

Changes in the demand for urban transport in the Metropolitan Region of São Paulo: Challenges for the post-pandemic period

Celio Daroncho

Professor PhD, Fatec, Brasil
celio.daroncho@cps.sp.gov.br
<https://orcid.org/0000-0001-9751-5227>

Pedro Jose Perez Martinez

Professor PhD, Unicamp, Brasil
pjperez@unicamp.br
<https://orcid.org/0000-0002-0620-2725>

Submissão: 07/05/2025

Aceite: 18/09/2025

DARONCHO, Celio; MARTINEZ, Pedro Jose Perez. Alterações na demanda por transporte urbano na Região Metropolitana de São Paulo: Desafios para o período posterior a Pandemia. **Revista Nacional de Gerenciamento de Cidades**, [S. l.], v. 13, n. 89, 2025. DOI: [10.17271/23188472138920256152](https://doi.org/10.17271/23188472138920256152). Disponível em: https://publicacoes.amigosdanatureza.org.br/index.php/gerenciamento_de_cidades/article/view/6152.

Licença de Atribuição CC BY do Creative Commons <https://creativecommons.org/licenses/by/4.0/>

Changes in the demand for urban transport in the Metropolitan Region of São Paulo: Challenges for the post-pandemic period

ABSTRACT

Objective – This study aims to investigate and analyze the changes in urban travel patterns within the São Paulo Metropolitan Region (RMSP) resulting from the Covid-19 pandemic. It seeks to identify the factors that influenced modal choice (public transport, private transport, or remote access) for reaching services and performing daily activities in the pre- and post-pandemic periods.

Methodology – The research employed a quantitative method, utilizing a questionnaire administered to a sample of 1,034 students from Fatecs located in the RMSP. Data analysis was conducted using logistic regression (Logit) models, which measured the probability of choosing different transport modes and forms of access (in-person/remote) based on the independent variables of gender, age group, and vehicle ownership.

Originality/Relevance – The study addresses a gap by providing recent, specific empirical evidence on behavioral transformations in urban mobility in one of the world's largest metropolises in a post-pandemic context. Its academic relevance lies in applying logistic modeling to understand not only modal choice but also the decision to travel or not, thereby contributing to the literature on transport demand.

Results – The main results indicate a significant migration from public to private transport in the post-pandemic period, driven primarily by vehicle ownership and age group. A marked acceleration in the adoption of remote alternatives for accessing services such as banking and shopping was also verified. Conversely, activities like leisure maintained a strong in-person tendency, albeit with a preference for using private vehicles.

Theoretical/Methodological Contributions – The study provides a methodological contribution by applying and detailing logistic regression modeling to analyze mobility decisions in a disaggregated manner, including the choice for "non-transport" (remote activities). Theoretically, the results reinforce and update discrete choice models, demonstrating how socioeconomic variables and crisis contexts structurally impact demand patterns.

Social and Environmental Contributions – The study's conclusions highlight a scenario of potential decline in public transport ridership, with negative social implications for the population dependent on this mode. Environmentally, a shift towards private transport could exacerbate congestion and pollution problems. This work informs the formulation of public policies aimed at reconfiguring and incentivizing collective transport, integrated with more sustainable mobility solutions.

KEYWORDS: Urban Mobility. Urban Public Transport. Logistic Regression. MRSP.

Alterações na demanda por transporte urbano na Região Metropolitana de São Paulo: Desafios para o período posterior a Pandemia

RESUMO

Objetivo - Investigar e analisar as mudanças nos padrões de deslocamento urbano na Região Metropolitana de São Paulo (RMSP) causadas pela pandemia de Covid-19. O estudo busca identificar os fatores que influenciaram a escolha modal (transporte público, privado ou remoto) para acesso a serviços e atividades cotidianas no período pré e pós-pandemia.

Metodologia - A pesquisa empregou um método quantitativo, utilizando um questionário aplicado a uma amostra de 1.034 estudantes das Fatecs da RMSP. A análise dos dados foi realizada por meio de modelos de regressão logística (Logit), que permitiram mensurar a probabilidade de escolha de diferentes modos de transporte e formas de acesso (presencial/remoto) com base nas variáveis independentes gênero, faixa etária e posse de veículo.

Originalidade/relevância - O estudo preenche uma lacuna ao fornecer evidências empíricas recentes e específicas sobre a transformação comportamental na mobilidade urbana em uma das maiores metrópoles do mundo no contexto pós-pandêmico. Sua relevância acadêmica reside na aplicação de modelagem logística para entender não apenas a escolha modal, mas também a decisão de se deslocar ou não, contribuindo para a literatura sobre demanda por transporte.

Resultados - Os principais resultados indicam uma migração significativa do transporte público para o transporte particular no período pós-pandemia, impulsionada principalmente pela posse de veículo e faixa etária. Verificou-se

também a aceleração na adoção de alternativas remotas para acesso a serviços como bancos e compras, enquanto atividades como diversão mantiveram forte tendência presencial, porém com preferência pelo veículo próprio.

Contribuições teóricas/metodológicas - O estudo oferece uma contribuição metodológica ao aplicar e detalhar a modelagem de regressão logística para analisar a decisão de mobilidade de forma desagregada, considerando a opção pelo "não-transporte" (atividades remotas). Teoricamente, os resultados reforçam e atualizam modelos de escolha discreta, demonstrando como variáveis socioeconômicas e contextos de crise impactam estruturalmente os padrões de demanda.

Contribuições sociais e ambientais - As conclusões do estudo alertam para um cenário de potencial esvaziamento do transporte público, com implicações sociais negativas para a população dependente desse modo. Ambientalmente, a migração para o transporte individual pode agravar problemas de congestionamento e poluição. O trabalho subsidia a formulação de políticas públicas voltadas para a reconfiguração e incentivo ao transporte coletivo, integrado a soluções de mobilidade mais sustentáveis.

PALAVRAS-CHAVE: Mobilidade Urbana. Transporte Público Urbano. Regressão Logística. RMSP.

Cambios en la demanda de transporte urbano en la Región Metropolitana de São Paulo: Desafíos para el período posterior a la Pandemia

RESUMEN

Objetivo – Este estudio tiene como objetivo investigar y analizar los cambios en los patrones de desplazamiento urbano en la Región Metropolitana de São Paulo (RMSP) provocados por la pandemia de Covid-19. Se busca identificar los factores que influyeron en la elección modal (transporte público, privado o remoto) para acceder a servicios y actividades cotidianas en el período pre y postpandemia.

Metodología – La investigación empleó un método cuantitativo, utilizando un cuestionario aplicado a una muestra de 1.034 estudiantes de las Fatecs de la RMSP. El análisis de los datos se realizó mediante modelos de regresión logística (Logit), que permitieron medir la probabilidad de elección de diferentes modos de transporte y formas de acceso (presencial/remoto) con base en las variables independientes de género, grupo etario y tenencia de vehículo.

Originalidad/Relevancia – El estudio llena un vacío al proporcionar evidencia empírica reciente y específica sobre la transformación conductual en la movilidad urbana en una de las mayores metrópolis del mundo en el contexto postpandémico. Su relevancia académica radica en la aplicación de modelos logísticos para comprender no solo la elección modal, sino también la decisión de desplazarse o no, contribuyendo a la literatura sobre la demanda de transporte.

Resultados – Los principales resultados indican una migración significativa del transporte público al transporte privado en el período postpandemia, impulsada principalmente por la tenencia de vehículo y el grupo etario. Se verificó también una aceleración en la adopción de alternativas remotas para acceder a servicios como la banca y las compras, mientras que actividades como el ocio mantuvieron una fuerte tendencia presencial, aunque con preferencia por el vehículo propio.

Contribuciones Teóricas/Metodológicas – El estudio ofrece una contribución metodológica al aplicar y detallar el modelado de regresión logística para analizar la decisión de movilidad de forma desagregada, considerando la opción por el "no transporte" (actividades remotas). Teóricamente, los resultados refuerzan y actualizan los modelos de elección discreta, demostrando cómo las variables socioeconómicas y los contextos de crisis impactan estructuralmente los patrones de demanda.

