Choosing TTC Subway Service Provides the Most Time Stability during Weekday Rush-Hours*

Analysis on the Delay Magnitude of different TTC Services

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September 26, 2024

This paper analyzes the magnitude of TTC delays in 2023 based on service types. Delay data for buses, streetcars, and subways are obtained through Open Data Toronto and the data collected are used to visualize delay magnitude during different days and hours throughout the year. We find that, although TTC streetcars offered the least number of delays in 2023, riding on TTC subways provides the least average time of delay during weekday rush-hour traffic. Our results suggest that, if the time required to arrive at one's office is the same for all TTC service options, choosing subway over other services could provide the most time stability.

Table of contents

*Code and data are available at: https://github.com/Jingying-yu/ttc_delay.git

1 Introduction

Public transits serves as the transportation backbone for city residents, facilitating the daily commute of millions of people. For office workers, students, and the elderly, selecting the appropriate TTC service is crucial in maintaining a reliable and efficient schedule. Despite the importance of this choice, there has been limited effort to evaluate the reliability of different TTC services to guide commuters'choices.

Publicly accessible TTC delay data can be tracked back to 2014 on the Sharla Gelfand (2022) portal, yet a comprehensive visualization of how each type of service – bus, streetcar, and subway -— performs in terms of delay time remains narrowly explored. This paper addresses this gap by using data from the TTC delay data to analyze and visualize delay patterns across different services.

This paper specifically focuses on TTC bus, streetcar, and subway delay data from 2023, extracting and comparing them to identify which service type experienced the least amount of delay during weekday rush hours. Throughout the paper, *rush-hour* refers to the periods from 7:00 AM to 9:00 AM (morning rush) and 4:00 PM to 7:00 PM (evening rush). Our findings indicate that, in 2023, the TTC subway system consistently demonstrated the shortest average delays.

Understanding these patterns is crucial for helping commuters make informed choices about which TTC service to use, especially when they have equal access to different types of stations. By providing this analysis, the paper aims to assist readers in optimizing their travel choices and enhancing their overall commuting experience.

Analyses and findings in this paper are structured into several sections: Section 2 – Data, Section 3 – Results, and Section 4 – Discussion. The Data section introduces the context of the datasets and examines all datasets and variables kept for analysis. The Result section

focuses on visualizing and presenting the data results in Data section. The Discussion section further evaluate the implications behind the data results presented in the previous section, expands the topic beyond pure data, and touches on any weaknesses and next steps.

2 Data

Where the data comes from - All data used for and throughout the paper are extracted from Open Data Toronto Portal (Sharla Gelfand 2022). TTC Bus Delay data (Commission 2024b), TTC Streetcar Delay (Commission 2024c), TTC Subway Delay (Toronto 2024) and TTC Subway Delay Codes (Toronto 2024) are retrieved to compare the delay magnitudes of different services. Data is cleaned and analyzed using the open source statistical programming language R (R Core Team 2022) and supporting packages tidyverse (Wickham et al. 2019), janitor (Firke 2023), dplyr (Wickham, François, et al. 2023), hms (Müller and Wickham 2021), ggplot2 (Wickham, Chang, et al. 2023), patchwork (Pedersen 2023), kableExtra (Zhu 2023), and knitr (Xie 2023).

For all delay datasets, only data in 2023 was chosen. There are three main reasons for this choice:

1. 2023 data is the most recent full-year data and offers the best reference for current (2024) delay patterns.

2. COVID-19 impacted TTC operating capacity and styles in other years close to 2024.

3. data from earlier years (before 2020) were structured very differently.

Therefore only 2023 delay data were chosen in this paper.

2.1 TTC Bus Delay

TTC bus delay data are collected and published by the Toronto Transit Commission (Commission 2024b), with latest update in September of 2024. A total of 7 attributes of the data are kept for further evaluation: *date of recorded delay, bus route, scheduled time of arrival, scheduled day of the week* (ex. Sunday, Monday, etc.)*, station, cause of delay,* and *total minutes delayed*. Additional data attributes, such as *vehicle number*, were excluded from the final dataset as they are less relevant to the focus of our analysis—weekday rush-hour delay patterns.

