The Effect of Fare-Free Public Transport on Mode Choice:
Evidence from São Caetano do Sul, Brazil

Aidan Rossi de Araujo[1] and Prof. Dr. André Luis Squarize Chagas[2]

[1]Master Candidate at Economic Department at the University de São Paulo (USP)
[2]Professor at Economic Department at the University de São Paulo (USP)

Abstract

This paper estimates the effect of municipal fare-free public transport on the mode choice of workers and students in São Caetano do Sul, a dense municipality in the São Paulo Metropolitan Region. The policy took effect on 1 November 2023, part-way through the fieldwork of the 2023 Origin–Destination Household Survey, creating a natural setting to compare travel behaviour with and without free fares. Mode choice in the absence of the policy is recovered through a Multinomial Logit discrete choice model estimated exclusively on trips unaffected by the policy, and the fitted model is used to impute the counterfactual choices of the treated group. The public transport share of mandatory trips is estimated to rise by roughly 22% (from 23.1% to 28.3%), drawing primarily from car and motorcycle trips, with a smaller increase in walking. The groups that switch most strongly are non-residents of the city, non-white travellers, individuals below median income, and those under 40. Public transport exhibits the largest own-price and own-time elasticities among all modes. The annual welfare gain measured through consumer surplus is estimated at R$49.7 million, exceeding the R$35 million annual fiscal cost, for a benefit–cost ratio of about 1.42; the gain is distributed progressively, favouring lower-income travellers. Results are robust to placebo tests in time and space and to an alternative GTFS-based routing specification.

Keywords: Fare-free public transport; mode choice; multinomial logit; consumer surplus; urban mobility.

JEL codes: C25, R41, R51.

1 Introduction

Transport and mobility are central to daily life in large urban agglomerations, mediating access to work, education, leisure and health services. Limitations in the transport system — excessive expenditure, long travel times, crowding, or plain inaccessibility — directly affect residents' quality of life. Because agglomeration generates increasing returns to scale and imperfect competition, the location of firms and households cannot be separated from the monetary and non-monetary cost of movement (Fujita & Thisse, 1996; Isard, 1949). Collective transport plays a key role in bringing people closer to opportunities, yet its provision through the market is limited: competition typically occurs only at the concession stage, contracts are long, and the sector tends toward monopoly, while the exclusion of passengers on an under-occupied bus is inefficient (Dias, 1991). Excessive car use, in turn, produces congestion, accidents and pollution (Carvalho et al., 2013). These considerations justify a public role in organising urban transport.

The importance of transport in Brazil is such that, in 2015, it was added as a social right to Article 6 of the Federal Constitution. Popular mobilisations against fare increases have punctuated Brazilian history, from the 2013 "June Journeys" to older revolts against fare hikes. One recurring proposal from this history is the elimination of fares altogether. Fare-free public transport (FFPT) has grown rapidly in Brazil, reaching roughly 150 cities by mid-2026 and covering on the order of 7 million people living in municipalities with universal free fares. São Caetano do Sul is among the ten most populous Brazilian cities to have adopted the policy.

This paper asks whether the introduction of free municipal public transport in São Caetano do Sul (SCS) changed the modal composition of mandatory trips (to work and study) and, if so, which population groups drove that change. It further evaluates the welfare generated by the policy, measured through consumer surplus, against the fiscal cost of implementation. The empirical strategy exploits a fortunate coincidence: the policy took effect on 1 November 2023, in the middle of the fieldwork window of the 2023 Origin–Destination (OD) Household Survey for the São Paulo Metropolitan Region (SPMR). This allows trips observed *without* free fares to identify the structural preference parameters, which are then used to impute the counterfactual choices of travellers exposed to the policy.

The main result is an estimated increase in the public transport share of mandatory trips of about 22%, with the share rising from 23.1% to 28.3%. The modes whose shares fall most in absolute terms are motorcycle and car, while walking increases. Every demographic group analysed increases its use of public transport, but the effect concentrates among non-residents of SCS, non-white travellers, people under 40, and those with below-average income. The estimated welfare gain from the policy is R$49.7 million per year, above the 2024 fiscal cost of R$35 million, and the gains accrue disproportionately to lower-income travellers.