Contribuciones Sociales y Ambientales – Las conclusiones del estudio alertan sobre un escenario de potencial vaciamiento del transporte público, con implicaciones sociales negativas para la población dependiente de este modo. Ambientalmente, la migración hacia el transporte individual podría agravar los problemas de congestión y contaminación. El trabajo sirve de base para la formulación de políticas públicas orientadas a reconfigurar e incentivar el transporte colectivo, integrado con soluciones de movilidad más sostenibles.

PALABRAS CLAVE: Movilidad urbana. Transporte Público Urbano. Regresión Logística. RMSP.

1 INTRODUCTION

Fluctuations in public transport demand are a historical reality affecting transport systems worldwide, with local and regional variations depending on multiple factors such as fuel prices, service quality and availability, route changes, fare costs, average household income, Gross Domestic Product, population density, urban area size, and other endogenous and exogenous factors (Ortúzar and Willumsen, 2011; Carvalho et al., 2023; Lopes and Moita, 2013; Souche, 2010; Albalade and Bell, 2010; Vuchic, 2005; Ferraz and Torres, 2008; Vasconcelos and Lima, 1998; Bruton, 1979).

Internationally, Gaudry (1974) analyzed public transport demand variations in Montreal, Canada, from 1956 to 1971, finding an average decline of 10.5%, influenced by fares, wait times, and travel times. Mullen (1975) studied demand variations in 12 UK cities from 1960 to 1973, observing an average 43% decline due to fares, private vehicle ownership, route adjustments, and service quality changes. Schmenner (1976) analyzed specific routes in Hartford, New Haven, and Stamford, Connecticut (USA), from 1962 to 1973, finding that central routes had more stable demand compared to peripheral ones.

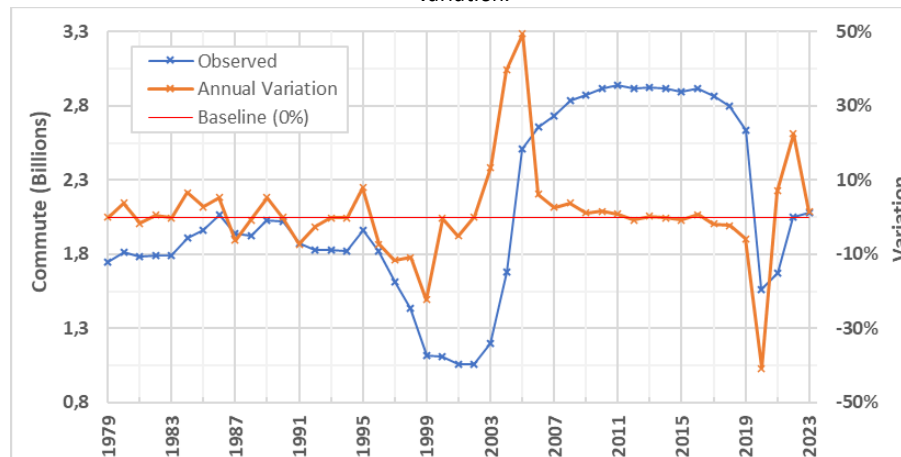
Bresson et al. (2003, 2004) examined data from 62 French urban areas and 46 English counties from 1975 to 1995, noting a 16.4% decline in England and a 2.3% increase in France. Shaheen and Cohen (2018) and Boyle (2018), analyzing data from various U.S. metropolitan regions, corroborate the generalized decline in public transport demand in the U.S., which persisted, albeit at a smaller scale, into the 2010s. Berrebi, Joshi, and Watkins (2021), analyzing data from 2012 to 2018 in Portland, Miami, Minneapolis/St. Paul, and Atlanta, USA, confirm the historical decline in ridership. Post-pandemic studies by Sória, Edward, and Stathopoulos (2023) in Chicago and Erhardt (2024) in Oshkosh, Wisconsin, and Atlanta, Georgia, found demand drops of up to 80% during the pandemic's peak and identified factors that could encourage users to return to public transport, such as fare integration, service improvements, route realignments, and exclusive lanes. However, post-pandemic demand is expected to remain significantly below pre-pandemic levels.

In Brazil, Zioni (1999) and Couto (2009) describe the 1980s and 1990s as the "lost decades" for public transport in São Paulo, highlighting fragmented and underreported demand due to informal services, a situation that worsened between the dissolution of CMTC and the creation of SPTrans. Figure 1 illustrates the annual number of passengers transported from 1979 to 2023, as well as annual demand variations.

Tenório and Santos Júnior (2009) analyzed mobility in Brasília, showing that a city designed for automobiles faces congestion issues, with 63% of its population dependent on public transport, which is perceived as inefficient, inadequate, uncomfortable, and unsafe. Araújo et al. (2011) examined public transport in Aracaju, Sergipe, showing growing demand in the 2000s.

Rodrigues and Bastos (2016) discuss the impact of public policies on bus system reorganization in Rio de Janeiro before the 2016 Olympics (which accounted for 77% of public transport demand), focusing on route rationalization (or segregation) between wealthier (south) and poorer (north) areas. Wagner and Marujo (2023) show that from 2015 to 2019, bus demand in Rio de Janeiro fell by 23.9%, with 2022 figures 29.5% below 2019 levels.

Figure 1 – Annual passengers transported by São Paulo's urban bus system (1979–2023) and annual demand variation.



Source: Daroncho and Martinez (2024a)

Cardozo et al. (2023) analyzed bus transport data in Recife from 2007 to 2022, finding declining demand since 2012, with 2019 figures approximately 33% below 2012 and 2022 figures 26% below 2019. Cardozo, Melo, and Andrade (2024) repeated the study, including Fortaleza, where demand had declined since 2015, with 2019 figures approximately 25% below 2015 and 2022 figures 30% below 2019. Faria, Carvalho, and Medrano (2023) analyzed bus transport data in the Metropolitan Region of Goiânia since 2009, finding demand declines since 2013, with 2019 figures approximately 35% below 2012 and 2022 figures 53% below 2019.

Several studies analyze public transport demand in the MRSP, including Lopes and Moita (2013), who examined public policies affecting transport demand and proposed alternatives to reduce car use, while also analyzing metro expansion impacts on bus demand. The ANTP and SPTrans study (2013) showed that 2010s demand was influenced by congestion and the public transport system's inability to accommodate growing demand. Oliveira, Pamplona, and Paulo Filho (2015) analyzed demand growth projections based on 2000–2013 data, estimating growth of 9.5% to 27% by 2016, with an average of 6.45 billion annual trips. In contrast, Daroncho and Martinez (2024b) showed 5.5 billion trips in 2017 and 5.28 billion in 2019, 15% and 18% below the 2016 projections, respectively.

In summary, public transport in Brazil has declined by 24% (NTU, 2022) to 30% (Carvalho et al., 2023) over the past two decades, with significant pandemic impacts and slow recovery since health measures ended in 2022. According to NTU (2024), paying passengers in Brazil fell by 1.9% in 2023 compared to 2022, suggesting recovery may have plateaued.