Please see Table 1 for an overview of the data.

Table 1: Sample of Cleaned TTC Bus Delay Dataset

Date	Line	Time	Day	Station	Cause of Delay	Min Delay
2023-01-01	91	02:30	Sunday	WOODBINE AND MORTIMER	Diversion	81
2023-01-01	69	02:34	Sunday	WARDEN STATION	Security	22
2023-01-01	35	03:06	Sunday	JANE STATION	Cleaning - Unsanitary	30

2.2 TTC Streetcar Delay

Streetcar delay data are also collected and published by the Toronto Transit Commission (Commission 2024b). Latest update of this dataset occurred in September of 2024. A total of 7 attributes of the data are kept for further evaluation: *date of recorded delay, streetcar line, scheduled time of arrival, scheduled day of the week* (ex. Sunday, Monday, etc.), *station, cause of delay,* and *total minutes delayed*. Additional data attributes, such as *time gap between current and next vehicle*, were excluded from the final dataset as they are less relevant to the focus of our analysis—weekday rush-hour delay patterns.

Table 2 contains an overview of streetcar delay data.

Table 2: Sample of Cleaned TTC Streetcar Delay Dataset

Date	Line	Time	Day	Station	Cause of Delay	Min Delay
2023-01-01	509	02:37	Sunday	QUEENS QUAY AND SPADIN	Operations	0
2023-01-01	505	02:40	Sunday	BROADVIEW AND GERRARD	Held By	15
2023-01-01	504	02:52	Sunday	KING AND BATHURST	Cleaning - Unsanitary	10

2.3 TTC Subway Delay

Publisher of data, update cycle (last updated date) Streetcar delay data are also collected and published by the Toronto Transit Commission (Commission 2024b). Latest update of this dataset occurred in September of 2024.

Table 3 contains an overview of subway delay data.

2.3.1 Delay Data

A total of 7 attributes of the data are kept from the 2023 subway delay data file for further evaluation: *date of recorded delay, scheduled time of arrival, scheduled day of the week* (ex. Sunday, Monday, etc.), *station, cause of delay, total minutes delayed,* and *subway line*. One potentially confusing aspect of the subway data is the *cause of delay* attribute, which is represented as codes in the dataset.

An additional dataset containing the code descriptions – subway delay code – was extracted and cleaned for reference. Please see Table 4 for a sample of subway incident codes.

Table 3: Sample of Cleaned TTC Subway Delay Dataset

Date	Time	Day	Station	Delay Code	Min Delayed	Line
2023-01-01	02:22	Sunday	MUSEUM STATION	MUPAA	3	YU
2023-01-01	02:30	Sunday	KIPLING STATION	MUIS	0	BD
2023-01-01	02:33	Sunday	WARDEN STATION	SUO	0	BD

2.3.2 Delay Code

The table below contains a cleaned dataset used to reference TTC subway delay causes. This delay code dataset contains two key attributes: *code*, and *code description*. Delay code data is used throughout this paper as an reference for the subway delay data discussed in the Section 2.3.1.

Table 4: Sample of TTC Subway Delay Code

Code	Code Description
EUAC	Air Conditioning
EUAL	Alternating Current
EUATC	ATC RC&S Equipment

3 Results

The results section provides a comprehensive analysis of TTC service delays in 2023, with a focus on identifying patterns and factors contributing to these delays across bus, streetcar, and subway services. We begin by examining which service experienced the highest total number of

delays, followed by an evaluation of delays specifically occurring on weekdays. Subsequently, we delve into delay patterns during rush hours to understand how peak travel times affect each service type. The section also explores the most common reasons for delays, highlighting issues unique to each service. Finally, we identify the routes most frequently affected by delays, offering insights into potential areas for targeted improvements. This multi-faceted analysis aims to provide a clearer picture of how delays impact TTC services and which areas may require attention for enhancing service reliability.