The paper contributes to two literatures. First, it adds applied evidence on the mode-substitution effects of FFPT, in a dense metropolitan setting where whole-metropolis experiences of the policy are absent. Second, it contributes methodologically by using a discrete choice model to impute the counterfactual needed for an *ex post* policy evaluation, in the spirit of Athey et al. (2021), rather than the more common *ex ante* simulation. The remainder of the paper is organised as follows. Section 2 describes São Caetano do Sul; Section 3 reviews the literature; Section 4 presents the data; Section 5 develops the methodology; Section 6 reports the results; Section 7 presents robustness checks; and Section 8 concludes.

2 The Setting: São Caetano do Sul

São Caetano do Sul lies in the São Paulo Metropolitan Region, within the industrial belt known as the ABC Paulista (Santo André, São Bernardo do Campo and São Caetano do Sul). FFPT was introduced under mayor José Auricchio Júnior on 1 November 2023. The SPMR is home to roughly 20.7 million inhabitants and is one of the largest and economically most important metropolitan areas in Latin America. In the absence of any whole metropolis adopting FFPT, the experience of SCS — located at the heart of the metropolis — offers useful evidence on the policy's effects in a dense urban context.

Historically, São Caetano developed as an industrial suburb of the city of São Paulo, anchored by large plants installed from the 1910s onward, most notably the General Motors do Brasil factory that still operates in the city. The strong imprint of the automobile industry, together with the city's high income, is associated with a pronounced "car culture": in 2024 there were about 0.75 automobiles per adult, against 0.61 for the SPMR as a whole.

The municipality is the third smallest in area in Brazil (15.3 km^2) and has no rural area, so its transport must be understood as that of a densely populated urban area. It has roughly 165,000 inhabitants and ranks among the most highly developed municipalities in the country, with a 2010 Human Development Index of 0.862 — then the highest in Brazil and comparable to that of Uruguay. Its population is richer, older and whiter than the SPMR average: about 11.7% belong to socioeconomic class A and 49.9% to class B (against 4.7% and 33.4% for the SPMR), and roughly 79.9% identify as white (against 53.7% regionally). Importantly, non-residents who work in SCS tend to earn substantially less than residents: average household income is about

R$6,465 for the former group and R$9,843 for the latter. This income gap between residents and in-commuters is central to interpreting the distributional effects of the policy.

When the policy began, the municipal bus system comprised nine lines and a fleet of 46 buses, expanded to 57 by May 2024. Rail and metro lines connect SCS chiefly to central São Paulo, while intercity (EMTU) bus lines connect it mostly to the south-eastern portion of the metropolis. Nineteen intercity bus lines crossed the municipality during the study period, a detail that matters for interpreting substitution between intercity and municipal buses.

3 Related Literature

FFPT has attracted interdisciplinary attention from political science, transport engineering, anthropology, architecture and economics. One strand interprets the policy through the lens of political returns and the coalitions — bureaucracies, social movements, parties — that secure its adoption, often in the specific historical conjuncture of the COVID-19 pandemic and the associated difficulty of financing transport through traditional means (Carr & Hesse, 2020; Kębłowski et al., 2019). A second strand estimates behavioural effects: changes in the number and profile of trips (Bull et al., 2021; Cats et al., 2017), effects on employment, health, pollution, and electoral outcomes.

Among *ex post* studies of permanent FFPT schemes, findings include reductions in trips by other modes — including active mobility — economies of scale from higher ridership, and increased off-peak travel and mobility among lower-income users (Cats et al., 2017; Štraub, 2020; Guzman & Hessel, 2022). Effects are heterogeneous across places and shaped by cultural factors, so results from one city need not transfer to another (Witte et al., 2006). For the SPMR specifically, Perez & Pereira (2025) study São Paulo's universal Sunday free-fare scheme and find increased ridership but no clear evidence of car users switching to public transport, with the largest gains on peripheral lines — suggesting greater inclusion of lower-income groups.

