CEE 504: California High Speed Rail Economic Analysis – Term Project

I have neither given nor received unauthorized aid on this assignment, nor have I concealed any violations of the Honor Code.

Mariana I. Fernández Correa

ABSTRACT

This report examines the economic implications of the California High-Speed Rail (CHSR) project. The planned rail system will connect San Francisco to Anaheim, with this analysis focusing on the 171-mile Central Valley segment between Merced, Fresno, and Bakersfield. The report uses published sensitivity analyses and evaluates the impact of construction delays, first documented in 2018, which shifted the expected completion date from 2022 to the 2030s. Current projections estimate that the project will be completed between 2030 and 2033 at a capital cost of approximately $36 billion. This analysis outlines the cost-benefit ratio (2.38), the total cost under a 2050 planning horizon ($63 billion), and an anticipated capital cost increase to $45 billion by project completion. Additionally, a sensitivity analysis is conducted to explore the consequences of the existing $7 billion funding shortfall and potential mitigation strategies.

TABLE OF CONTENTS

INTRODUCTION

The high-speed rail systems around the world have expanded and defined exemplary public transportation infrastructure. Some of the most prominent routes today are the Chinese Rail Transit (CRT) routes; these have revolutionized high-speed rail by setting a mass-scale example, totaling over 25,000 miles (Visual Capitalist, 2025) . In Europe, Trenitalia and RENFE's AVE in Spain provide users with efficient, affordable, and fast transportation across the country, and these services are often connected to the broader, interoperable, multinational high-speed rail network in Western Europe through Eurail (RENFE & AVE; Trenitalia; European Commission, 2025). This Eurail network links major cities across France, Germany, the Netherlands, Belgium, and beyond, enabling seamless cross-border mobility (Eurail, 2025). Alongside Morocco's Al Boraq line, every continent except the Americas and Oceania lacks high-speed rail systems (Al Boraq, n.d.). However, existing high-speed rail demonstrates the transformative potential of linking major towns and lowering carbon emissions.

The US has lagged in developing extensive public transportation infrastructure. However, the California High-Speed Rail (CHSR) is America's first large-scale project aiming to connect major cities (California High-Speed Rail Authority, 2024; U.S. Government Accountability Office, 2013). It's a fully electrified rail network that, once both phases are completed, will span over 800 miles (California High-Speed Rail Authority, 2022; California High-Speed Rail Authority, 2024). The project was approved in 2008, and construction began in January 2015 (California High-Speed Rail Authority, 2020; U.S. Government Accountability Office, 2013). The project focuses on the Initial Operating System (IOS) between Merced, Fresno, and Bakersfield (California High-Speed Rail Authority, 2024; California High-Speed Rail Authority, 2025). This report focuses on the financial balances of the IOS. A map of the different segments is listed in Figure 1.

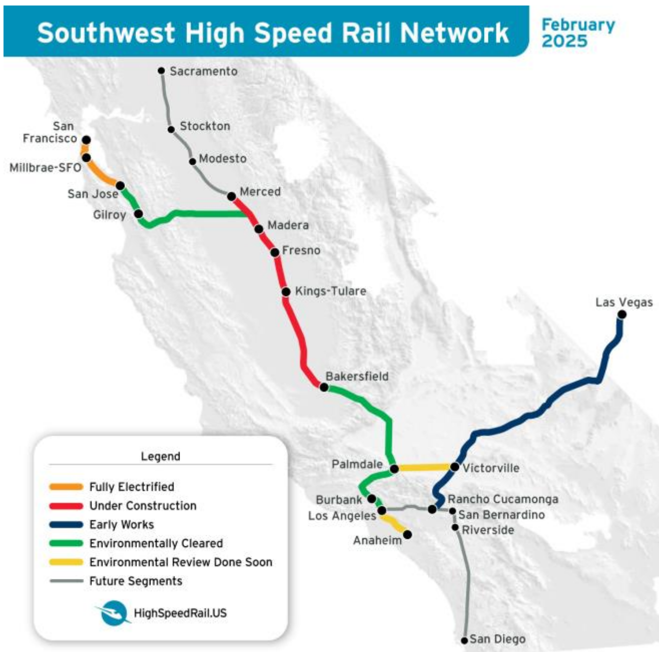


Figure 1: Current design status for each of the rail segments of phase 1. Initial Operating Segment (IOS) is the section "under construction" (California High-Speed Rail Authority, 2025).

