Urbanization and Public Transportation of Los Angeles

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Abstract

This paper will examine how Los Angeles's demand for public transportation has been affected the last few years, utilizing derivatives to determine the rate of change in public transportation usage and studying the elasticity of demand for transportation options based on pricing, availability, convenience, and modes.

Introduction

Los Angeles – the sprawling metropolis that we call home – has become synonymous with both opportunity and urban challenges and has experienced rapid growth in recent decades. This growth has significant implications for various sectors, particularly the public transportation system. As one of the most car-dependent cities in the United States, Los Angeles faces unique challenges in scaling its public transportation network to meet increasing demand. Understanding the dynamics of public transportation usage and the factors influencing ridership is critical for planning and policy development.

The aim of this study is to examine how the rapid growth of Los Angeles affects the demand for public transportation. The investigation includes a quantitative assessment utilizing derivatives to determine the rate of change in public transportation usage. Additionally, the study examines the elasticity of demand for transportation options in Los Angeles based on pricing, availability, convenience, and modes. This analysis offers insights into the responsiveness of ridership to changes in these factors, informing strategies to enhance the public transportation system.

This information is crucial for making impactful decisions related to resource allocation, service expansion, and policy adjustments. Transit agencies can use this information to optimize fare structures, implement dynamic pricing models, or introduce discounts and incentives to attract more riders during specific times or for particular modes. Additionally, knowing how pricing, availability, and convenience impact ridership allows for targeted marketing and communication strategies.

Methodology

Data Collection

The analysis is based on comprehensive datasets including average weekend and weekday ridership from 2019 to 2023, as well as a range of urban metrics such as crime rates, accident statistics, and city maintenance records. Yearly transportation budget figures also contribute to understanding the financial aspects influencing public transportation operations.

The methodological approach consists of two primary quantitative analyses:

Rate of Change Analysis:

- Utilize time-series data to calculate the first derivative of ridership numbers, yielding the rate of change over the years. This derivative analysis will be conducted separately for bus and rail services, offering a granular view of usage trends.
- Data transformation into a suitable format for analysis using the tidyverse collection of R packages.

- Visualization of trends through line plots, elucidating patterns and growth trajectories.

Elasticity of Demand Analysis:

- Analyze the responsiveness of public transportation demand to changes in price (fare changes), availability (service hours, frequency), convenience (route changes, wait times), and modes (bus vs. rail).
- Employ econometric modeling to estimate the price elasticity of demand, cross-elasticity, and income elasticity, using regression analysis where ridership

Visualization

- Data visualization was implemented using the `ggplot2` package in R
- Line plots were created to illustrate the trends in public transportation ridership over time, broken down by transportation type (bus and rail)
- Adjustments were made to display actual numbers instead of scientific notation for clarity