This paper also engages the discrete choice literature. The work of McFadden established the tools for modelling qualitative choice, later generalised to the multi-alternative case relevant to mode choice (McFadden, 1974; Ben-Akiva & Lerman, 1985). The multinomial logit (MNL) is a workhorse for mode choice, in which utility depends on attributes of the mode, of the individual, and of their interaction. For the SPMR, several studies use such models to evaluate policies — urban tolls, fuel taxes, fare reductions — but typically for *ex ante* simulation, holding the economic structure constant to predict the effect of a hypothetical shock. Following Athey et al. (2021), this paper instead treats the structure of the economy as unchanged before and after the policy, and uses trips observed without free fares to approximate the true counterfactual choice matrix of the treated group. It also departs from studies that disaggregate public transport into separate modes: for the purposes of this setting, the municipal bus is treated as integrated into a larger public transport system linked by fare-integration cards.

4 Data

The core data source is the 2023 Origin–Destination (OD) Household Survey for the SPMR, produced by the São Paulo Metro. The OD is a public, household-based survey; the 2023 edition collected roughly 143,000 trip records from about 79,000 people in 32,000 households, on weekdays, between 3 August and 10 December 2023 and again between 20 February and 5 May 2024. Sampling stratifies by household income to represent the total number of trips in each OD zone, with a margin of error below 6% at a 92% confidence level. Walking trips enter the survey only if they exceed 500 metres or have work or school as their purpose; for other modes, all trips are recorded.

The discrete choice model is estimated on 72,413 trips whose purpose was work or study and which used one of four modes — public transport, car, motorcycle, or walking — across the whole SPMR, excluding the second fieldwork wave. For the treated group, only trips with origin or destination in SCS after 1 November 2023 are retained, leaving 346 trips.

Because the OD does not record trip *cost* or a precise network *time*, these were estimated. Public transport and car routes and times were obtained from the Google Maps APIs, supplemented by General Transit Feed Specification (GTFS) files for São Caetano do Sul, EMTU (intercity), and São Paulo (including rail and metro). Fuel prices came from the National Petroleum Agency (ANP), vehicle fuel efficiency from the Inmetro vehicle-labelling programme, public parking locations in São Paulo from the CET, and aggregate intercity bus ridership from the state regulator (ARTESP).

Descriptive profile. The OD estimates the SCS population at roughly 169,800, close to the IBGE figure. The city is older, richer and whiter than the SPMR. Its economically active share is somewhat smaller than the region's, and a substantial number of workers commute in from neighbouring municipalities — chiefly Santo André, São Paulo, Mauá and São Bernardo do Campo — while many residents commute out. In-commuters are concentrated in industry and commerce and earn markedly less on average than residents, a pattern that shapes who benefits most from free fares.

5 Methodology

The methodology has five components: estimating the monetary cost of each mode; estimating travel time for each mode; determining mode availability; the empirical strategy for identifying the policy effect; and the consumer surplus calculation.

5.1 Travel cost and time

For car and motorcycle, the monetary cost of trip i combines fuel consumption over the network distance with parking (for cars only):

$$p_i^m \;=\; \frac{\mathrm{dist}_i}{g^m}\,\rho_{c,t} \;+\; \mathrm{est}_{i,c}^m, \tag{1}$$

where dist_i is trip distance, g^m is fuel efficiency (12.3 km/L for cars and 40.5 km/L for motorcycles, averaged over the ten best-selling 2024 models), $\rho_{c,t}$ is a four-week moving average of the municipal gasoline price, and est is a parking cost (set to zero for motorcycles). For public transport, rather than treating municipal bus, intercity bus, train and metro as separate alternatives, they are treated as one integrated mode, reflecting the fare-integration cards (Bilhete Único, TOP) widely used in the SPMR. A pricing algorithm assigns each trip its fare under three regimes: before 1 November 2023 (SCS bus at R$5.00), between then and the January 2024 readjustments, and afterwards.

Travel times for car, public transport and walking are estimated in two stages. First, the Google Directions API supplies a base estimate that accounts for road type, permitted speed, traffic direction and departure time (for cars) and service frequency, transfer waiting and effective itineraries (for public transport). Second, the prediction error (observed minus API estimate) is modelled with an XGBoost regressor — trained on trips actually made by the mode — and the predicted error is added back, calibrating the API estimate toward the durations reported in the OD. This correction captures, for instance, the time needed to park a car, which the API ignores. Motorcycle times are derived from matched car trips via propensity score matching, applying the estimated motorcycle-to-car speed ratio, which varies by time of day (motorcycles are 35% faster than cars in the morning peak, 29% between peaks, 31% in the afternoon peak and 19% at night).