BACKGROUND

The CHSR has some obvious benefits, the first being reduced travel time across California. The reduction of travel time is seen in Figure 2.

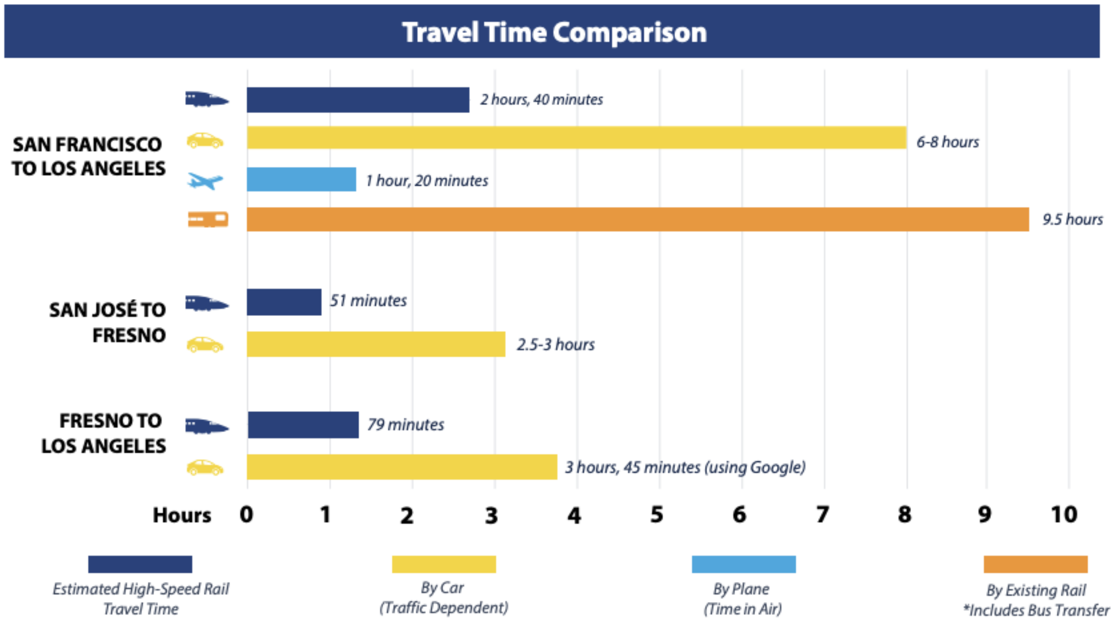


Figure 2: Expected travel times by car, current rail, air, and the proposed High-Speed Rail. Source (California High Speed Rail, 2024)

Apart from commute times, there are numerous economic benefits associated with the construction and implementation of the overall CHSR components. Seen in Figure 3.

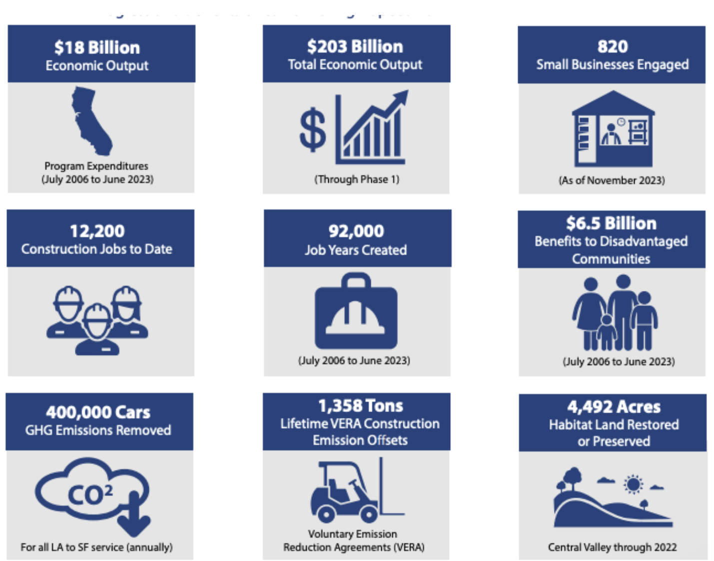


Figure 3: Other benefits of the CHSR. Source (California High Speed Rail, 2024)

