

# The MBTA underground trains case



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## Executive summary

The MBTA faces a customer demand that is subject to seasonal trends and uncertainty.

We developed a **robust** optimization framework to model the number of trains to run where we could also model decisions under a limited fleet.

## Problem Statement

- **Minimize the cost** of running trains and the cost of unmet demand, while ensuring that the unmet demand and the capacity of the trains are greater or equal than the demand of customers, and there is a **balance in the train flow**.
- Model the total number of trains to be less than a certain value, to **explore solutions under a limited fleet**.
- Model uncertainty in the demand using a **polyhedral uncertainty set**.
- Run different models for different lines

## Why do we care?

This project has potential to impact both the MBTA, by achieving **reduced costs**, and its riders, who will have a **better train schedule** at their favorite station.

## The data

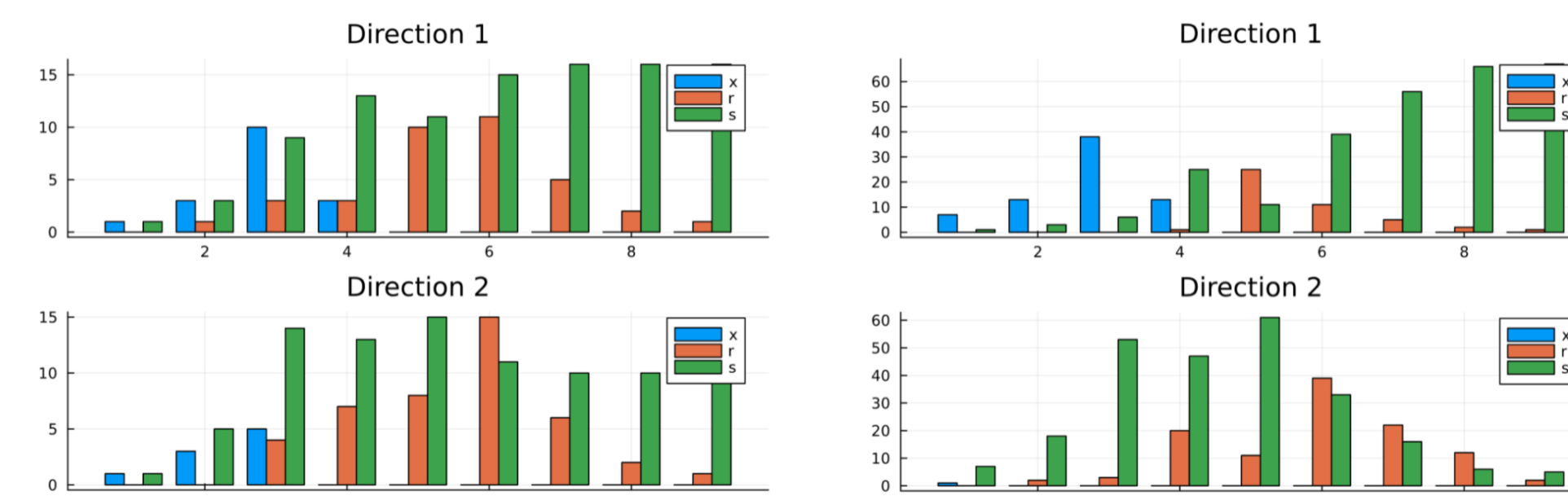
We used data reporting the **Average Flow** per station in the 2019 Fall season.

$$Avg\ Flow_{i,t,l} = \begin{cases} Avg\ On_{i,t,l} - Avg\ Off_{i,t,l} + Avg\ Flow_{i-1,t,l} & \text{if } i \neq 0 \\ Avg\ On_{0,t,l} & \text{if } i = 0 \end{cases}$$