5.2 Availability

Public transport is deemed available whenever the API can route a trip by that mode. Walking is available for distances up to 8 km. A private vehicle is available to an individual over 18 if at least one household vehicle is not otherwise in use; only trips in which the person drives are considered, excluding car passengers, whose choice depends on a driver.

5.3 Empirical strategy

The identifying assumption is that the structural preference parameters of the economy do not change before and after 1 November 2023. Control (unaffected) and treated (affected) travellers therefore make mode choices on the same basis, and the only element distinguishing the two groups is the free municipal fare in SCS. Let treatment be

$$D_i \;=\; \mathbf{1}\{\text{ori}_i = \text{SCS or dest}_i = \text{SCS}\} \cdot \mathbf{1}\{t_i \geq t^*\}, \tag{2}$$

with t^* the policy start date. The object of interest is the average treatment effect on the treated (ATT) for each mode,

$$\text{ATT}^m \;=\; \mathbb{E}[\, Y_i^m(1) - Y_i^m(0) \mid D_i = 1\,], \tag{3}$$

where $Y_i^m(1)$ is observed choice under free fares and $Y_i^m(0)$ is the unobserved choice absent the policy. Since $Y_i^m(0)$ is not observed for the treated, it is imputed from an MNL estimated on all untreated observations. The utility specification is

$$U_i^m \;=\; \alpha^m + Z_i^\top \boldsymbol{\alpha}^m + \beta_{tt}\, tt_i^m + \big(\beta_p + \gamma_p\, Ie_i\big)\, p_i^m + \varepsilon_i^m, \tag{4}$$

where α^m is a mode-specific constant (ASC), Z_i a vector of socio-demographic and trip covariates (sex, race, age, log per-capita household income, peak-hour, trip purpose, intra-zone and spatial indicators), β_{tt} and β_p are generic sensitivities to travel time and monetary cost, and γ_p captures heterogeneity in cost sensitivity with respect to mean-centred log per-capita household income Ie_i. The term ε_i^m is an i.i.d. Gumbel error, and walking is the reference mode. The choice probability takes the usual logit form,

$$P_i^m \;=\; \frac{\exp(V_i^m)}{\sum_{m' \in C_i} \exp(V_i^{m'})}, \tag{5}$$

with V_i^m the deterministic utility component and C_i the choice set. The model is estimated by maximum likelihood using the `Apollo` package (Hess & Palma, 2019). The estimated ATT is then

$$\widehat{\text{ATT}}^m \;=\; \frac{1}{N_1} \sum_{i:\, D_i = 1} \Big[\, Y_i^m(1) - \widehat{Y}_i^m(0) \Big], \qquad N_1 = \sum_i D_i, \tag{6}$$

obtained by adding R\$5.00 back to the public transport fare of each treated trip and recomputing choice probabilities.

5.4 Consumer surplus

To weigh benefits against fiscal cost, the change in consumer surplus is computed from the log-sum formula (Train, 2009). Because the marginal disutility of expenditure declines with income, it is written $\lambda_i = |\beta_p + \gamma_p Ie_i|$, so lower-income individuals ($Ie_i < 0$) have a larger λ_i and hence a larger money-metric surplus per unit of utility. The per-trip change in surplus between the free-fare (TZ) and no-free-fare (nTZ) regimes is

$$\Delta CS_i \;=\; \frac{1}{\lambda_i}\left[\,\ln\sum_{m\in C_i}\exp\!\big(V^m_{i,\mathrm{TZ}}\big) - \ln\sum_{m\in C_i}\exp\!\big(V^m_{i,\mathrm{nTZ}}\big)\,\right]. \tag{7}$$

The logit demand is not linear; equation (7) integrates choice probabilities over the price change without imposing a functional form.