This project focuses on the first stretch of the CSHR, the Initial Operating System (IOS). The construction cost for the Initial Operating System (IOS) varies and tends to increase with each revision of the construction plan. The supplemental report estimates the project's cost to be between $30 billion and $35 billion (California High-Speed Rail Authority, 2025). While the details of funding for the IOS will be elaborated upon in the financial overviews, it has been confirmed that $28 billion in funding has already been secured. However, a $7 billion funding deficit remains for the IOS. (California High-Speed Rail Authority, 2024; California High-Speed Rail Authority, 2025)

To recover the cost of capital, fare revenue is structured by passenger count and miles traveled. The discount rate for this project has been established at 7% real discount rate (California High-Speed Rail Authority, 2014). The planning horizon is set to 2050 at the latest, allowing for a planning period of 25 to 30 years following the completion of the IOS. In my economic analysis, I will utilize a 30-year planning horizon. Inflation from 2011 to 2025 has averaged 2.65% (U.S. Inflation Calculator, 2025), and I will assume it remains constant until 2050.

When the high-speed rail project was initiated, the Central Valley, used interchangeably in this report with the IOS starter segment, was projected to cost approximately $ 6 billion in Year of Expenditure Dollars (YOE$). As the segment matured into the whole 171-mile Initial Operating Segment between Merced and Bakersfield, updated engineering designs, expanded civil works, right-of-way acquisition, and inflation increased the estimated cost to approximately $36 billion in the 2024–2025 planning documents. (California High-Speed Rail Authority, 2024; California High-Speed Rail Authority, 2025)

FINANCIAL OVERVIEW

Cost Creep:

As hinted before, the cost estimates of the IOS have increased drastically as the project becomes more defined. The IOS has been formally described in more recent reports; however, the general route from Merced – Bakersfield has been the initial functional segment of the IOS. Table 1 contains these estimates, all in YOE$, making them directly comparable.

Table 1: Cost Estimates for selected revisions of the CHSR

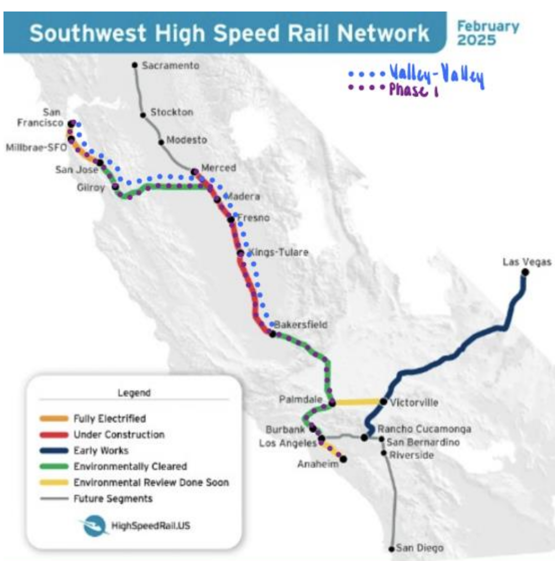
Year	Number	Source	Expected Initial Service
2011	"The combined funding of $6.0 billion represents the full amount of funding the Authority believes is needed to complete the Initial Construction Section."	(California High-Speed Rail Authority, 2011)	2022
2020	"The additional construction and development costs for Interim Service as described in the 2019 Project Update Report would require the Board to increase the program budget by an estimated cost of $4.8 billion, bringing the total program budget to an estimated $20.4 billion."	(California High-Speed Rail Authority, 2020)	2030
2025	"The Merced - Bakersfield scenario, as shown in Exhibit 1.0, is now estimated to cost $36.75 billion."	(California High-Speed Rail Authority, 2025)	2033

These three numbers will be used to generate a possible estimate of future cost creep. The IOS is expected to be complete and operational by 2030.

