, while Manhattan (existing

Variable	Chicago	Synthetic
% college	41.0%	40.9%
% HH income >$100k	35.1%	35.0%
% ages 18–34	9.8%	9.9%
Median age	35.88	35.92
Median income	$74k	$74k
% STEM	43.1%	43.2%
% broadband	85.2%	85.3%
Log users (Mar–Jun)	4.72	4.72
Log users (Jul–Sep)	5.09	5.09
Median price (pre)	$20.11	$20.12

Table 2: Covariate balance for synthetic control.

ZIP3	Area	Weight
900	39.0%	Los Angeles, CA
303	26.2%	Atlanta, GA
588	7.9%	Rapid City, SD
288	7.6%	Asheville, NC
701	5.8%	Unknown
865	4.9%	Flagstaff, AZ
830	4.1%	Wyoming
828	2.2%	Unknown
803	1.8%	Columbia, SC

Table 3: Top donor ZIP3s for synthetic Chicago.

tax) shows no discrete jump. This confirms the tax is being passed through to Chicago consumers.

6.3 Placebo Check: ZIP3 077 (New Jersey Shore)

ZIP3 077 (Long Branch / Red Bank, NJ) produces an RMSPE ratio of 6.90,exceeding Chicago's 8.96. However, the direction differs: 077's post-treatment gap is *positive* (+0.115), meaning actual usage *exceeded* the synthetic control. Chicago's gap is negative (−0.118), meaning actual usage *fell below* the synthetic control.

Figure **??** shows flat median prices for 077 throughout the sample—no discrete tax-induced jump. The high RMSPE ratio reflects idiosyncratic positive shocks (perhaps local growth or demographic shifts), not a tax effect.

This pattern does not threaten our causal interpretation: 077's divergence is in the opposite direction from Chicago's. A true confounder would need to produce *negative* gaps in untreated areas around October 2023.

6.4 Placebo Inference

Figure 3 shows the spaghetti plot of placebo gaps for all ZIP3s with pre-treatment RMSPE within 2× of Chicago's. Chicago (solid black) diverges visibly below the placebo distribution post-treatment.

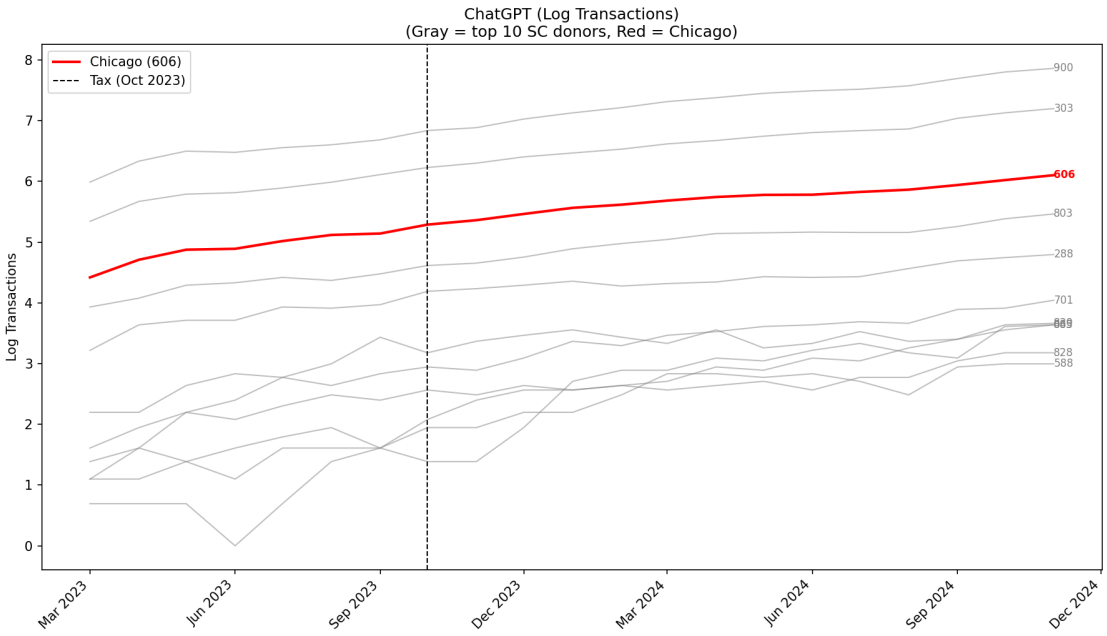

Figure 2: Log unique users: Chicago vs. top donor ZIP3s.

Figure 4 shows the distribution of gap ratios (post-treatment gap / pre-treatment RMSPE) across placebo units.

7 Technical Notes

- **Constant panel:** Restricted to cardlinkids active in all 70-day windows throughout the sample period.
- **Demographics source:** ACS 5-year 2022 estimates, aggregated from ZCTA to ZIP3 using population weights.
- **Pre-period price matching:** Matching on pre-period median price helps select donors with similar existing tax exposure.