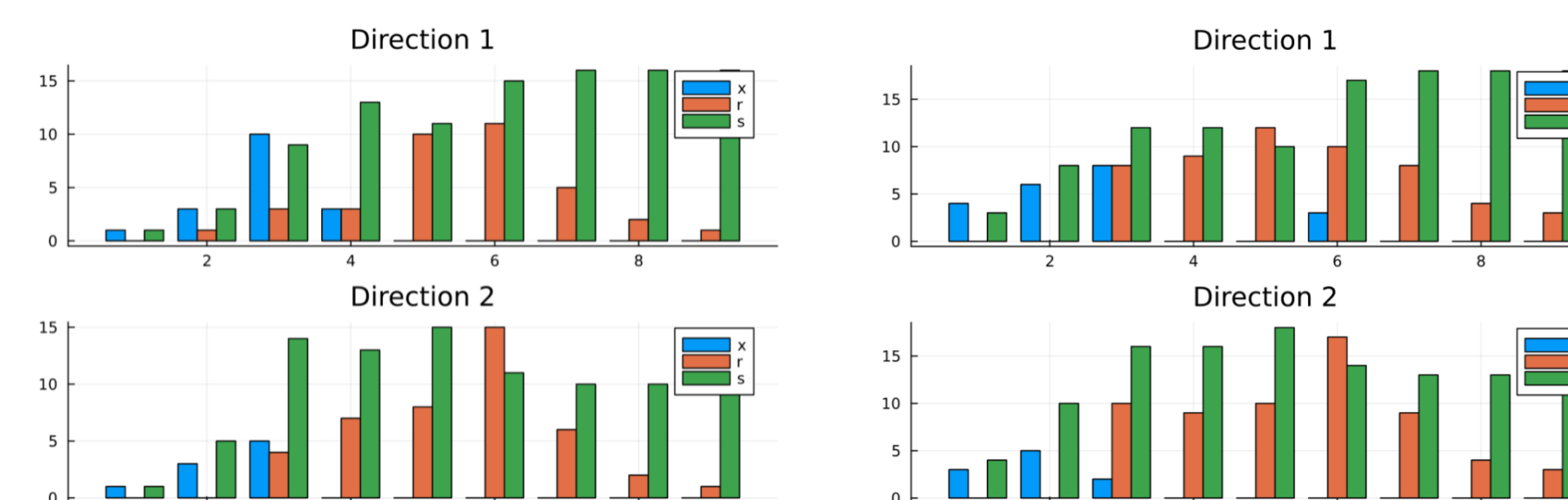
Cost and capacities of trains for each line were found online.