3.1 Highest Number of Total Delayed

Figure 1 shows that the TTC bus service experienced the highest number of total delays in 2023, with 56,207 delays recorded, followed by the subway service with 22,949 delays, and the streetcar service with 14,413 delays. However, it is important to note that while buses are the most frequently delayed service, the number of delays does not necessarily reflect the overall magnitude of delay experienced by passengers. The next section – Section 3.2 – will dive deeper into the average delay time experienced by passengers, specifically during rush-hours on weekdays.

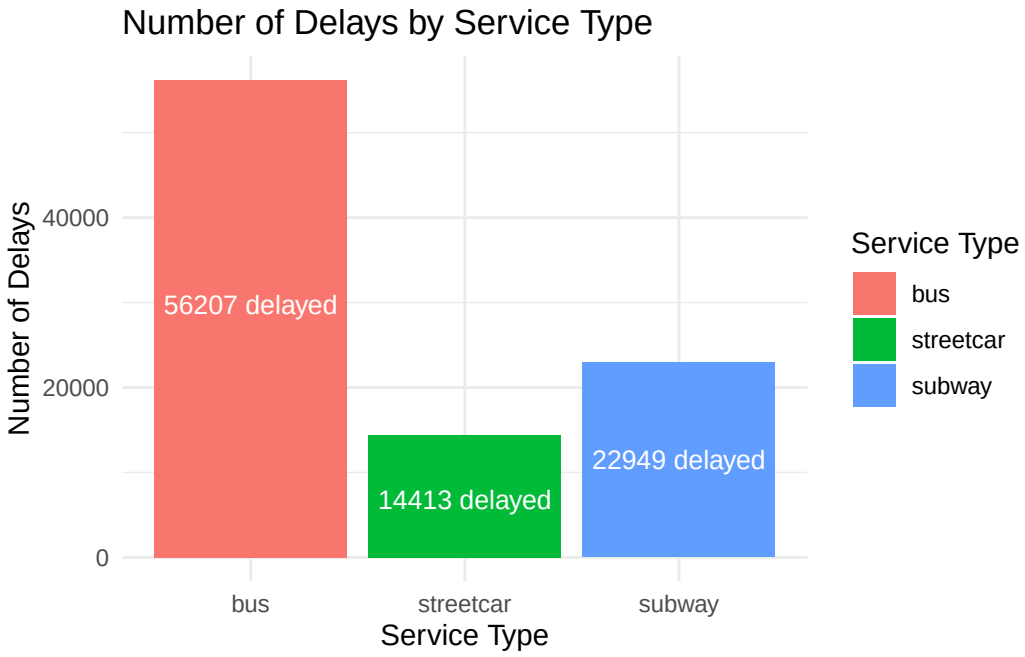

Figure 1: Visualization to show the TTC service that has the highest number of delays in year 2023

3.2 Most Delayed during Weekday

The figure below, Figure 2, reveals that the total weekday delay in hours was highest for buses, reaching approximately 18971.37 hours, followed by streetcars with 3736.2 hours, and finally, subways with 1136.32 hours. When examining the average delay per incident, buses experienced the longest average delay time at 20.3 minutes, streetcars averaged 15.6 minutes, and subways had the shortest average delay of just 3 minutes per incident. These two visualizations complement each other to indicate that TTC subway consistently exhibited the least delay on weekdays, making it the most reliable option for weekday travel.