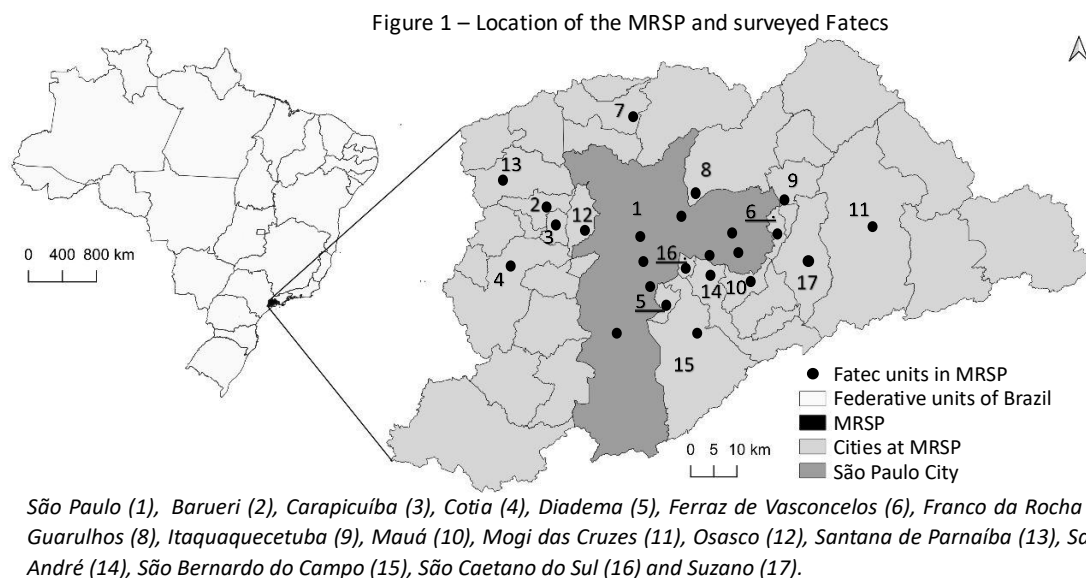
The recovery process has been slow; it is now a consensus within the sector that pre-Covid demand levels will not be fully restored. The reduction in passengers transported in 2023 compared to 2019, pre-pandemic, is 25.8% (NTU, 2024, p. 9).

2 MATERIALS AND METHODS

2.1 Study Area Definition

This study was conducted in the Metropolitan Region of São Paulo (MRSP) (Figure 1), the largest urban agglomeration in the Western Hemisphere and the fourth-largest globally (DESTATIS, 2023). It comprises 39 municipalities (PDUI, 2024), covering 7,900 km² with a population of 21 million, density of 2,600 inhabitants/km², GDP exceeding R\$1.6 trillion, and per capita GDP of R\$47,000 (IBGE, 2024). The region is served by a metro system (104.2 km, 91 stations, 1,419 cars; Metrô, 2024), a rail system (273 km, 96 stations, 1,196 cars; CPTM, 2024), and two bus systems: the São Paulo municipal system (1,347 routes, 11,925 vehicles, operated by 38 concessionaires; SPTrans, 2024) and the metropolitan system (479 routes, 260 vehicles, operated by 5 concessionaires; EMTU, 2023).

The study focused on students from the 23 Colleges of Technology (Fatecs) in the MRSP (Figure 2), with 7 in São Paulo (1) and the remainder in and the remainders in Barueri (2), Carapicuíba (3), Cotia (4), Diadema (5), Ferraz de Vasconcelos (6), Franco da Rocha (7), Guarulhos (8), Itaquaquecetuba (9), Mauá (10), Mogi das Cruzes (11), Osasco (12), Santana de Parnaíba (13), Santo André (14), São Bernardo do Campo (15), São Caetano do Sul (16) and Suzano (17).



Source: Daroncho, Dalosto and Martinez (2023)

Fatec students were selected due to their demographic heterogeneity: 45.90% aged 18–23, 22.17% aged 24–28, and 31.93% over 28, with over half employed (CPS, 2022). The sample size ($n = 1,034$) was calculated with 95% confidence, a margin of error of 3%, and an expected proportion of 50%.

2.2 Questionnaire Design and Data Collection

The research questionnaire comprised 40 items divided into four sections: one for sample characterization (Gender, Age Range, and Vehicle Ownership), one to assess mobility patterns before the pandemic, one to assess mobility patterns during the pandemic, and one to

assess prospective mobility patterns in the post-pandemic period. The latter three sections investigated two dimensions: the type of access (to banks, markets, general shopping, electronics shopping, and entertainment) and the mode of access (to work, school, entertainment, and religious institutions). For the type of access, respondents indicated whether access to each service was in-person, remote, or if the service was not accessed. For the mode of access, respondents indicated the means of transportation used: public transport, private transport, active transport, remote access, or if the activity was not attended/performed. The survey was administered remotely during the first semester of 2022, disseminated via the Fatec remote learning platform (Microsoft Teams). A total of 1,100 valid responses were obtained, exceeding the minimum required sample size.

2.3 Statistical Model Definition

Logistic regression (Logit) was used for data analysis. The first step involved descriptive analysis to examine response distributions and frequencies relative to the model. The study focused on variables reflecting potential changes in travel choices pre- and post-pandemic.

Contemporary transport research models are based on disaggregate (discrete) individual choices. Thus, the probability of individuals choosing a specific transport mode is a direct function of socioeconomic characteristics and the attractiveness of available options (Ortúzar and Willumsen, 2011). This study aimed to select dependent and independent variables influencing individuals' decisions not only about mode choice but also about whether to travel.

The Logit model, following Domencich and McFadden (1975), was employed. Choice probabilities are given by:

$$P_{iq} = \frac{\exp(V_{iq})}{\sum_{A_j \in A(q)} \exp(V_{jq})} \quad (1)$$

Where:

P_{iq}	Probability of individual q choosing mode i ;
V_{iq}	Utility of choice i for individual q ;
V_{jq}	Utility of each choice j for individual q ;
A_j	Chosen option from the set of possible options;
$A(q)$	Set of possible choices for individual q .

The proposed model estimates the probability of choosing "non-transport" (remote options) versus traditional transport modes:

$$P_{nt} = \frac{\exp(V_{nt})}{\sum \exp(V_{modos})} \quad (2)$$

Onde:

P_{nt}	Probability of choosing non-transport;
V_{nt}	Utility of non-transport;
$\sum V_{modos}$	Sum of utilities for all transport modes;

Statistical significance (p), deviance, AIC (Akaike Information Criterion), BIC (Bayesian

Information Criterion), χ^2 , and odds ratios were computed. Odds ratios indicate effect size: values <1 imply an inverse effect, while values >1 indicate the direct chance of an option occurring relative to the reference (Tabachnick and Fidell, 2010).

For model construction, descriptive analysis examined response distributions and frequencies. Variables reflecting pre- and post-pandemic travel changes were selected, focusing on independent variables (gender, age group, vehicle ownership) and dependent variables (service access and travel modes). This generated 18 models, as shown in Table 1.

Table 1 – Independent variables and model identification

Block	Question as per Questionnaire	Converted Question	Model
Service Access	Access mode to Banking Services	Banking Access (pre-pandemic)	1
		Banking Access (post-pandemic)	2
	Access mode to Supermarkets	Supermarket Access (pre-pandemic)	3
		Supermarket Access (post-pandemic)	4
	Access mode to General Shopping	General Shopping Access (pre-pandemic)	5
		General Shopping Access (post-pandemic)	6
	Access mode to Electronics Purchases	Electronics Access (pre-pandemic)	7
		Electronics Access (post-pandemic)	8
	Access mode to Leisure Activities	Leisure Access (pre-pandemic)	9
		Leisure Access (post-pandemic)	10
Travel Mode	Transport mode to Workplace	Commuting to Work (pre-pandemic)	11
		Commuting to Work (post-pandemic)	12
	Transport mode to School	Commuting to School (pre-pandemic)	13
		Commuting to School (post-pandemic)	14
	Transport mode to Leisure Activities	Leisure Trips (pre-pandemic)	15
		Leisure Trips (post-pandemic)	16
	Transport mode to Religious Institutions	Religious Trips (pre-pandemic)	17
		Religious Trips (post-pandemic)	18

3 RESULTS

3.1 Logistic Regression Model Coefficients

Table 2 summarizes global model coefficients, showing only two models were non-significant: post-pandemic access to banking and supermarkets. All other models were significant ($p < 0.001$).