6 Results

6.1 Baseline model

Table 1 reports the estimated MNL, fitted on control trips only (pre-treatment and outside SCS). The signs are economically sensible: travel time and monetary cost both generate disutility, and the cost disutility is mitigated for higher-income travellers ($\gamma_p > 0$). Relative to walking, cars deliver higher utility to older and higher-income travellers, while motorcycles are strongly disfavoured by women. The implied Value of Time is

$$\mathrm{VoT} \;=\; \frac{\widehat{\beta}_{tt}}{\widehat{\beta}_p}\times 60 \;\approx\; \mathrm{R\$}\,30.82/\mathrm{hour}, \tag{8}$$

about 53% of the sample's mean hourly wage — close to the 50% benchmark commonly reported. The model classifies 79.3% of in-sample choices correctly, rising to 81.9% for trips touching SCS in the pre-treatment period.

Table 1: Selected coefficients of the Multinomial Logit (reference mode: walking)

Variable	Estimate	Std. error	p-value
Trip attributes (generic)			
Travel time	−0.045	0.001	< 0.001
Monetary cost	−0.087	0.005	< 0.001
Cost × log(income)	0.019	0.006	0.001
Alternative-specific constants			
ASC Car	−1.209	0.106	< 0.001
ASC Public transport	−0.114	0.067	0.045
ASC Motorcycle	−1.237	0.238	< 0.001
Selected interactions			
ASC Car × log(income)	0.492	0.047	< 0.001
ASC PT × log(income)	−0.120	0.037	< 0.001
ASC Car × age	0.035	0.002	< 0.001
ASC Motorcycle × woman	−2.152	0.134	< 0.001
ASC PT × work trip	0.612	0.054	< 0.001
Fit statistics			
Final log-likelihood	−32,722.53		
McFadden ρ^2	0.3155		
Observations (N)	72,413		

Notes: Huber–White robust standard errors; two-sided p-values. Estimated on the control group (pre-treatment trips and trips outside SCS). Full specification includes interactions of each ASC with sex, race, age, income, peak-hour, work purpose, intra-zone and spatial indicators.

Elasticities. Public transport has the largest own-price elasticity in absolute value: a 10% fare increase lowers its demand by about 0.157 in proportional terms, with car and motorcycle absorbing most of the diverted trips (Table 2). Public transport also has the largest own-time elasticity (−0.570), consistent with a mode whose attractiveness depends heavily on frequency and travel time. The income elasticity of public transport is negative, so it behaves as an inferior good relative to the car, underscoring the role of public coordination in sustaining ridership as incomes rise.

Table 2: Own- and cross-price elasticities of demand by mode

	Change in the price of		
Mode	Car	Public transport	Motorcycle
Walking	0.012	0.055	0.000
Car	−0.126	0.098	0.003
Public transport	0.090	−0.157	0.003
Motorcycle	0.081	0.098	−0.052

Notes: Elasticities computed from a marginal 10% increase in the price of each mode. Diagonal entries are own-price elasticities. Values are proportional changes in choice probability.

6.2 Counterfactual and the policy effect

Applying the fitted model to the treated group under a restored R$5.00 fare yields the counterfactual mode shares that would have prevailed without free fares. Comparing observed and counterfactual shares gives the policy effect reported in Table 3 and illustrated in Figure 1. The public transport share rises by about 5.3 percentage points (from 23.1% to 28.3%), a relative increase of roughly 22%. This gain is drawn from a fall in car and, especially, motorcycle trips, alongside an increase in walking. Every effect is statistically significant at the 5% level, with confidence intervals obtained from a parametric bootstrap over the asymptotic distribution of the estimated coefficients (Krinsky & Robb, 1986), and the intervals for public transport and walking lie entirely above zero while those for car and motorcycle lie entirely below.

Table 3: Policy effect on modal shares in the treated group

Mode	Observed (%)	Counterf. (%)	Effect (p.p.)	CI low	CI high	p-value
Walking	25.72	21.00	4.70	2.34	6.90	< 0.001
Car	41.33	44.60	−3.28	−6.07	−0.12	0.042
Public transport	28.32	23.10	5.26	2.39	7.45	< 0.001
Motorcycle	4.62	11.30	−6.69	−9.23	−4.12	< 0.001

Notes: Effect = observed share − estimated counterfactual share. The counterfactual is obtained by adding R$5.00 to the public transport fare of each treated trip and recomputing MNL probabilities. Confidence intervals and standard errors from a Krinsky–Robb parametric bootstrap (1,000 draws); normal-approximation 95% CIs.