Exploratory Data Analysis

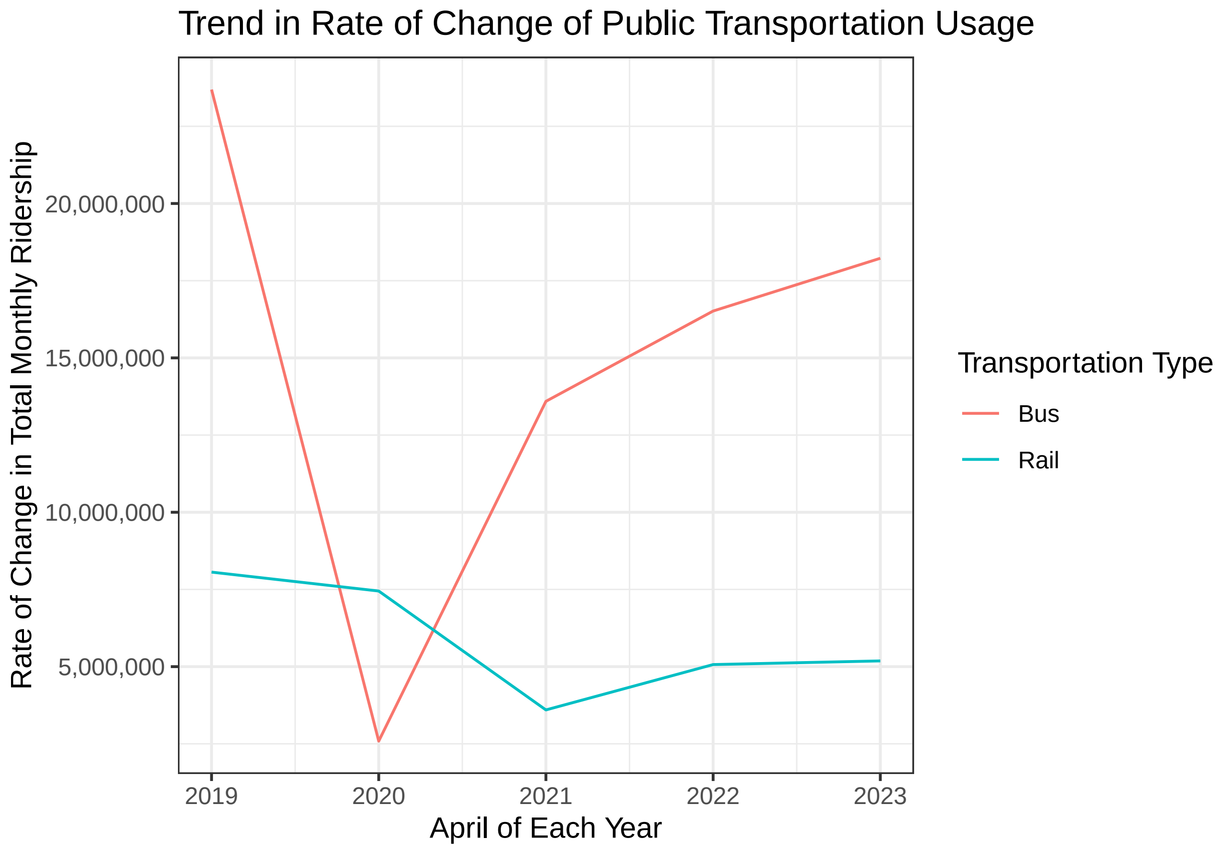

Figure 1: Line plot of rate of change in public transportation ridership over time

Derivative Analysis

The rate of change in public transportation usage offers valuable insights into trends and can help forecast future demand. By differentiating the ridership data with respect to time, we can obtain the instantaneous rate of change, which is expressed mathematically as:

$$R'(t) = \frac{dR}{dt}$$

where $R(t)$ represents the ridership at time t. This derivative analysis provides the velocity of ridership change, indicating whether usage is increasing or decreasing over time.

It is important to keep in mind the usage of information like such. For Metro, getting their ridership to pre-pandemic numbers would be a huge accomplishment in the public transit landscape of Los Angeles. Total ridership in May 2023 was at 77% of 2019 levels, and in June 2023, it was at 81% of its 2019 pre-pandemic level. When using March of 2020 as our reference point, we can analyze the potentially differing rates of change in the ridership of Metro Bus and Metro Rail usage over time. Over the first year from 2020, the total monthly ridership went down roughly by roughly 22.5 million users.

The derivative of bus rider usage in Los Angeles from 2019 to 2022 shows a gradual recovery in ridership, with consistent year-over-year increases and efforts to restore pre-pandemic levels. The recovery of bus ridership in Los Angeles reflects the ongoing efforts of Metro to improve mobility and public transit accessibility in the region. These changes indicate a positive trend in bus rider usage, with a focus on restoring and surpassing pre-pandemic ridership levels.

Table 1: Linear Regression Results

	Dependent variable:	
	BusRateOfChange	RailRateOfChange
	(1)	(2)
Observations	4	4
R^2	0.319	0.184
Adjusted R^2	−0.021	−0.223
Residual Std. Error (df = 2)	13,934,596.000	2,498,636.000
F Statistic (df = 1; 2)	0.938	0.452
Note:		*p<0.1; **p<0.05; ***p<0.01

$$\text{Total Monthly Bus} = -16456298.50 + 6036028.40 \cdot (Year - 2019)$$

$$\text{Total Monthly Rail} = -2597795.50 + 751531.80 \cdot (Year - 2019)$$

$$\text{Total Monthly Bus} = -58111913.49 + 33688766315.52 \cdot (Year - 2019) + -8331123.00 \cdot (Year - 2019)^2$$

$$\text{Total Monthly Rail} = -239513.00 + -1906155697.79 \cdot (Year - 2019) + 471656.50 \cdot (Year - 2019)^2$$