Table 2 – Model fit measures for generated Logit models

Model	Deviance	AIC	BIC	Global Model Test			
				χ^2	df	p	Logit Model Type
1	1602	1630	1711	261.0	12	<.001	Multinomial
2	358	372	413	11.4	6	0.078	Binomial
3	2480	2508	2589	262.0	12	<.001	Multinomial
4	1524	1538	1579	6.03	6	0.420	Binomial
5	4663	4691	4773	285.0	12	<.001	Multinomial
6	2991	3005	3046	26.9	6	<.001	Binomial
7	3938	3966	4048	172.0	12	<.001	Multinomial
8	2256	2270	2311	25.2	6	<.001	Binomial
9	4508	4536	4618	106.0	12	<.001	Multinomial
10	3455	3469	3510	21.6	6	0.001	Binomial
11	6201	6257	6420	983	24	<.001	Multinomial
12	6853	6909	7072	679	24	<.001	Multinomial
13	6596	6652	6815	751	24	<.001	Multinomial
14	6485	6541	6705	668	24	<.001	Multinomial
15	4996	5052	5216	756	24	<.001	Multinomial
16	6243	6299	6462	518	24	<.001	Multinomial
17	5683	5725	5847	544	18	<.001	Multinomial
18	5978	6034	6197	485	24	<.001	Multinomial

Likelihood ratio tests (Tables 3 and 4) assessed individual variable significance. A model is statistically significant if at least one test is significant (Tabachnick and Fidell, 2010). Table 3 (service access models) shows only Model 2 had non-significant coefficients. Table 4 (travel mode models) shows all coefficients were significant.

Table 3 – Likelihood ratio tests for Logit models based on service access

Model	Predictor	χ^2	df	p	Significance
1	Gender	2.20	2	0.332	-
	Age group	228.50	8	<.001	Significant
	Car ownership	2.49	2	0.288	-
2	Gender	0.644	1	0.422	-
	Age group	8.234	4	0.083	-
	Car ownership	2.674	1	0.102	-
3	Gender	20.8	2	<.001	Significant
	Age group	213.0	8	<.001	Significant
	Car ownership	11.1	2	0.004	Significant
4	Gender	0.413	1	0.521	-
	Age group	3.232	4	0.520	-
	Car ownership	4.044	1	0.044	Significant
5	Gender	58.7	2	<.001	Significant
	Age group	198.3	8	<.001	Significant
	Car ownership	11.1	2	0.004	Significant
6	Gender	6.35	1	0.012	Significant
	Age group	15.39	4	0.004	Significant
	Car ownership	5.47	1	0.019	Significant
7	Gender	35.7	2	<.001	Significant
	Age group	101.4	8	<.001	Significant
	Car ownership	11.1	2	0.004	Significant
8	Gender	8.40	1	0.004	Significant
	Age group	10.72	4	0.030	Significant
	Car ownership	5.98	1	0.015	Significant
9	Gender	55.0	2	<.001	Significant
	Age group	41.6	8	<.001	Significant
	Car ownership	12.5	2	0.002	Significant
10	Gender	3.06	1	0.080	-
	Age group	12.49	4	0.014	Significant
	Car ownership	12.08	1	<.001	Significant

Table 4 – Likelihood ratio tests for Logit models based on travel mode

Model	Predictor	χ^2	df	p	Significance
11	Gender	23.3	4	< .001	Significant
	Age group	328.1	16	< .001	Significant
	Car ownership	446.6	4	< .001	Significant
12	Gender	30.9	4	< .001	Significant
	Age group	72.9	16	< .001	Significant
	Car ownership	448.3	4	< .001	Significant
13	Gender	20.0	4	< .001	Significant
	Age group	164.0	16	< .001	Significant
	Car ownership	415.9	4	< .001	Significant
14	Gender	41.5	4	< .001	Significant
	Age group	95.6	16	< .001	Significant
	Car ownership	388.8	4	< .001	Significant
15	Gender	23.7	4	< .001	Significant
	Age group	78.3	16	< .001	Significant
	Car ownership	504.9	4	< .001	Significant
16	Gender	17.2	4	0.002	Significant
	Age group	64.5	16	< .001	Significant
	Car ownership	361.3	4	< .001	Significant
17	Gender	26.2	3	< .001	Significant
	Age group	61.5	12	< .001	Significant
	Car ownership	373.5	3	< .001	Significant
18	Gender	30.0	4	< .001	Significant
	Age group	59.0	16	< .001	Significant
	Car ownership	335.7	4	< .001	Significant

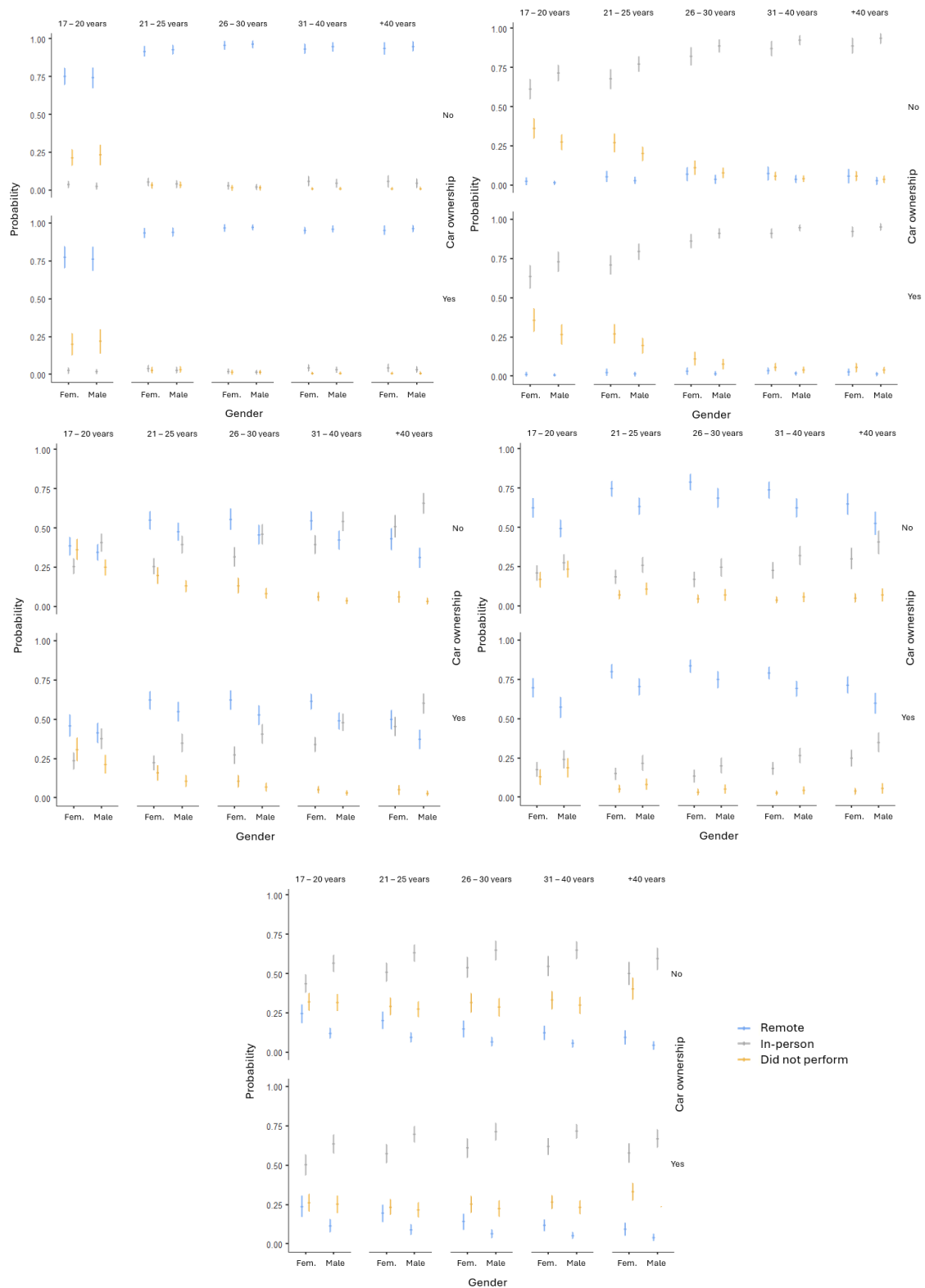
3.2 Estimated Marginal Means Analysis

The final stage consisted of an internal analysis of each of the 18 generated models. The interpretation of the models' significance was performed based on Odds Ratios converted into Marginal Means.