Rider Revenue analysis – Source: California High-Speed Rail Authority, 2024 - Rider Revenue analysis

The 2024 rider revenue analysis is based on demographic and socioeconomic numbers from 2018. This report has two case studies: "Phase 1" and "Valley to Valley." These two vary in length and scope. The one that most closely resembles the IOS, which is the focus of this study, is the Valley to Valley study. References to both routes are in Figure 4.

Figure 4: Valley to Valley and Phase 1 comparison showcasing the scope differences. Source: (California High-Speed Rail Authority, 2025)



This report contains a comprehensive analysis using sensitivity analysis. It accounts for different transportation modes (bus, rideshare, personal vehicle, airplane, and taxi), as well as variable vs.

fixed pricing options based on mileage, rush times, and trip frequency. This is the most reputable source of ridership revenue currently available. To summarize their results for the Valley-to-Valley section, I will refer to table 2.

Table 2: Reference Ridership Revenue Values, in Millions. Source: (California High-Speed Rail Authority, 2024 - Rider Revenue analysis)

Year	Ridership	Revenue (YOE$)	Passenger Miles Traveled	Passenger Hours Traveled
2030	11.80	$960.40	1530.77	15.28
2040	12.22	$1206.43	1569.01	15.70
2050	12.54	$1501.42	1594.06	15.98

Operations and Maintenance cost – Source: California High Speed Rail. 2024 Business Plan

The 2024 business plan has updated numbers and estimates, categorized as "high", "medium", and "low", for Operation and Maintenance costs. In this report, I will use the "medium" costs as an average. Numbers shown in Table 3.

Table 3: Operation and Maintenance costs YOE$ in Millions. Source (California High Speed Rail, 2024 - Business Plan)

O&M Cost Levels/Year	2030	2040	2050
High	789	965	1179
Medium	721	882	1077

Low	693	848	1036

These Operation and Maintenance (OM) values treat the valley-to-valley segment as an isolated system. However, the Valley-to-Valley system is part of the much broader first phase. Because construction will still be ongoing, partial service will continue, and a transition to the larger phase 1 system will be underway; these operational numbers are likely to be much higher in the first few years to account for an incomplete yet functional system. The higher operating cost is shown in Table 4. Because I focus on the IOS segment, a subset of Phase 1, I will *not* include these in my calculations.

Table 4: Comparison Chart highlighting increased Maintenance cost for years 1-5. Source (California High Speed Rail, 2024 - Business Plan)

Table 5.5: Net Operating Cash Flow Valley to Valley Through Phase 1 High Case (YOE $ in Millions)

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Total Revenue	1,119	1,145	3,399	3,475	3,554
Less: O&M	(805)	(821)	(1,718)	(1,754)	(1,790)
Net Cash Flow from Operations	314	324	1,680	1,722	1,764

Table 5.5.1: Net Operating Cash Flow Valley to Valley Through Phase 1 Medium Case (YOE $ in Millions)

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Total Revenue	1,016	1,039	3,114	3,184	3,257
Less: O&M	(735)	(750)	(1,571)	(1,603)	(1,636)
Net Cash Flow from Operations	280	289	1,543	1,581	1,621

Table 5.5.2: Net Operating Cash Flow Valley to Valley Through Phase 1 Low Case (YOE $ in Millions)

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Total Revenue	775	793	2,274	2,325	2,378
Less: O&M	(707)	(722)	(1,512)	(1,543)	(1,574)
Net Cash Flow from Operations	68	71	763	783	803

Existing breakeven numbers. Source (California High Speed Rail, 2024 - Business Plan)

The 2024 business plan has updated breakeven year estimates. They measure it as their confidence in breaking even in 2040, which highlights the uncertainty surrounding any construction estimate. This report clearly shows that these numbers represent a probability band, not single values. Table 5 shows this probability in the breakeven future year (YOE$).

Table 5: Valley-to-Valley Breakeven Future Year (YOE $ Millions)

Probability Distribution	Net Operating Cash Flow
10%	(71)
25%	46
Median	204
75%	386
90%	580

A note regarding the Valley to Valley vs. the Initial Operation Segment (IOS)

The Valley-to-Valley service concept depends on, but is not limited to, the Initial Operating Segment (IOS). Valley-to-Valley does not have separate construction cost estimates because it is a ridership and service pattern framework rather than a standalone capital project; parts of the Valley-to-Valley travel market extend beyond the IOS and rely on existing infrastructure. As a result, this analysis uses IOS capital cost estimates, which cover the expense of building the physical rail infrastructure in the Central Valley. Meanwhile, ridership, operations, maintenance, and revenue assumptions are based on the Valley-to-Valley simulation results. In this context, the IOS functions as a metric for construction and capital costs, while Valley-to-Valley serves as a measure of travel demand and operational performance.

