Understanding the Effect of COVID-19 on Fuel Consumption of Public Transportation: The Case Study of Chattanooga, TN

Le Tuan Phan, Thanh-Nam Doan, Mina Sartipi
Center for Urban Informatics and Progress
University of Tennessee at Chattanooga
bbz181@mocs.utc.edu, thanh-nam-doan@utc.edu, mina-sartipi@utc.edu

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***Abstract*—The COVID-19 pandemic has caused a drastic change in traffic in the U.S and throughout the world. With the drop in traffic volume, the fuel consumption used for traveling should decline. This study focuses on the changes in fuel consumption of public transportation before and during the pandemic. The fuel consumption volumes of diesel bus fleet in Chattanooga were analyzed to identify the changes between the two periods. Our study provides preparation for future disasters.**

I. Introduction

Coronavirus disease 2019 (COVID-19) was declared as a global pandemic by World Health Organization on March 11^{th}, 2020. As of November 11^{th}, 2020, there were 51,636,989 confirmed cases and 1,275,124 persons reported as the number of deaths [1]. This virus has affected our jobs, health, social lives, and how we travel and commute. There has been more than a 40% reduction in highway traffic in Tennessee at the end of March 2020 compared to the same month in the previous year [2]. In Florida, traffic volumes by March 22^{th}, 2020, dropped by 47.5% of the volume that it was at the same point in 2019 [3]. Social distancing is another factor that can affect public transportation riders since it is a requirement on each bus.

Given the changes in people's usage of public transportation, we would like to study this affect of the pandemic to bus fuel consumption before and during COVID-19. This knowledge will help us understand the impact of the pandemic on public transportation and also prepare for any disasters in future. Moreover, we provide an insightful picture for transportation agencies to optimize the public transportation of mid-sized cities such as Chattanooga, Tennessee.

Our objective is to compare the fuel consumption, the distance traveled and the number of buses, especially diesel ones, before and during the COVID-19 pandemic. We will check if the fuel consumption of buses during the pandemic are less then before the pandemic because people were less likely to use public transportation for their daily commute.

II. Experiment

A. Dataset

We collect data from sensor devices deployed on all buses in Chattanooga, Tennessee. The API is provided by the bus management agency of the city i.e. Chattanooga Area Regional Transportation Authority (CARTA). The data is collected every five seconds and we focus on the fields: bus id, location, fuel consumption and timestamp.

TABLE I
Statistics of the Dataset Between Before and During COVID-19

	Before	During
Total Fuel Consumption (Gallons)	14745.85	13575.33
Total Distance Traveled (Miles)	73286.63	69749.38
# Unique Buses	27	30

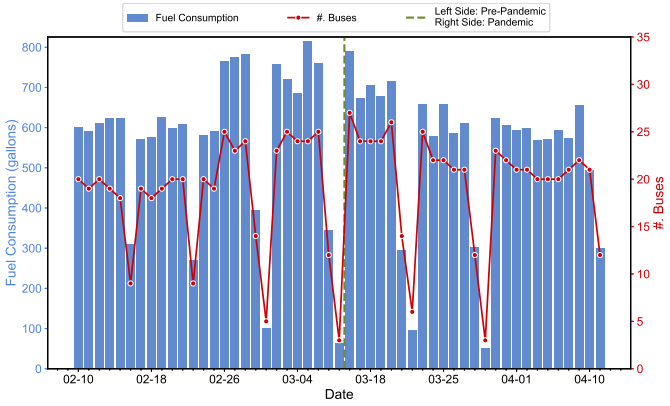

Fig. 1. Total Fuel Consumption and Number of Buses In Service Per Day

Our collected data spans from February 7^{th}, 2020 to April 11^{th}, 2020 which corresponds to two months. In this dataset, we use March 8^{th} 2020 as a separator for the two periods: before and during pandemic. February 16^{th}, February 23^{rd}, April 4^{th}, and April 5^{th} were excluded because we didn't have the information for these days. Table I shows some detailed statistics of our dataset.

B. Analysis

Since our interest is the fuel consumption of the buses when they were in service, we refined our data to exclude all the data points from the buses that were not operating. The longest valid sequence contains 7077 data points. We then investigated the total and average fuel consumption, the number of buses in service, and distance traveled per day and per weekday for each period. From the summary, it shows that accumulated fuel consumption before COVID-19 is approximately 8.7% higher than during the pandemic.