## Key findings

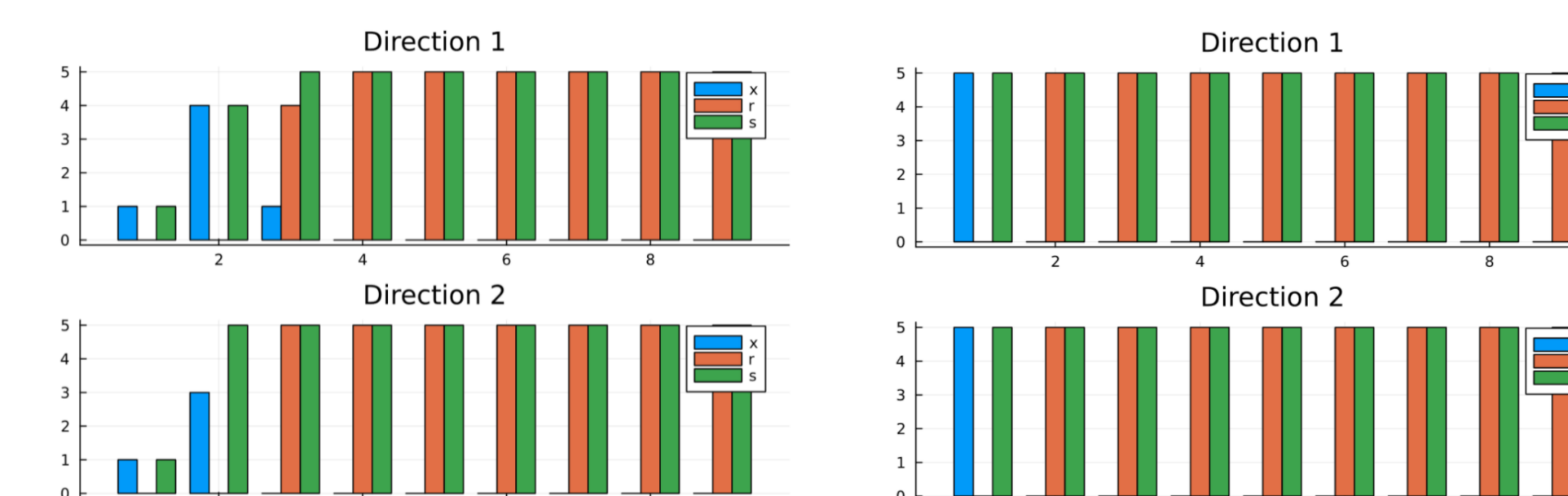
### Symmetrical vs Asymmetrical



### Deterministic vs Robust

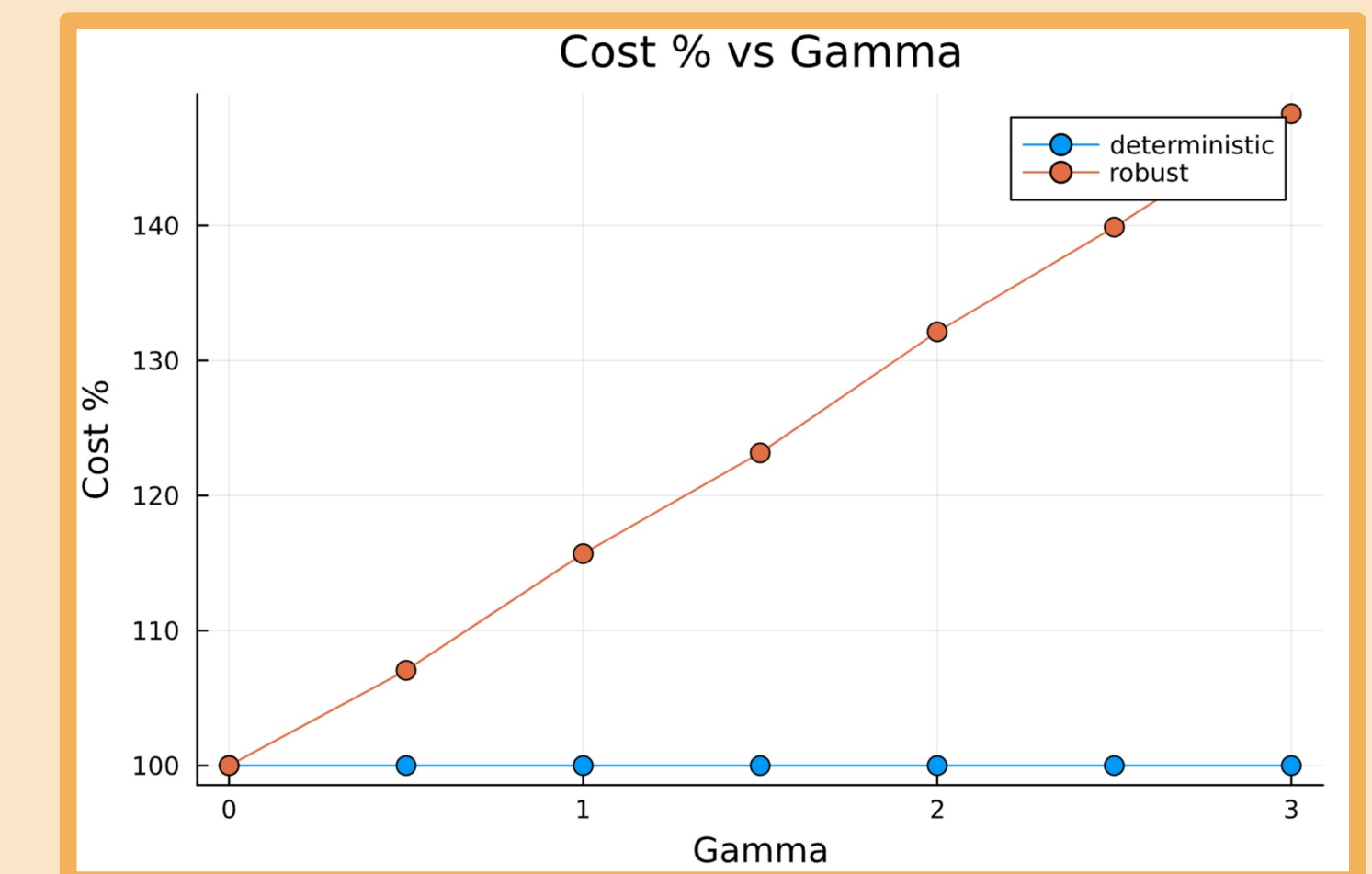


### Models under limited fleet



## What is the impact?

1. Optimize the model in order to **reduce MBTA running costs**
2. Modelling uncertainty according to a **conservative robust framework** in a way that favors the customers



3. Understand **where to run trains** in the case of limited fleet when the MBTA needs to best decide how to allocate their trains across different sublines or which trains to rest versus keep in depot

## What would we do with an extra week?

- Implement a new variable to model the number of trains in the depot
- Brainstorm how to model a train's ability to travel in more than one direction during a given time period