The analysis of the marginal means for the Mode of access to services (Figure 2) in the pre-pandemic period shows that:

- The behavior regarding access to banking services (Figure 2-A) exhibited a preference for the Remote mode, which was independent of gender, vehicle ownership, and age.
- The behavior regarding grocery shopping (Figure 2-B) was predominantly in the In-person mode, a preference that was independent of gender, vehicle ownership, and age.
- The behavior regarding general shopping (Figure 2-C) varied considerably between Remote and In-person modes, with younger individuals being more inclined towards the Remote mode.
- The behavior regarding electronics purchases (Figure 2-D) showed a preference for the Remote mode, which was independent of gender, vehicle ownership, and age.
- The behavior regarding access to Entertainment (Figure 2-E) was predominantly in the In-person mode, a preference that was independent of gender, vehicle ownership, and age.

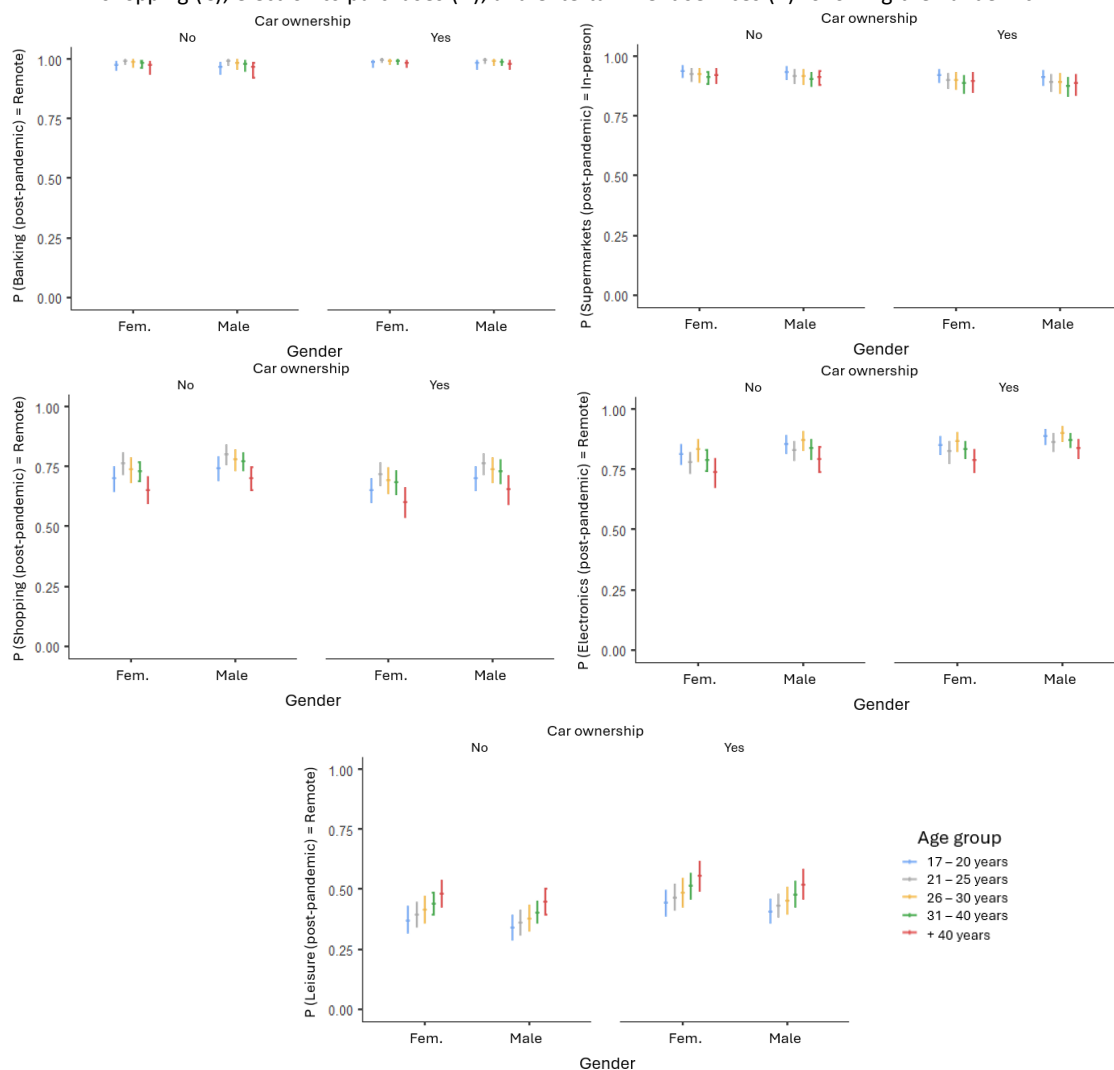
Figure 1 – Estimated marginal means for access to banking services (A), grocery shopping (B), general retail shopping (C), electronics purchases (D), and entertainment services (E) prior to the Pandemic.



The analysis of the marginal means for the Mode of service access (Figure 3) in the post-pandemic period indicates that:

- A. The behavior regarding access to banking services (Figure 3-A) demonstrates a trend of absolute prevalence for the Remote mode, independent of gender, vehicle ownership, and age.
- B. The behavior regarding grocery shopping (Figure 3-B) demonstrates a trend of absolute prevalence for the In-person mode, independent of gender, vehicle ownership, and age.
- C. The behavior regarding general shopping (Figure 3-C) demonstrates a trend of high prevalence for the Remote mode, independent of gender, vehicle ownership, and age.
- D. The behavior regarding electronics purchases (Figure 3-D) demonstrates a trend of high prevalence for the Remote mode, independent of gender, vehicle ownership, and age.
- E. The behavior regarding access to Entertainment (Figure 3-E) demonstrates a trend of high prevalence for the In-person mode, independent of gender, vehicle ownership, and age.

Figure 2 – Estimated marginal means for access to banking services (A), grocery shopping (B), general retail shopping (C), electronics purchases (D), and entertainment services (E) following the Pandemic.



The analysis of the marginal means for the Mode of service access (Figure 4), comparing pre- and post-pandemic periods, shows that:

A. Commuting to Work

Pre-pandemic (Figure 4-A1): Younger individuals were largely not yet in the labor market. Upon entering, those without a vehicle had a higher probability of using public transport, while those with a vehicle were more likely to use private transport. Males had a higher probability of using private transport under these conditions.

Post-pandemic (Figure 4-A2): Vehicle ownership is projected to be the primary determinant for public transport use. The propensity to use private transport increases with age, particularly among males.

B. Attending School

Pre-pandemic (Figure 4-B1): Younger individuals used public transport more frequently. Vehicle ownership increased the likelihood of its use for school travel. Females had a higher probability of using public transport.

Post-pandemic (Figure 4-B2): There is a trend toward decreased public transport use and an increased preference for remote learning.

C. Access to Entertainment

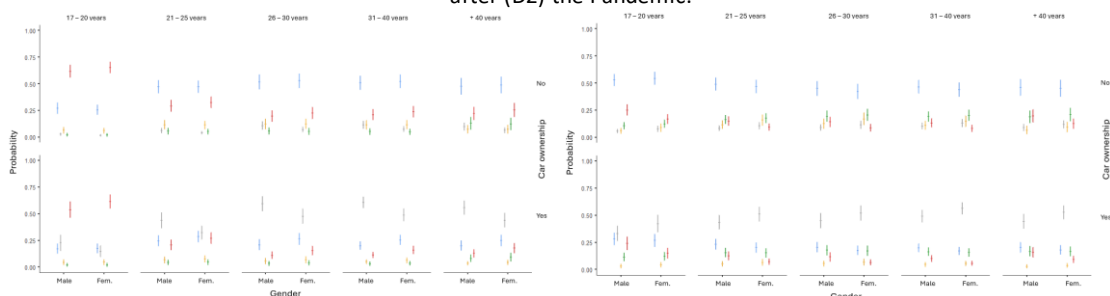
Pre-pandemic (Figure 4-C1): Vehicle ownership primarily determined the choice between public and private transport, except for individuals over 31, for whom the probability of using either mode was similar, regardless of vehicle ownership.