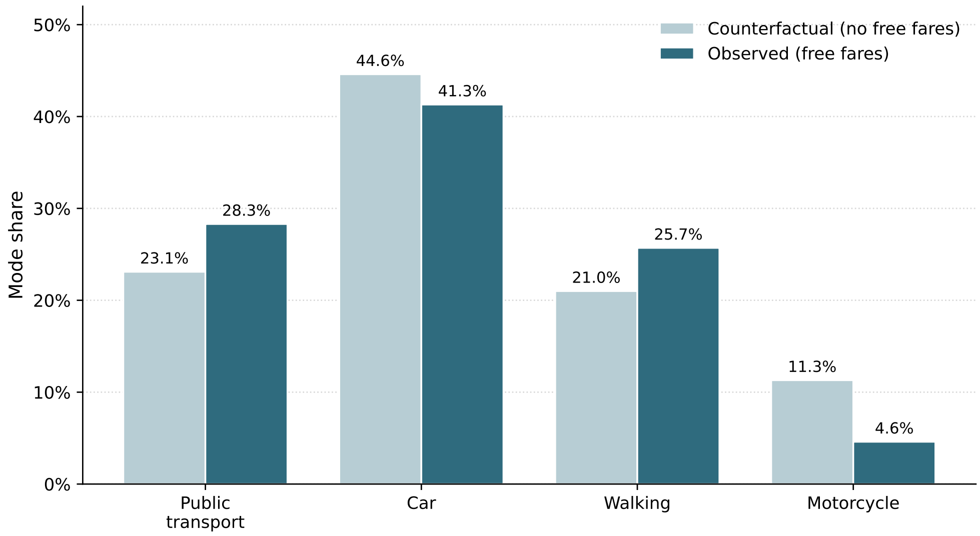

Figure 1: Observed modal shares under free fares versus the estimated counterfactual without the policy, treated group (trips touching SCS after 1 November 2023). The difference between the bars is the estimated policy effect.

The fall in motorcycle trips is the largest in proportional terms. In the SPMR the motorcycle is associated chiefly with lower-income travellers, and free fares can have a larger relative impact on this group; the motorcycle also has the most negative income elasticity of the four modes. Because reduced motorcycle use is linked in the literature to fewer traffic accidents, this shift may carry safety co-benefits beyond the scope of the model. The increase in walking is consistent with evidence that FFPT can raise active mobility, though the direction differs across cities; here, within mandatory trips, walking increases, driven mainly by SCS residents.

Heterogeneity. Disaggregating the effect on the public transport share (Table 4) shows that the groups switching most strongly are non-residents of SCS, non-white travellers, individuals below median income, and those under 40. Since SCS is richer and whiter than the SPMR and in-commuters earn about a third less than residents, these patterns point to an equity-enhancing effect: the policy disproportionately benefits lower-income and non-white travellers and those commuting in from other municipalities. This last point carries a policy tension, since the municipality subsequently restricted free fares to residents, which would primarily affect exactly the non-resident workers and students who switched most.

Table 4: Heterogeneous effect on the public transport share, by subgroup

Dimension	Subgroup	N	Walk	Car	PT	Moto
Race	Non-white	98	2.89	−4.33	7.25	−5.81
	White	248	5.42	−2.87	4.48	−7.03
Income	Above mean	111	5.51	2.34	1.61	−9.45
	Below mean	235	4.32	−5.93	7.00	−5.38
Residence	Non-resident	168	−0.29	−5.05	9.26	−3.93
	Resident in SCS	178	9.40	−1.61	1.50	−9.29
Age	40 or older	193	3.79	−1.15	4.03	−6.67
	Under 40	153	5.84	−5.97	6.83	−6.71

Notes: Effect (p.p.) = observed share − counterfactual share predicted by the main MNL. Income is per-capita household income relative to the treated-group mean. All values in percentage points. PT = public transport.