Benefits Report. Source: (California High Speed Rail, 2014)

The benefits report, created in 2014, includes an in-depth analysis of the economic benefits, such as reduced emissions and savings from medical and property damage resulting from vehicle crashes, as well as the disbenefits, such as the loss of wetlands, loss of agricultural land, and noise from the CHSR. The benefit and cost breakdowns are in Tables 6 and 7.

Table 6: Benefits, disbenefits and costs. Source: (California High Speed Rail, 2014)

Table 20. Summary of Benefits and Costs, IOS

Category	Discounted 2013 $
Benefits	
Roads and Highways	
Highway User Travel Time Savings	$8,890,488,343
Highway User Fuel Savings	$1,806,363,849
Highway User Non-fuel O&M Savings	$1,683,534,333
Oil Import Savings	$251,017,469
Reduction in Pavement Damages	$38,437,731
Highway CO2 Emissions Savings	$101,841.510
Highway Non CO2 Emissions Savings	$16,737,921
Noise Savings	$44,730,617
Road Fatality Reductions	$1,766,779,006
Road Injury Reductions	$1,791,513,912
Vehicle Property Damage Reductions	$665,039
HSR Mode Shift	
Travel Time Savings for Auto Transfers to HSR	$19,393,903,111
Transfers to HSR Fuel Savings	$1,508,725,285
Transfers to HSR Non-Fuel O&M Savings	$1,812,200,574
HSR Mode Shift reliability benefits	$3,116,402,253
Productivity Increases from Auto Transfers to HSR	$3,880,315,648
Reductions in Parking Infrastructure Needs	$106,023,279
Aviation	
Productivity Increases from Air Transfers to HSR	$277,261,453
Operator Savings from Delay Reductions (non-fuel)	$19,161,724
Fuel Savings, aviation	$134,623,132
Air System Savings from Propagated Delay	$9,580,862
Air Passenger Travel Time Savings/Delay Reduction	$19,638,923
Aviation CO2 Reductions	$16,694,999
Aviation Non-CO2 Emissions Reductions	$6,979,133
Other Externalities	
CO2 Reductions from Tree Program	$1,902,004
Construction Emissions Disbenefit	-$29.768,877
Train CO2 Emissions	-$8,405,607
Value of Lost Wetlands	-$22,281,282
Agricultural Productivity Loss	-$72,996,794
Train Noise Disbenefit	-$13,840,642
Total Benefits	**$46,548,228,907**
Costs	
Capital Costs	$17,832,842,345
Life Cycle Costs	$317,467,407
O&M Costs	$2,713,361,526
ROW Residual Value Offset	-$31,356,982
Subtotal Costs before ROW Offset	*$20,863,671,278*
Grand Total Discounted Costs	**$20,832,314,296**

In addition, they have provided a Benefits/Cost (B/C) ratio as their concluding thought. In the analysis, I will replicate that to ensure completeness. Based on this report, I have adopted a 7% discount rate.

Table 7: The B/C ratio indicates that projects are favorable based on benefits. Source: (California High Speed Rail, 2014)

8.1 Results in Brief

All scenarios presume a 7 percent discount rate. The results for each scenario are outlined in Table 19, and presume the completion of each step and the ones preceding it:

Table 19. Benefit Cost Analysis Summary Results

Scenario	Net Present Value (NPV, 2013 $)	Economic Rate of Return (ERR)	Benefit Cost Ratio (B/C)
IOS	$25,715,914,611	12.2%	2.23
Bay to Basin	$38,223,901,450	12.6%	2.35
Phase 1 Blended	$45,902,781,948	12.5%	2.33

ANALYSIS

Estimating the real total capital cost of the Project – Analysis 1

As hinted in Table 1, the capital cost of the IOS is likely to increase as the project nears completion (another deadline that has been extended), now expected to be 2033. Still, for this report, we will use 2030. Figure 5 shows the total cost of the IOS at about 45 (YOE$) billion by the expected completion of the project. A logarithmic prediction was used because the cost estimates are expected to plateau as the construction nears its end and estimates become more certain and accurate.