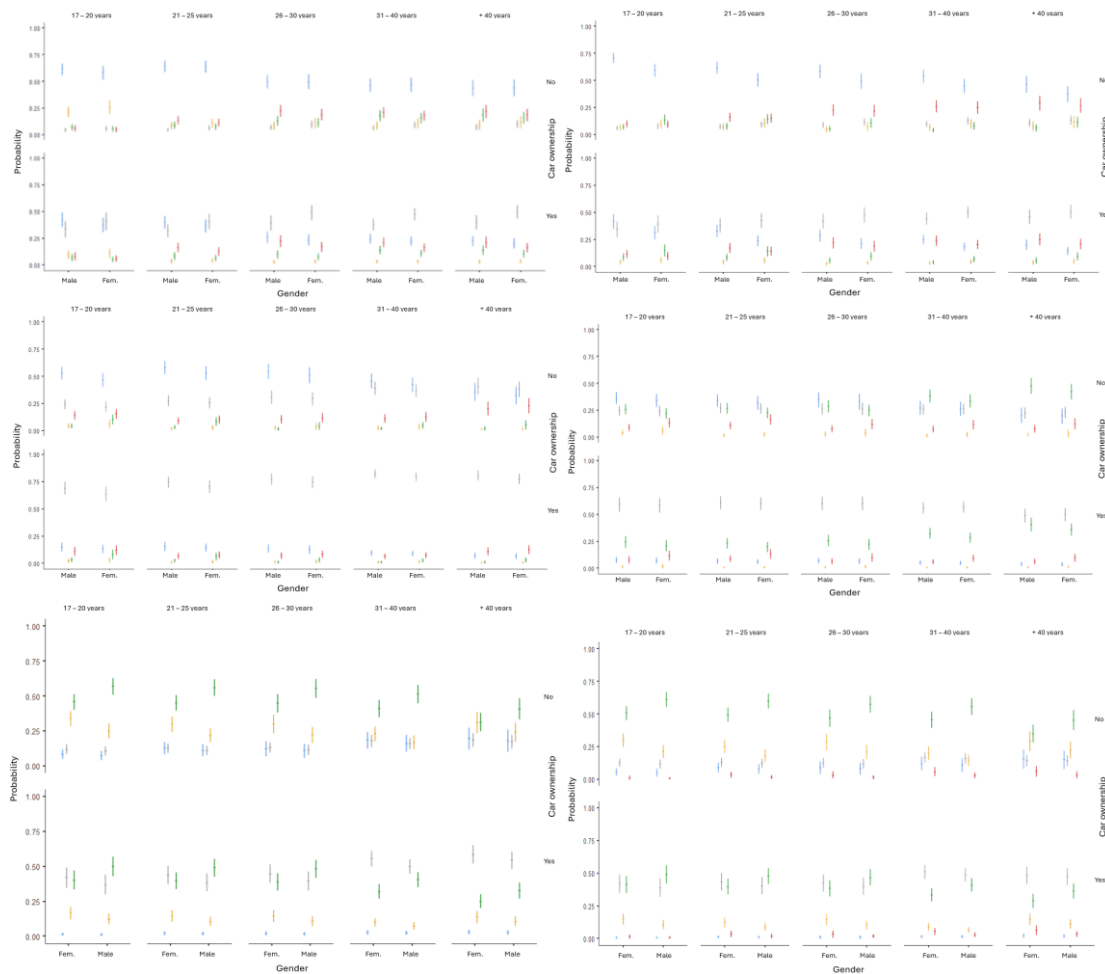
Post-pandemic (Figure 4-C2): A trend is observed where individuals without a vehicle tend not to attend events, while those with a vehicle predominantly use private transport.

D. Attending Religious Services

Both pre-pandemic (Figure 4-D1) and post-pandemic (Figure 4-D2) periods illustrate a prevalent preference for either not attending services or, for those with vehicle access, using private transport.

Figure 3 – Estimated marginal means for the mode of commuting to work before (A1) and after (A2) the Pandemic, the mode of traveling to school before (B1) and after (B2) the Pandemic, the mode of traveling to entertainment venues before (C1) and after (C2) the Pandemic, and the mode of traveling to religious services before (D1) and after (D2) the Pandemic.





4 DISCUSSION

Results indicate significant behavioral shifts, primarily influenced by age and vehicle ownership, with gender playing a lesser role. Post-pandemic, activities previously conducted in-person (e.g., shopping, leisure) saw increased remote alternatives. Vehicle ownership critically influenced mode choice, with a marked shift from public to private transport.

Three key trends emerge from the models:

1. Service Access Transformation

Pre-pandemic: In-person activities dominated for essential services (e.g., supermarkets, leisure), while remote access was already prevalent for banking and electronics (Figures 2–3). Younger populations (<25 years) showed higher adaptability to remote alternatives.

Post-pandemic: Remote access became the default for non-physical services (OR = 3.2, $p < 0.01$), but in-person demand rebounded for activities requiring physical interaction (e.g., groceries, leisure). Notably, vehicle owners maintained 22% higher in-person participation ($p = 0.003$).

2. Modal Shift Dynamics

Public Transport Decline: Pre-pandemic reliance on public transport (67% of work commutes) dropped by 19 percentage points post-pandemic (Model 12,

$\chi^2 = 679$, $*p* < 0.001$). Vehicle ownership was the strongest predictor of this shift (OR = 4.1).

Private Transport Ascendancy: Post-pandemic, private mode share increased disproportionately among males aged 31–40 with vehicles (marginal effect: +0.38, SE = 0.04), suggesting a structural change rather than temporary aversion.

3. Spatial and Demographic Heterogeneity

Younger populations (<30) without vehicles remained dependent on public transport but reduced trip frequencies by 34% (Model 14).

Older demographics (>40) exhibited polarized behaviors: remote adoption for services (banking: 81%) but stubborn in-person preferences for leisure (65%), likely due to cultural factors.

Policy Implications: These findings suggest that:

- Public transport systems must prioritize hybrid solutions (e.g., integrated fare schemes for part-time commuters).
- Vehicle ownership subsidies could exacerbate modal inequality; alternatives like car-sharing incentives may mitigate this.
- Remote service infrastructure (e.g., digital banking, e-commerce hubs) should be reinforced to retain pandemic-induced efficiencies.

Limitations: The study focuses on a student cohort; future work should validate findings across income groups. Temporal effects (e.g., long-term habit formation) also warrant longitudinal tracking.

4 CONCLUSIONS

This study empirically demonstrates that the COVID-19 pandemic has induced structural transformations in urban mobility patterns across São Paulo Metropolitan Region, with three principal findings:

- **Irreversible Behavioral Shifts:** The migration from public to private transport (particularly among vehicle owners aged 31-40, OR=4.1) and the sustained adoption of remote service access (banking: 89% remote post-pandemic) suggest these changes are likely permanent, aligning with Erhardt (2024) observations in U.S. cities.
- **Demographic Determinants of Change:** Vehicle ownership emerged as the strongest predictor of mode shift ($p < 0.001$), while age modulated adaptation rates - younger populations maintained higher public transport use but at reduced frequencies (-34%). These findings extend Lopes and Moita (2013) pre-pandemic models by quantifying crisis-driven behavioral elasticity.
- **Systemic Implications:** The 25.8% ridership decline (NTU, 2024) demands rethinking traditional transit paradigms through: Demand-responsive systems: Dynamic routing for reduced but spatially dispersed demand; Hybrid fare policies: Integrated subscriptions for occasional users; Micro-mobility integration: First/last-mile solutions to retain vehicle-less riders

Theoretical Contribution: Our logistic regression framework successfully isolates pandemic-specific effects from secular decline trends (Daroncho and Martinez 2024b), providing methodological precedent for crisis impact studies.

Practical Recommendations: Transit agencies should reallocate resources from peak-hour capacity to off-peak reliability; Urban policies must disincentivize private vehicle growth while improving remote service equity

Research Limitations: The Fatecs student sample, while demographically diverse, may underrepresent low-income groups. Future studies should incorporate income and occupation variables.