A Tax Detection Scan

B ZIP3 Reference

For reference, key ZIP3 codes mentioned in this analysis:

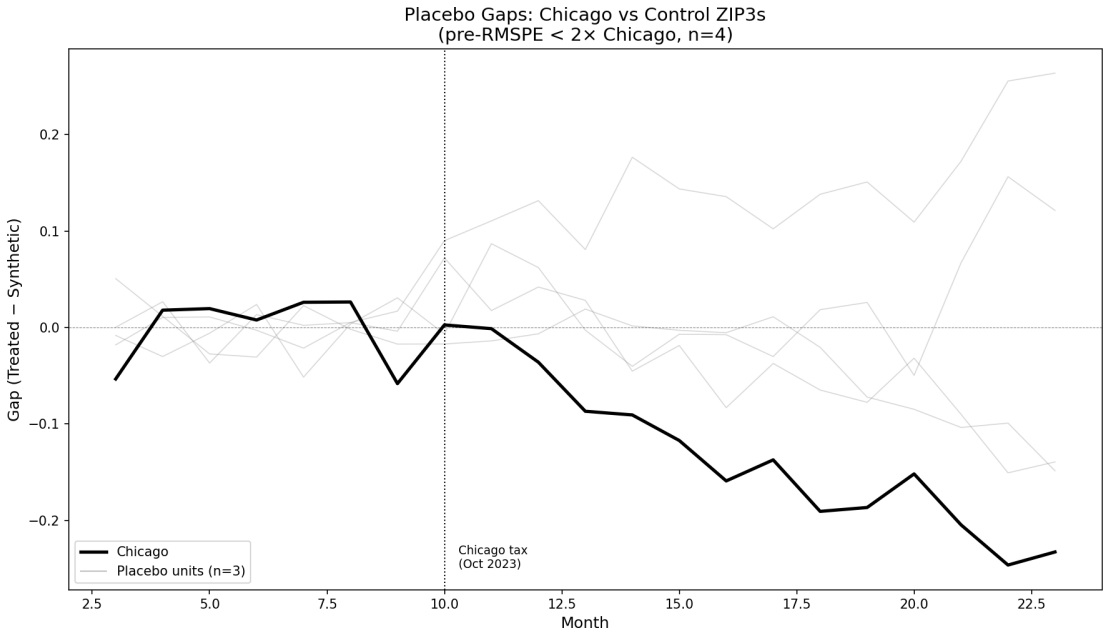

Figure 3: Placebo gaps for ZIP3s with pre-RMSPE $\leq 2\times$ Chicago's. Chicago is the solid black line; placebo units in gray.

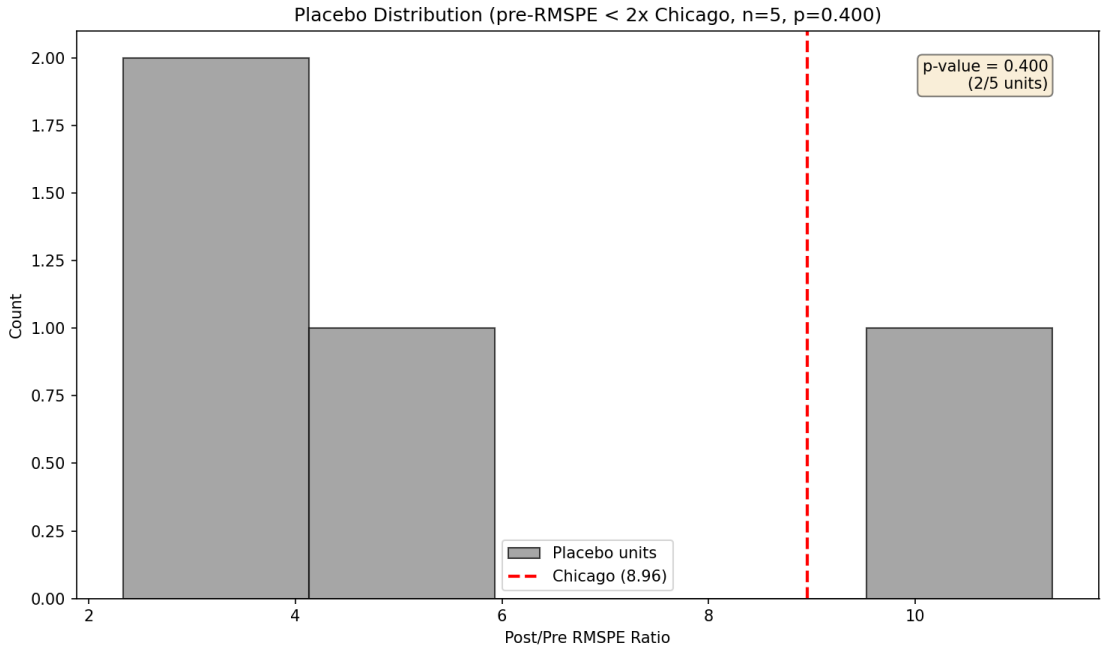

Figure 4: Distribution of gap ratios among placebo units ($2\times$ threshold). Chicago's gap ratio marked by vertical line.