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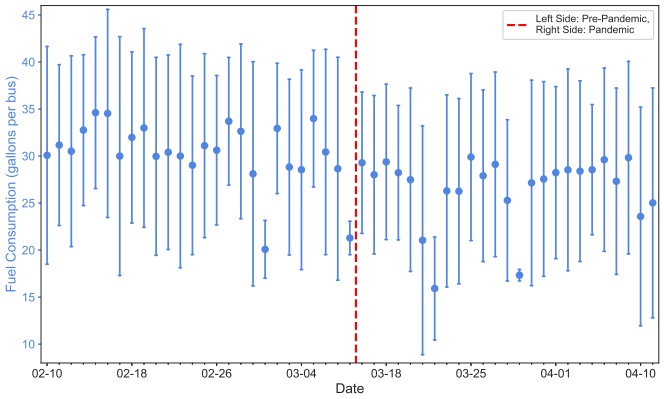

Fig. 2. Average Fuel Consumption Per Day

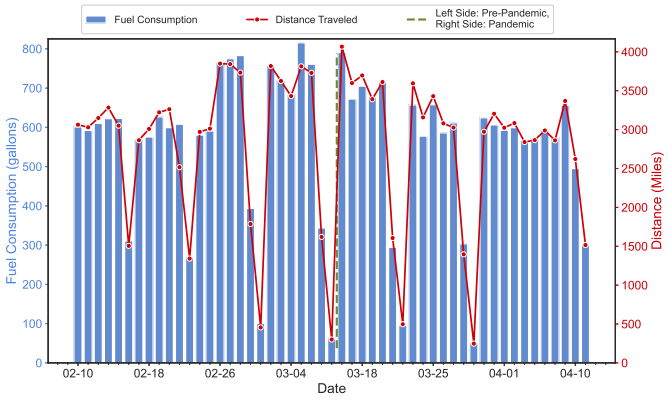

Fig. 3. Total Fuel Consumption and Distance Traveled Per Day

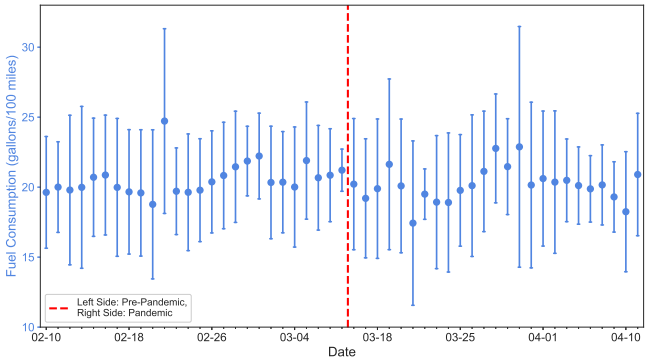

Fig. 4. Fuel Consumption Per 100 miles Per Day

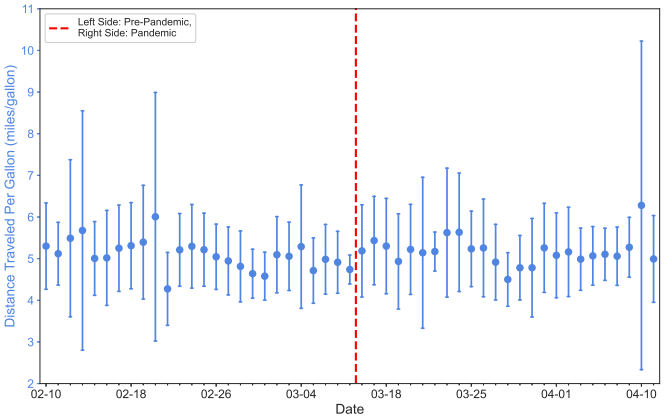

Fig. 5. Distance Traveled Per Gallon Per Day

To understand how fuel consumption was reduced during the pandemic, the total fuel consumption and the total number of unique buses were calculated for each day. Figure 1 shows the total fuel consumption per day and the number of buses in service per day for each period. From the figure, we observed that at the beginning of the COVID-19 pandemic, the fuel consumption was similar to the week before, but it declined for the later weeks.