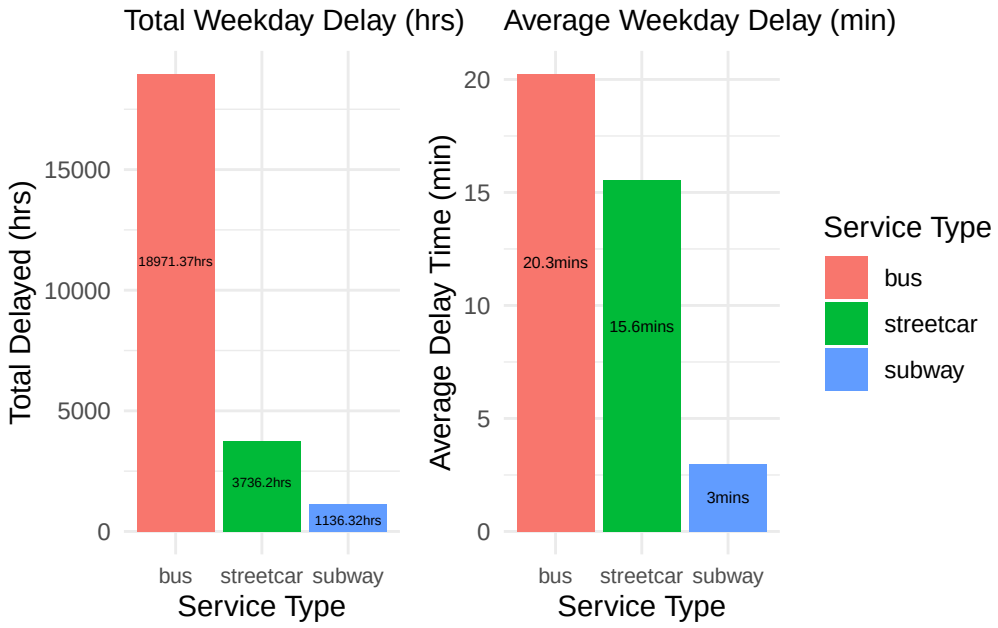

Figure 2: Visualization to show the total delayed time during weekdays in 2023

3.2.1 Most Delayed during Rush-Hours

Rush hour, as defined in this paper, refers to the periods from 7:00 AM to 9:00 AM in the morning and 4:00 PM to 7:00 PM in the evening. Figure 3 illustrates that during these periods, buses experienced the longest average delay times, with both the morning and evening rush periods showing an average delay of approximately 20.3 minutes. Streetcars followed, with an average delay of 15.6 minutes for both morning and evening rush hours, while subways had the shortest average delays, recording just 3 minutes in both periods. These results highlight that the subway consistently offers the most reliable service during rush-hour traffic compared to buses and streetcars.

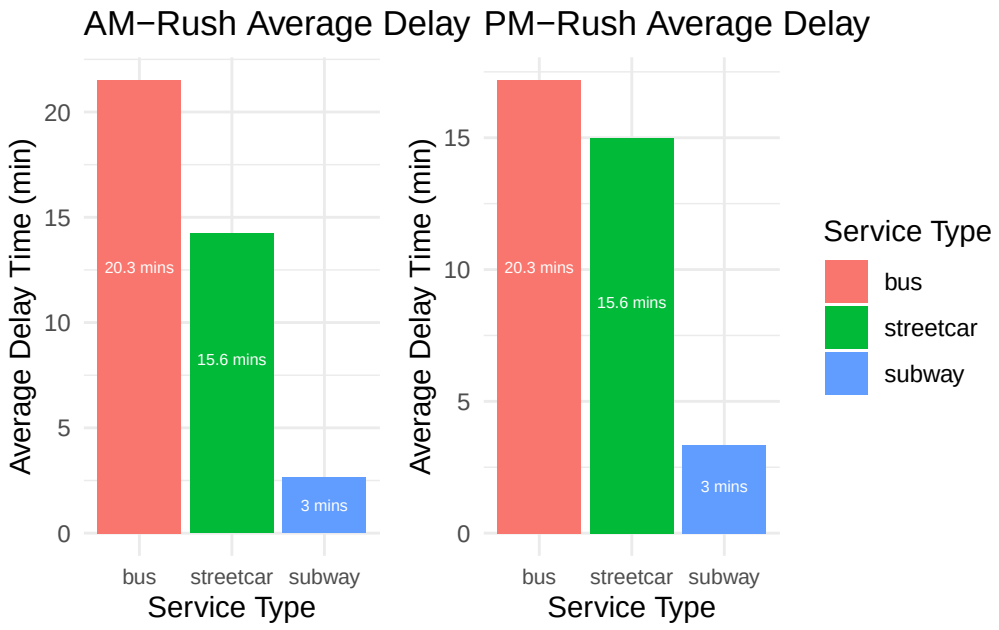

Figure 3: Barplot used to visualize the longest average delay time for different TTC services during Rush-Hours and Off-Peak Hours

3.3 Most Popular Delay Reasons

Table 5 presents the top 5 most frequent reasons for delays across the three TTC services. For buses, the most common causes included mechanical issues and security, while streetcars experienced delays primarily due to operations and mechanical problems. For subways, disorderly patrons and passenger assistance alarms were among the top delay causes. Understanding these reasons is essential for addressing service inefficiencies.