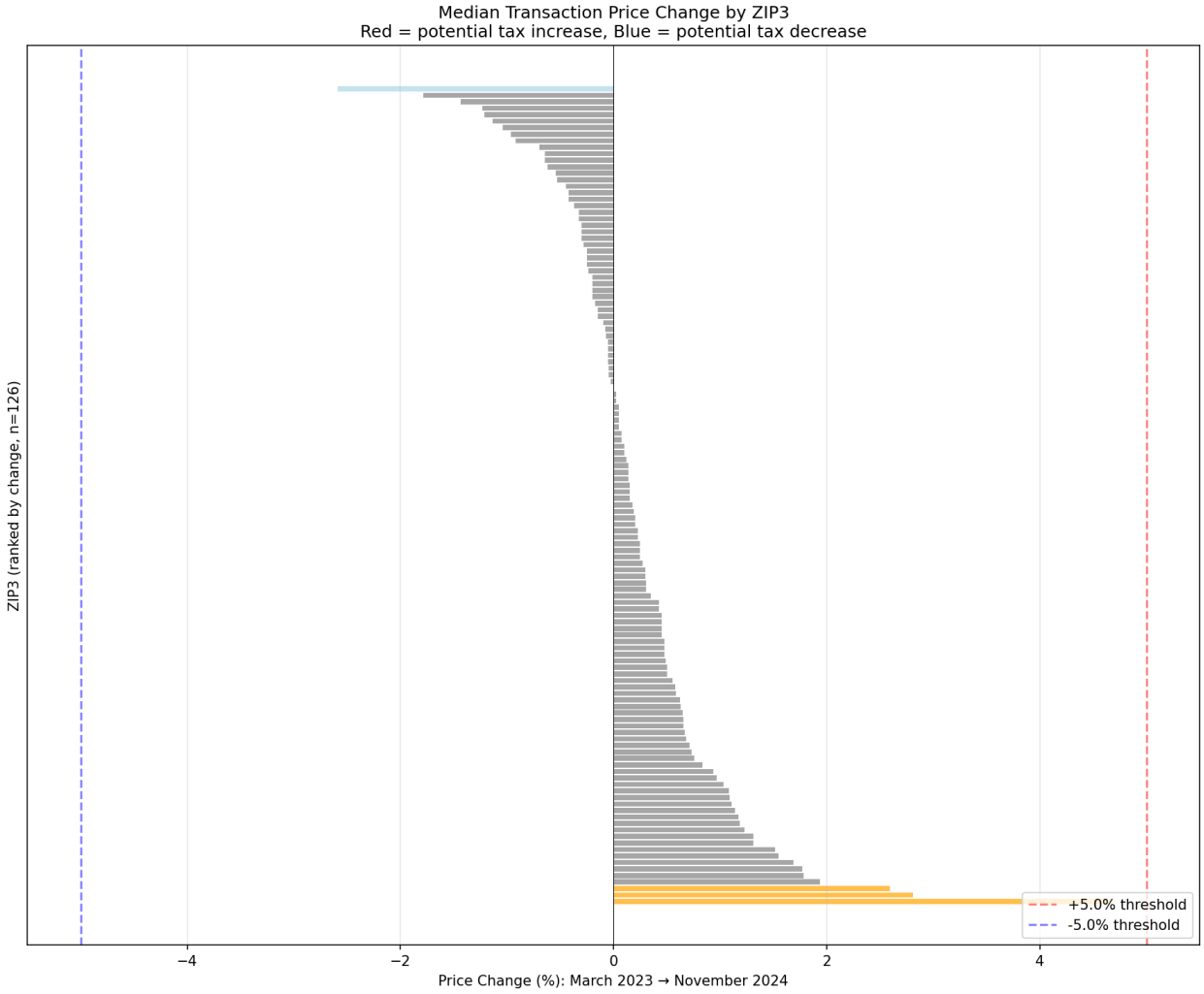

Figure 5: Median transaction price change by ZIP3 (March 2023 to November 2024). Chicago (606) is the only ZIP3 exceeding the 5% threshold. Manhattan (100) shows +2.6%, suggesting possible tax collection starting mid-sample. Full results in `zip3_price_changes.csv`.

ZIP3	Area
606	Chicago, IL (treated)
100	Manhattan, NY
077	Long Branch / Red Bank, NJ
069	Garden City / Long Island, NY
094	San Mateo / Silicon Valley, CA
174	Binghamton, NY
900	Los Angeles, CA
277	Raleigh, NC
303	Atlanta, GA

Table 4: ZIP3 codes referenced in this document.