Since the number of buses in service was different every day, we would like to know, on average, how much fuel a bus consumed every day for both periods. Figure 2 displays the average fuel consumption per day and the number of buses in service per day for each period. From the figure, we observe that the average fuel consumption of buses during the pandemic was less than before the pandemic. This is understandable due to the fact that the number of buses in service each day before the pandemic was less than during the pandemic (see Figure 1).

In addition to the fuel amount the buses consumed, we studied the fuel efficiency for each day. Figure 3 shows the total fuel consumption and the total distance driven of all buses in service per day for each period. From the figure, it was observed that the fuel consumption and the distance traveled for later weeks during pandemic were less than at the beginning of the pandemic.

Figure 4 displays the fuel consumption per 100 miles every day for each period while Figure 5 presents the distance traveled per gallon for each day. On average, the fuel consumption per 100 miles and the distance traveled per mile were 20.30 gallons per 100 miles and 4.94 miles per gallon respectively before the pandemic, while they were 19.57 gallons per 100 miles and 5.12 miles per gallon during the pandemic. This implied that there was probably less traffic during the pandemic than before, because fuel cost less for 100 miles before the pandemic[1].

During our observation with the fuel consumption per day, we noticed that the fuel consumption varies by weekday. Thus, we investigated the fuel consumption per weekday to identify the difference between the two periods. Figure 6 plots the total fuel consumption per weekday for each period. Figure 7 presents the average fuel consumption per weekday for each period. From these figures, With the exception of Monday that the fuel consumption during COVID-19 was approximately 5.35% higher than before the pandemic, all other weekdays showed less fuel consumption during the pandemic. Moreover, the average fuel consumption per vehicle per weekday during COVID-19 was less than the period before with the highest of 21.56% less on Saturday and the lowest of 6.39% less on Wednesday (Figure 8).

To understand how efficient the fuel was consumed per weekday for both periods, we investigated the distance travel along with the fuel consumption on weekdays. Figure 9 and Figure 10 indicate that the distance all the buses traveled for most of the weekday before the pandemic was higher than

[1]https://medium.com/center-for-urban-informatics-and-progress/covid-19s-impact-on-roadway-traffic-and-accidents-3-quick-takeaways-a15e10ad036

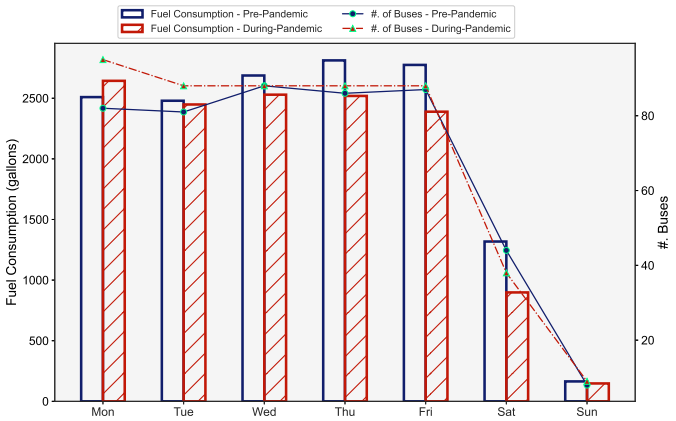

Fig. 6. Total Fuel Consumption Per Weekday

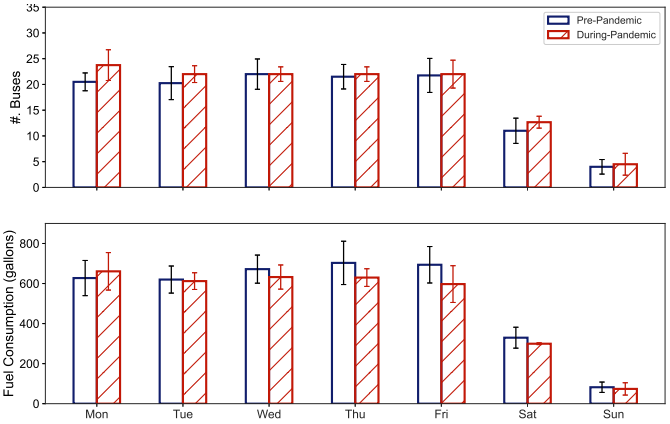

Fig. 7. Average Fuel Consumption and #. Buses Per Weekday

during the pandemic. This affirms our findings for the fuel consumption. Figure 11 illustrates fuel consumption per mile and distance traveled per gallon. Similar to the fuel efficiency per day, more fuel was consumed to travel 100 miles per week day before the pandemic than during COVID-19.