Table 5: Top 5 Most Popular Reason for Delay

Bus	Streetcar	Subway
Mechanical	Operations	Disorderly Patron
Operations - Operator	General Delay	Injured or ill Customer (In Station) - Transported
Security	Security	Passenger Other
Collision - TTC	Mechanical	Passenger Assistance Alarm Activated - No Trouble Found
Diversion	Diversion	Injured or ill Customer (In Station) - Medical Aid Refused

3.4 Most Popular Delayed Lines

Table 6 highlights the lines most prone to delays for each TTC service. The bus route 121, the streetcar line 506, and subway Line 3 (SRT line) were identified as the most frequently delayed routes. These insights indicate potential areas for service improvement, especially during peak travel times.

Table 6: Most delayed Lines for each TTC Service

bus	streetcar	subway
121	506	Line 3

4 Discussion

4.1 TTC Service Prices

All TTC services, whether you're taking a bus, streetcar, or subway, operate under a one-fare system, meaning the financial cost of using any TTC service is identical. This pricing structure simplifies travel across the Greater Toronto Area (GTA), as passengers don't need to worry about different costs when switching between services. The one-fare policy makes it easier for commuters to choose the most convenient transportation option without concern for cost differences, promoting greater accessibility and flexibility for daily travel across the city.

4.2 Importance of TTC Services

TTC services play a vital role in helping individuals navigate the GTA, providing an essential mode of transportation for millions of residents and visitors. According to the TTC's official website (Commission 2024a), these services have transported over 31 billion customers since their initial construction, highlighting the system's critical role in supporting Toronto's urban mobility. Despite the impact of the COVID-19 pandemic, the TTC has steadily regained ridership levels, currently operating at around 70% of its pre-pandemic capacity on weekdays and 75% to 90% on weekends. This re-bounce highlights the TTC's importance in serving the city's transportation needs, even as it continues to adjust to challenges after the pandemic.

4.3 TTC Service Amenities

One of the unique amenities of TTC services, particularly for subway passengers, is their integration with The PATH —- a vast underground pedestrian network that connects many

downtown subway stations with offices and buildings in Toronto's financial district. For commuters who work in buildings linked to The PATH, using subways or streetcars with direct PATH connections can provide a more convenient and sheltered travel experience, especially during extreme weather. Additionally, The PATH offers air conditioning during the summer and heating in the winter, ensuring a comfortable environment for passengers, making it a favorable choice over buses that lack such amenities. This integration highlights the advantages of certain TTC services, particularly for those commuting to downtown workplaces.

4.4 Errors in analysis, Limitations and Next Steps

The analysis presented in this paper is subject to certain limitations. Firstly, only data from 2023 was included, which may not provide a complete representation of TTC service performance over time. Including data from multiple years would offer a more comprehensive and fair evaluation of trends and patterns. Secondly, the study was unable to distinguish between on-time rates for different districts within Toronto, which limits the understanding of how delays vary across the different districts. As a next step, expanding the scope of the analysis to explore GO services, such as GO Trains, would provide a broader perspective on regional transit and allow for a comparison of how different transportation systems operate within and beyond the city.

5 Conclusion

This paper has analyzed the delay patterns of TTC bus, streetcar, and subway services in 2023, revealing significant insights into their performance during weekday and rush-hour periods. The findings demonstrate that TTC buses experienced the highest number of delays, whereas subways consistently offered the least delay in terms of both total hours and average delay time. These results underscore the reliability of the subway as the most time-efficient option for commuters, especially during weekday rush hours. Understanding these patterns is essential for making informed transportation choices, and future research could further expand this analysis by incorporating multiple years of data and exploring other regional transit services such as GO Trains. This evaluation of TTC services will contribute to improving urban mobility and ensuring that Toronto's public transportation system remains effective and reliable for all commuters.

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