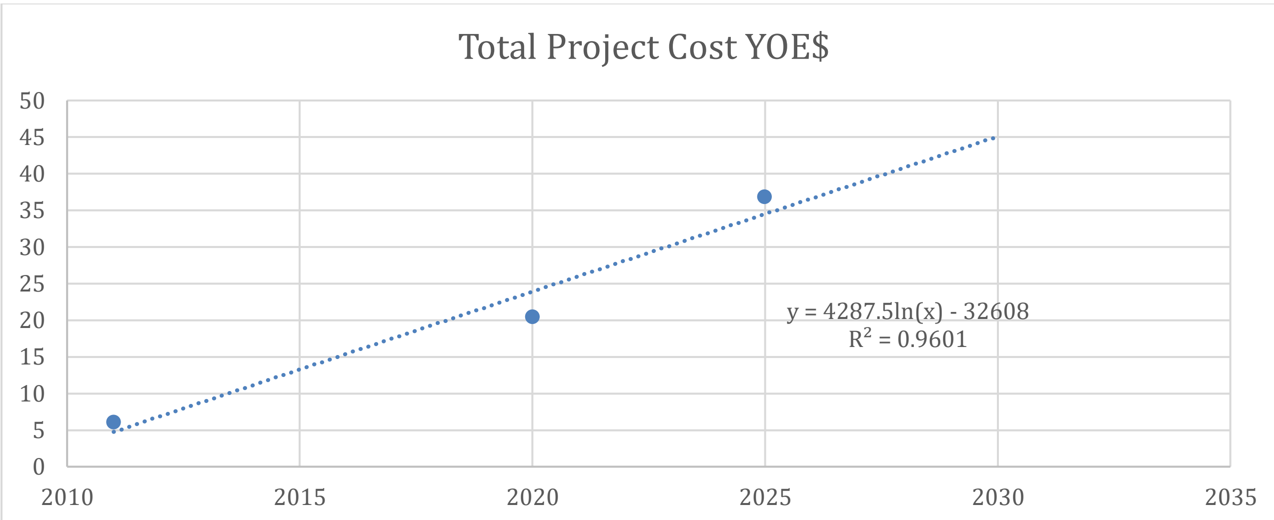


Figure 5: Cost creep and logarithmic fit show a total YOE$ Construction cost of 45 billion

Cash Flow Diagram

In the cash flow diagram, I chose a generic S-Curve to represent the project's progress, which typically correlates with project spending (Konior et al., 2020). I have assumed completion of the project in 2030 and have linearly interpolated the cash flows for operations and maintenance, as well as the revenue expectation, from tables 1, 2, and 3. The resulting cash flow diagram is in Figure 6.