III. Conclusion

Even though there was additional buses in service during COVID-19, the fuel consumption during the pandemic was lower than before the pandemic. Social distancing and traffic reduction were likely the cause to the reduction in fuel consumption since less people went out and used the services. We can extend our work by including some external features such as temperature, road topology, and driver characteristics to further understand the impact of COVID-19.

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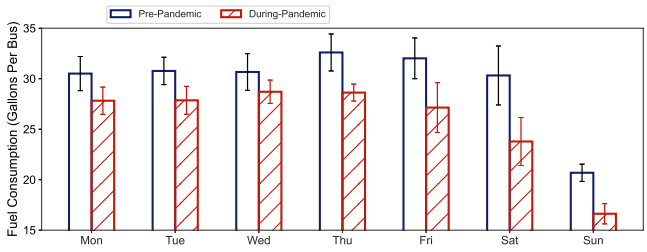

Fig. 8. Fuel Consumption Per Bus Per Weekday

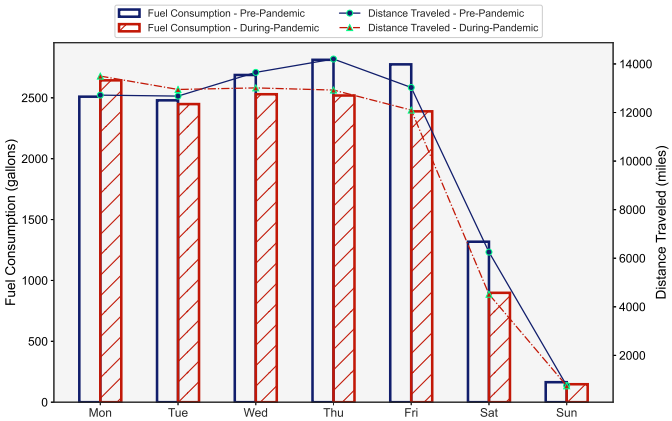

Fig. 9. Total Fuel Consumption and Distance Traveled Per Weekday

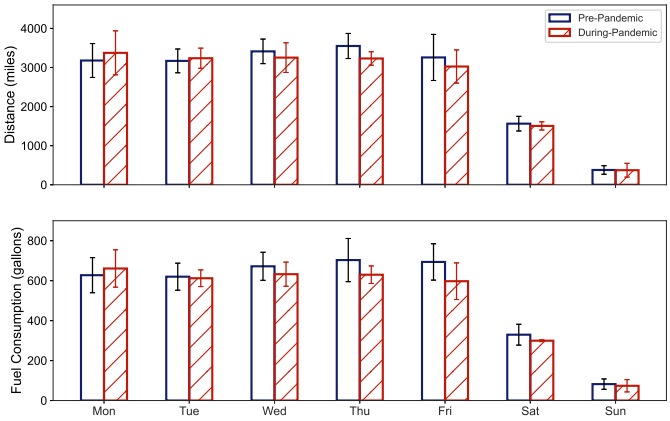

Fig. 10. Average Fuel Consumption and Distance Traveled Per Weekday

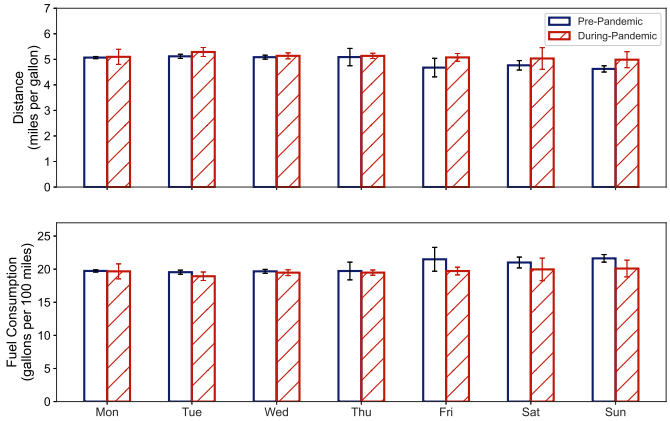

Fig. 11. Fuel Efficiency Per Weekday