6.3 Consumer surplus and benefit–cost

The city projected the fiscal cost of FFPT at R$2.9 million per month, or R$35 million per year — about 1.44% of the R$2.4 billion annual budget. Consumer surplus is computed separately for travellers who received the policy and those who did not, imputing the counterfactual in each case. Because the OD represents a typical weekday, the surplus is scaled to an annual figure.

The average surplus is R$0.64 per trip touching SCS, but it is distributed progressively: the bottom income tercile captures a surplus equivalent to about 1.2% of monthly income, against less than 0.1% for the top tercile (Table 5). Among direct public transport users affected by the policy, progressivity is sharper still, with the bottom tercile receiving surplus worth about 7% of income against 1.6% for the top.

Table 5: Consumer surplus by income tercile, treated group

Tercile	Mean income (R$)	CS (R$/trip)	CS monthly (R$)	CS (% income)
Panel A – all trips touching SCS (log-sum)				
Low income	3,504	0.95	41.80	1.19
Middle income	7,556	0.60	26.40	0.35
High income	19,195	0.36	15.84	0.08
Panel B – PT users affected by free fares				
Low income	3,159	5.00	220.00	7.0
Middle income	7,256	5.00	220.00	3.0
High income	14,119	5.00	220.00	1.6

Notes: Monthly figures assume 44 trips per month (two per day over 22 working days). Panel A is the log-sum surplus over all trips of the tercile regardless of mode; Panel B restricts to trips using public transport affected by free fares, for which the per-trip surplus equals the R$5.00 fare saving mechanically.

Aggregating over the 327,662 trips with origin or destination in SCS represented by the OD, the total consumer surplus is estimated at R$198,937 per day, or R$49.7 million per year over 250 working days. The benefit–cost ratio is therefore

$$\text{BCR} = \frac{49.7}{35} \approx 1.42. \tag{9}$$

This benefit combines a transfer — to travellers who already used public transport and now save the fare — with an efficiency gain, as new passengers board buses at a marginal cost near zero where spare capacity existed. A ratio above one indicates that benefits exceed the fiscal cost within the analysed scope. Importantly, the calculation excludes environmental effects, accident reductions, and congestion relief. A supplementary exercise using observed car speeds in SCS (11.7 km/h before versus 12.95 km/h after) suggests a decongestion channel that, though not statistically distinguishable from zero given the small post-policy sample, would raise the benefit–cost ratio to roughly 2.04 if taken at face value; it is best read as illustrative of the potential order of magnitude.

7 Robustness

Three exercises support the main result.

Temporal placebo. Assigning a fictitious policy start of 1 October 2023 and re-estimating the model yields an effect on the public transport share of +0.12 p.p., statistically indistinguishable from zero ($p = 0.912$), indicating no pre-existing trend toward public transport in SCS. A significant effect appears for the car (+5.38 p.p.), plausibly reflecting SCS's "car culture" not fully captured by the covariates; this operates conservatively for the main result, implying the counterfactual may *understate* the true reduction in car use.

Spatial placebo. Applying the design to the neighbouring ABC municipalities of Santo André and São Bernardo do Campo — which did not adopt free fares — produces no statistically significant effect for any mode. Notably, the car effect found in the temporal placebo does not reappear, suggesting it reflected sampling noise in SCS rather than a systematic model bias.

GTFS routing. Re-estimating with travel times and prices derived from GTFS routing (via the `r5r` package), restricting the control to trips within São Paulo and touching SCS, confirms the direction and significance of the effect: the public transport share rises by about 8.9 p.p., with significant declines in car and motorcycle use. The larger magnitude reflects the much smaller price variance in this restricted sample (the standard deviation of the public transport fare is 59% lower than in the API-based control), so the magnitude should be read with caution while the sign and significance are robust. Across all three checks, the central finding — a rise in the public transport share at the expense of car and motorcycle — is robust to different time windows, spatial samples, and sources of time and cost data.

8 Concluding Remarks

This paper provides evidence that fare-free public transport in São Caetano do Sul induced a shift in mode choice for mandatory trips, from cars and motorcycles toward public transport, alongside an increase in walking. Although every group increased its use of public transport, the largest shifts occurred among non-residents, non-white travellers, people below median income, and those under 40. The result echoes findings from other permanent, broad-based FFPT schemes, such as Tallinn, and complements the São Paulo Sunday-fare evidence for the SPMR.