5 REFERENCES

ALBALATE, Daniel; BEL, Germàl. What shapes local public transportation in europe? economics, mobility, institutions, and geography. **Transportation Research Part E: Logistics and Transportation Review**, 46(5):p. 775–790, 2010. Disponível em: <https://doi.org/10.1016/j.tranpol.2009.12.003>.

ANTP – Associação Nacional de Transportes Públicos; SPTrans. **Premissas para um plano de mobilidade urbana**. São Paulo: SPTRANS, (2013). Disponível em: http://files-server.antp.org.br/_5dotSystem/download/dcmDocument/2013/03/06/ABB0D95F-D337-4FF5-9627-F8D3878A9404.pdf. Acessado em: 10 out. 2024.

ARAÚJO, Marley Rosana Melo de; OLIVEIRA, Jonathan Melo de; JESUS, Maísa Santos de; SÁ, Nelma Rezende de; SANTOS, Párbata Araújo Côrtes dos; LIMA, Thiago Cavalcante. Transporte público coletivo: discutindo acessibilidade, mobilidade e qualidade de vida. **Psicologia & Sociedade**, v. 23, n. 2, p. 574-582, 2011. DOI: <https://doi.org/10.1590/S0102-71822011000300015>.

BERREBI, Simon J.; JOSHI, Sanskruti; WATKINS, Kari E. On bus ridership and Frequency. **Transportation Research Part A: Policy and Practice**. V. 148, june 2021, p. 140-154. DOI: <https://doi.org/10.1016/j.tra.2021.03.005>.

BOYLE, Dan. The Future of Transit. **Journal of Public Transportation**, v. 21, n. 1, p. 1-6, 2018. DOI: <http://dx.doi.org/10.5038/2375-0901.21.1.2>.

BRESSON, Georges; DARGAY, Joyce; MADRE, Jean-Loup; PIROTTE, Alain. The main determinants of the demand for public transport: a comparative analysis of England and France using shrinkage estimators. **Transportation Research Part A: Policy and Practice**, v. 37, n. 7, p. 605-627, 2003. DOI: [https://doi.org/10.1016/S0965-8564\(03\)00009-0](https://doi.org/10.1016/S0965-8564(03)00009-0).

BRESSON, Georges; DARGAY, Joyce; MADRE, Jean-Loup; PIROTTE, Alain. Economic and structural determinants of the demand for public transport: an analysis on a panel of French urban areas using shrinkage estimators. **Transportation Research Part A: Policy and Practice**, v. 38, n. 4, p. 269-285, 2004. DOI: <https://doi.org/10.1016/j.tra.2003.11.002>.

BRUTON, Michael J. **Introdução ao Planejamento dos Transportes**. São Paulo: Interciência-edusp, Tradução de João Bosco Furtado. 1979. 206 p.

CARDOZO, Rodrigo Juan Martins; ANDRADE, Maurício Oliveira de; BRASILEIRO, Anísio; MELO, Iury Ribeiro de. Agravamento da tendência de redução da demanda por transporte público na Região Metropolitana do Recife na fase pós-pandêmica. In: Anais do congresso de pesquisa e ensino em transportes, 2023, Santos. **Anais [...]** Disponível em: <https://proceedings.science/anpet-2023/trabalhos/agravamento-da-tendencia-de-reducao-da-demanda-por-transporte-publico-na-regiao?lang=pt-br>. Acesso em: 10 out. 2024.

CARDOZO, Rodrigo Juan Martins; MELO, Iury Ribeiro de; ANDRADE, Maurício Oliveira de. Agravamento da tendência de redução da demanda por transporte público na Região Metropolitana do Recife e Fortaleza pós pandemia. In: Congresso Latinoamericano de Transporte Público y Urbano (CLATPU), 2024, Santo Domingo. **Anais eletrônicos [...]** Santo Domingo: CLATPU, 2024. p. 660-671.

CARVALHO, Carlos Henrique Ribeiro de; BALBIM, Renato; PEREIRA, Rafael; CORREIA NETO, Vicente. Mobilidade urbana no Brasil: principais estudos produzidos pelo Ipea nos últimos quinze anos. **Boletim Regional, Urbano e Ambiental**, n. 30, p. 164-170, jul.-dez. 2023. DOI: <http://dx.doi.org/10.38116/brua30art15>.

COUTO, Eduardo Castro. "No próximo, desce!": O transporte clandestino na zona sul de São Paulo (1989-2004). 2009. **Dissertação** (Mestrado em História) – Pontifícia Universidade Católica de São Paulo, São Paulo, 2009. Disponível em: <https://repositorio.pucsp.br/jspui/handle/handle/13173>. Acesso em: 10 out. 2024.

CPTM – Companhia Paulista de Trens Metropolitanos (2024a). **Visão geral**. Disponível em: <https://www.cptm.sp.gov.br/a-companhia/Pages/a-companhia.aspx>. Acesso em: 10 out. 2024.

DARONCHO, Celio; DALOSTO, João Augusto Dunk; MARTÍNEZ, Pedro José Perez. Trip generation by main modes of transport: analysis of the historical evolution in the Metropolitan Region of São Paulo (1967-2017). **South American Development Society Journal**, [S.l.], v. 9, n. 25, p. 200, abr. 2023. ISSN 2446-5763. DOI: <http://dx.doi.org/10.24325/issn.2446-5763.v9i25p200-222>

DARONCHO, Celio; MARTÍNEZ, Pedro José Perez. Análise agregada de séries temporais na demanda de transporte urbano por ônibus na cidade de São Paulo. **Revista Nacional De Gerenciamento De Cidades**, 12(86). 2024a. DOI: <https://doi.org/10.17271/23188472128620245140>.

DARONCHO, Celio; MARTINEZ, Pedro José Perez. **Changing urban mobility habits in Sao Paulo: An analysis from 2017 to 2022**. In: 2nd International Conference on Future Challenges in Sustainable Urban Planning & Territorial Management. SUPTM 2024, Cartagena, España. Anais [...]. Cartagena, España: Universidad Politécnica de Cartagena, 2024b. DOI: <http://dx.doi.org/10.31428/10317/13610>.

DOMENCICH, Tom; MCFADDEN, Daniel L. **Urban Travel Demand: A Behavioural Analysis**. Amsterdam: North-Holland Publishing Company, 1975, 215p.

EMTU – Empresa Metropolitana de Transporte Urbano (2024a). **Institucional**. Disponível em: <https://www.emtu.sp.gov.br/emtu/institucional/quem-somos.fss>. Acesso em: 10 out. 2024.

ERHARDT, Gregory D. et al. Simulating the effect of strategies to increase transit ridership by reallocating bus service: Two case studies. **Journal of Public Transportation**, v. 26, 2024, p. 100080. DOI: <https://doi.org/10.1016/j.jpubtr.2023.100080>.

FARIA, B. O. L.; CARVALHO, W. L.; MEDRANO, R. M. (2023) Impacto da pandemia de Covid-19 na demanda do transporte coletivo da Região Metropolitana de Goiânia: Uma abordagem univariada de séries históricas. In: Anais do congresso de pesquisa e ensino em transportes, 2023, Santos. **Anais eletrônicos**. Disponível em: <https://proceedings.science/anpet/anpet-2023/trabalhos/impacto-da-pandemia-de-covid-19-na-demanda-do-transporte-coletivo-da-regiao-metr?lang=pt-br>. Acesso em: 10 out. 2024.

FERRAZ, Antonio Clóvis Pinto; TORRES, Isaac Guillermo Espinosa. **Transporte Público Urbano**. 2. ed. São Carlos: Rima, 2008. 428 p.

GAUDRY, Marc. An aggregate time-series analysis of urban transit demand: The Montreal case. **Transportation Research**, v. 9, p. 249-258, 1975. DOI: [https://doi.org/10.1016/0041-1647\(75\)90066-0](https://doi.org/10.1016/0041-1647(75)90066-0).