Table 2: Polynomial Regression Results

	Dependent variable:	
	BusRateOfChange	RailRateOfChange
	(1)	(2)
Observations	4	4
R^2	0.806	0.243
Adjusted R^2	0.418	−1.272
Residual Std. Error (df = 1)	10,522,144.000	3,405,367.000
F Statistic (df = 2; 1)	2.076	0.160
Note:		*p<0.1; **p<0.05; ***p<0.01

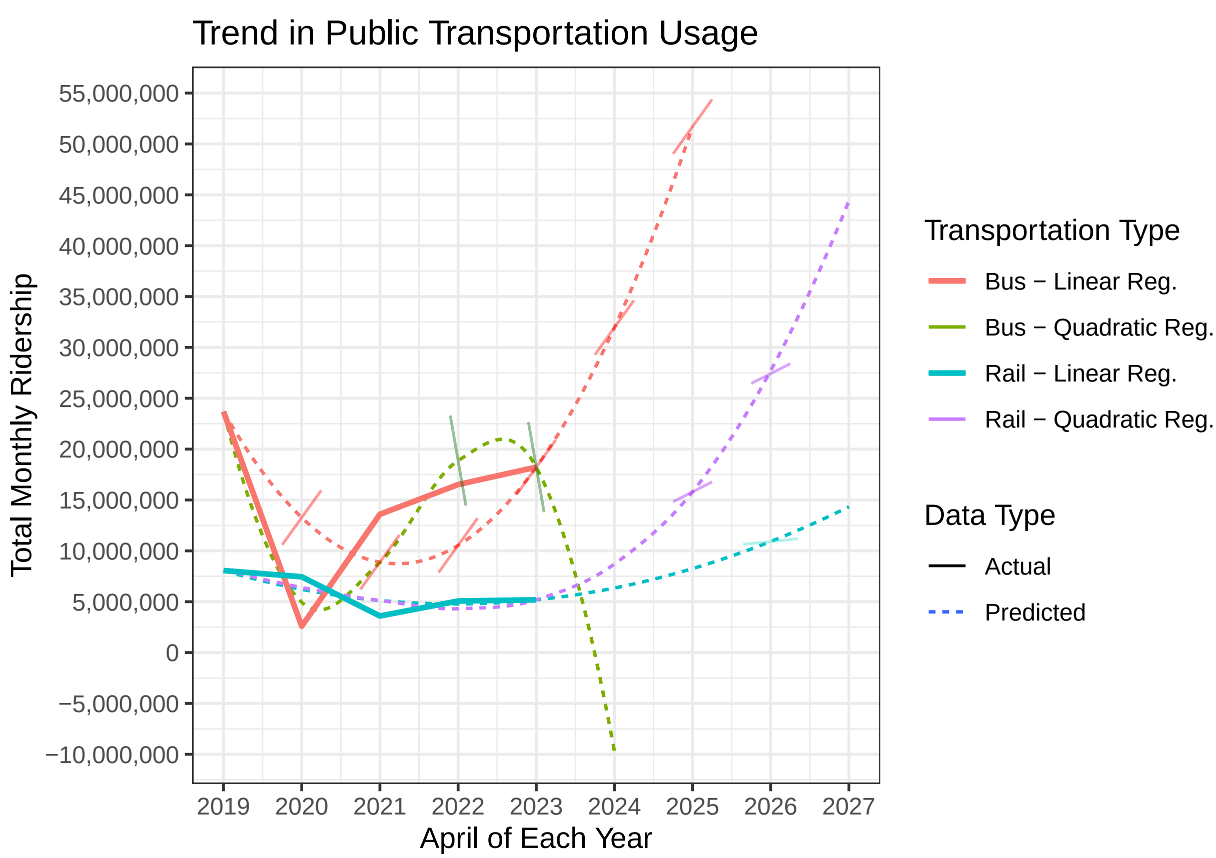

Figure 2: Line plot of public transportation ridership over time with regression lines

Sources:

- Transit ridership data: Los Angeles Metro “L.A. METRO TRANSIT RIDERSHIP UP 10 PERCENT, SETS POST-PANDEMIC RECORD”, Patrick Chandler