The welfare analysis reinforces the progressive character of the policy: the lowest income tercile captures surplus equivalent to about 1.2% of monthly income, against under 0.1% for the highest, and the benefit–cost ratio exceeds one even before accounting for congestion, environmental, or accident co-benefits. Because non-residents — who earn about a third less than residents — switched most, the subsequent decision to restrict free fares to residents may fall hardest on the group the policy most benefited.

Several limitations point to future work. The model holds the transport supply fixed, so changes in routes, frequency, fleet and crowding — which shape choice from the supply side — are not captured; the sharp rise in municipal bus boardings (up 143% in the first month) suggests substitution from intercity to municipal buses and possibly induced, previously suppressed demand, neither fully modelled here. The focus on mandatory work and study trips excludes leisure, shopping and other purposes, which may account for a large part of the policy's off-peak impact. Long-run responses, including vehicle purchase decisions that mature over years, also lie beyond a single cross-section. Finally, coordinating transport agencies above the municipal level emerges as a practical priority, since efficiency gains on municipal buses appear to coincide with under-utilisation of intercity lines. Future research on medium- and long-run effects, on the decongestion channel, and on non-mandatory trips would be valuable.

References

Athey, S., Bayati, M., Doudchenko, N., Imbens, G., & Khosravi, K. (2021). Matrix completion methods for causal panel data models. *Journal of the American Statistical Association*, 116(536), 1716–1730.

Ben-Akiva, M., & Lerman, S. R. (1985). *Discrete Choice Analysis: Theory and Application to Travel Demand*. MIT Press.

Bull, O., Muñoz, J. C., & Silva, H. E. (2021). The impact of fare-free public transport on travel behavior: Evidence from a randomized controlled trial. *Regional Science and Urban Economics*, 86, 103616.

Carr, C., & Hesse, M. (2020). Mobility policy through the lens of policy mobility: The post-political case of introducing free transit in Luxembourg. *Journal of Transport Geography*, 83, 102634.

Carvalho, C. H. R., Gomide, A. Á., & Pereira, R. H. M. (2013). *Tarifação e financiamento do transporte público urbano*. IPEA.

Cats, O., Susilo, Y. O., & Reimal, T. (2017). The prospects of fare-free public transport: Evidence from Tallinn. *Transportation*, 44(5), 1083–1104.

Dias, J. L. S. (1991). Tarifa zero e eficiência no transporte coletivo urbano. *Revista dos Transportes Públicos – ANTP*, 14.

Fujita, M., & Thisse, J.-F. (1996). Economics of agglomeration. *Journal of the Japanese and International Economies*, 10(4), 339–378.

Guzman, L. A., & Hessel, P. (2022). The effects of public transport subsidies for lower-income users on public transport use. *Transport Policy*, 126, 215–224.

Hess, S., & Palma, D. (2019). Apollo: A flexible, powerful and customisable freeware package for choice model estimation and application. *Journal of Choice Modelling*, 32, 100170.

Isard, W. (1949). The general theory of location and space-economy. *The Quarterly Journal of Economics*, 63(4), 476–506.

Kębłowski, W., Tuvikene, T., Pikner, T., & Jauhiainen, J. S. (2019). Towards an urban political geography of transport. *Environment and Planning C*, 37(6), 967–984.

Krinsky, I., & Robb, A. L. (1986). On approximating the statistical properties of elasticities. *The Review of Economics and Statistics*, 68(4), 715–719.

McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), *Frontiers in Econometrics*. Academic Press.

Perez, Y., & Pereira, F. H. (2025). Effects of Sunday free fare policy in São Paulo bus transportation. *Case Studies on Transport Policy*, 101595.

Štraub, D. (2020). The effects of fare-free public transport: A lesson from Frýdek-Místek (Czechia). *Sustainability*, 12(21), 9111.

Train, K. E. (2009). *Discrete Choice Methods with Simulation*. Cambridge University Press.

De Witte, A., Macharis, C., Lannoy, P., Polain, C., Steenberghen, T., & Van de Walle, S. (2006). The impact of "free" public transport: The case of Brussels. *Transportation Research Part A*, 40(8), 671–689.