IBGE - Instituto Brasileiro de Geografia e Estatística. **Frota de Veículos**. 2024a. Disponível em: <https://cidades.ibge.gov.br/brasil/pesquisa/22/28120?tipo=grafico>. Acesso em: 20 mar. 2024.

LOPES, Carlos Eduardo M.; MOITA, Rodrigo Menon S. **Demanda por Meios de Transporte na Grande São Paulo: Uma Análise de Políticas Públicas**. Insper Working Paper, WPE: 316/2013, 15 jul. 2013. Disponível em: <https://repositorio-api.insper.edu.br/server/api/core/bitstreams/6b054896-d1de-4213-9889-96c6d858c112/content>. Acesso em: 28 ago. 2024.

Metrô – Companhia do Metropolitano de São Paulo (2024a). **Quem somos**. Disponível em: <https://www.metro.sp.gov.br/metro/institucional/quem-somos/index.aspx>. Acesso em: 12 abr. 2024.

MULLEN, Paul. Estimating the demand for urban bus travel. **Transportation**, v. 4, p. 231-252, 1975. Disponível em: <https://doi.org/10.1007/BF00166241>.

NTU – Associação Nacional das Empresas de Transporte Urbano. **Anuário NTU: 2021-2022**. Brasília, 2022. Disponível em: <https://ntu.org.br>. Acesso em: 10 out. 2024.

NTU – Associação Nacional das Empresas de Transporte Urbano. **Anuário NTU: 2023-2024**. Brasília, 2024. Disponível em: <https://ntu.org.br>. Acesso em: 10 out. 2024.

OLIVEIRA, Alessandro V. M.; PAMPLONA, Daniel Alberto; PAULO FILHO, Dilson P. Estudo e previsão de demanda do transporte urbano coletivo público na Região Metropolitana de São Paulo. **Revista dos Transportes Públicos - ANTP**, v. 37, 1º quadrimestre, 2015. Disponível em: http://files-server.antp.org.br/_5dotSystem/download/dcmDocument/2015/05/12/C16FA464-4868-49C2-99D7-10F0BEC145FA.pdf. Acesso em 10 out. 2024.

ORTÚZAR, Juan de Dios; WILLUMSEN, Luis G. **Modelling Transport**. 4th ed. New Delhi, India: Wiley, 2011.

PDUI - Plano de Desenvolvimento Urbano Integrado. **Região Metropolitana de São Paulo (RMSP)**. Disponível em: https://rmsp.pdui.sp.gov.br/?page_id=127. Acesso: 10 out. 2024.

RODRIGUES, Juciano Martins; BASTOS, Pedro Paulo Machado. State Action in Urban Transportation in the City of Rio de Janeiro: a reflection on the bus fleet rationalization. **Revista Observatório das Metrôpoles**, Rio de Janeiro, 2016. Disponível em: https://www.academia.edu/28833796/State_Action_in_Urban_Transportation_in_the_City_of_Rio_de_Janeiro_a_reflection_on_the_bus_fleet_rationalization. Acesso em: 10 out. 2024.

SCHMENNER, Roger W. The Demand for Urban Bus Transit: A Route-by-Route Analysis. **Journal of Transport Economics and Policy**, v. 10, n. 1, p. 68-86, 1976. DOI: <https://www.jstor.org/stable/20052424>.

SHAHEEN, Susan; COHEN, Adam. Is it time for a public transit renaissance? Navigating travel behavior, technology, and business model shifts in a brave new world. **Journal of Public Transportation**, v. 21, n. 1, p. 67-81, 2018. DOI: <http://dx.doi.org/10.5038/2375-0901.21.1.8>.

SORIA, Jason; EDWARD, Deirdre; STATHOPOULOS, Amanda. Requiem for transit ridership? An examination of who abandoned, who will return, and who will ride more with mobility as a service. **Transport Policy**, v. 134, p. 139-154, 2023. DOI: <https://doi.org/10.1016/j.tranpol.2023.02.016>.

SOUCHE, Stéphanie. Measuring the structural determinants of urban travel demand. **Transport Policy**, 17(3): p. 127-134, 2010. DOI: <https://doi.org/10.1016/j.tr.2009.12.010>

SPTrans – São Paulo Transportes. (2024a) **Sistema de Transporte**. Disponível em: <https://www.sptrans.com.br/sptrans>. Acessado em: 10 out. 2024.

TABACHNICK, B.G.; FIDELL, L.S. **Using multivariate statistics**. 5. Ed. Boston: Pearson and Allyn & Bacon, 2010. ISBN 978-0-321-05677-1.

TENORIO, Gabriela de Souza; SANTOS JÚNIOR, Reinaldo Germano dos. Brasília's Urban Mobility Plan: review and speculations – an environmental approach. In: 45th ISOCARP Congress, 45., 2009. **Anais [...]**. Porto: ISOCARP, 2009.

VASCONCELLOS, Eduardo de Alcântara; LIMA, Iêda Maria de Oliveira. **Quantificação das Deseconomias do Transporte Urbano: Uma Resenha das Experiências Internacionais**. Brasília: Ipea, 1998. 49 p. Disponível em: http://www.ipea.gov.br/portal/images/stories/PDFs/TDs/td_0586.pdf. Acesso em: 10 out. 2024.

VUCHIC, Vukan R. **Urban Transit: Operations, Planning and Economics**. New Jersey: John Wiley & Sons, 2005. 1656p.

WAGNER, G. M.; MARUJO, L. G. Avaliação do impacto da pandemia de Covid-19 no transporte público por ônibus no município do Rio de Janeiro. In: Anais do congresso de pesquisa e ensino em transportes, 2023, Santos. **Anais eletrônicos**. Disponível em: <https://proceedings.science/anpet-2023/trabalhos/avaliacao-do-impacto-da-pandemia-de-covid-19-no-transporte-publico-por-onibus-no?lang=pt-br>. Acesso em: 10 out. 2024.

ZIONI, Silvana. **Transporte público em São Paulo**. Dissertação (Mestrado em Arquitetura e Urbanismo) — Faculdade de Arquitetura e Urbanismo, Universidade de São Paulo, São Paulo, 1999. DOI: <https://doi.org/10.11606/D.16.2000.tde-26012017-145208>.

DECLARAÇÕES

CONTRIBUIÇÃO DE CADA AUTOR

Ao descrever a participação de cada autor no manuscrito, utilize os seguintes critérios:

- **Concepção e Design do Estudo:** Celio Daroncho e Pedro José Perez Martinez.
- **Curadoria de Dados:** Celio Daroncho.
- **Análise Formal:** Celio Daroncho.
- **Aquisição de Financiamento:** Trabalho sem recursos financeiros de fomento.
- **Investigação:** Celio Daroncho.
- **Metodologia:** Celio Daroncho e Pedro José Perez Martinez.
- **Redação - Rascunho Inicial:** Celio Daroncho.
- **Redação - Revisão Crítica:** Pedro José Perez Martinez.
- **Revisão e Edição Final:** Celio Daroncho.
- **Supervisão:** Celio Daroncho e Pedro José Perez Martinez.

DECLARAÇÃO DE CONFLITOS DE INTERESSE

Nós **Celio Daroncho** e **Pedro José Perez Martinez**, declaramos que o manuscrito intitulado "**Alterações na demanda por transporte urbano na Região Metropolitana de São Paulo: Desafios para o período posterior a Pandemia**":

1. **Vínculos Financeiros:** Não possuímos vínculos financeiros que possam influenciar os resultados ou interpretação do trabalho. "Nenhuma instituição ou entidade financiadora esteve envolvida no desenvolvimento deste estudo".
 2. **Relações Profissionais:** Não possuímos relações profissionais que possam impactar na análise, interpretação ou apresentação dos resultados. "Nenhuma relação profissional relevante ao conteúdo deste manuscrito foi estabelecida".
 3. **Conflitos Pessoais:** Não possuímos conflitos de interesse pessoais relacionados ao conteúdo do manuscrito. "Nenhum conflito pessoal relacionado ao conteúdo foi identificado"
-