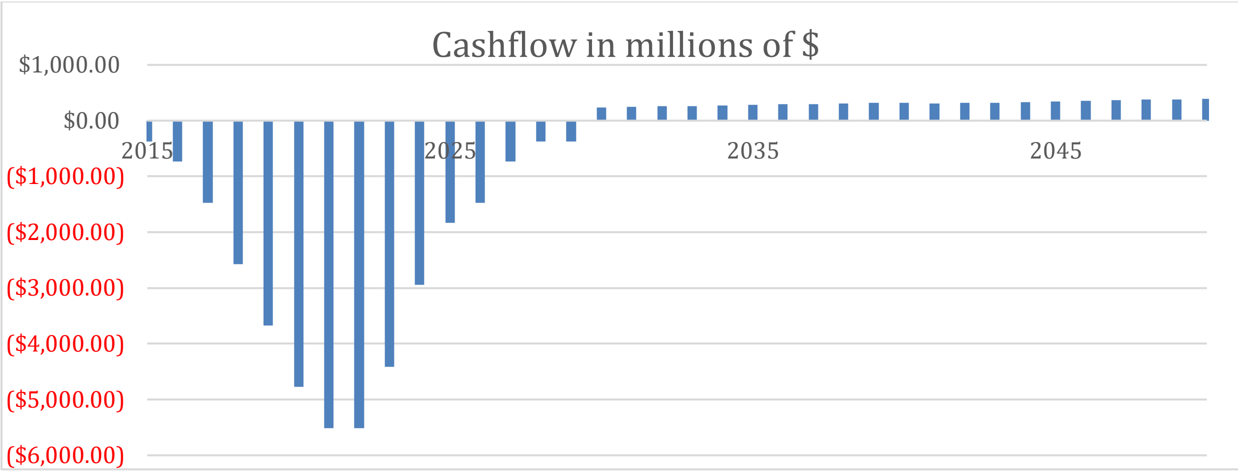


Figure 6: Cash Flow of the project until selected horizon (2050) in Millions.

Cumulative breakeven point - Analysis 2

Another important consideration is the cumulative cash flow, which can indicate the project's breakeven point. Like most civil infrastructure projects, the CHSR will not break even when solely using revenue. This is pictured in Figure 7.

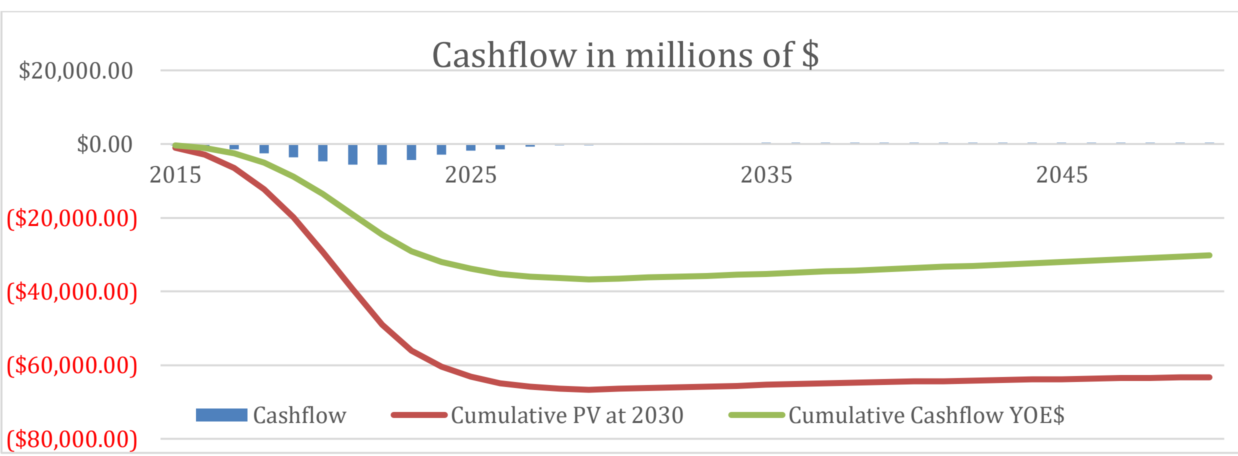


Figure 7: Cash flow, Cumulative Value in 2030 dollars, and YOE$

An important variable in large civil infrastructure projects is the accounting of the benefits and disbenefits of the project. Doing so makes the project very economically logical.

Table 6: Economic value based on 2030 dollars

Based on Valley-to-Valley ridership revenue and OM until 2050	**-63.2 Billion Dollars**
Including Benefits and disbenefits Reference Table 6 transformed to 2030 dollars (their evaluation period is from 2013-2071 so assumed uniform distribution until 2050) with a completion around 2030.	**+10.27 Billion Dollars**

Benefit / Cost Ratio – Analysis 3

I have recreated the B/C ratio using updated cost numbers and a span of 2050, rather than 2071, given confidence in current planning horizons. The original 2014 cost benefit report has a planning horizon until 2071.

Table 7: Results of Benefit/Cost Ratio

Conditions	B/C
Original 2014 benefits report	2.23
Current (Based on analysis until 2050)	1.16
Current (Based on analysis until 2071)	2.38

Sensitivity Analysis – Analysis 4

The sensitivity analysis, using the same base assumptions as in the cash flow section, is shown in Figure 8. The study indicates that Capital Cost is the most sensitive variable impacting total project cost.

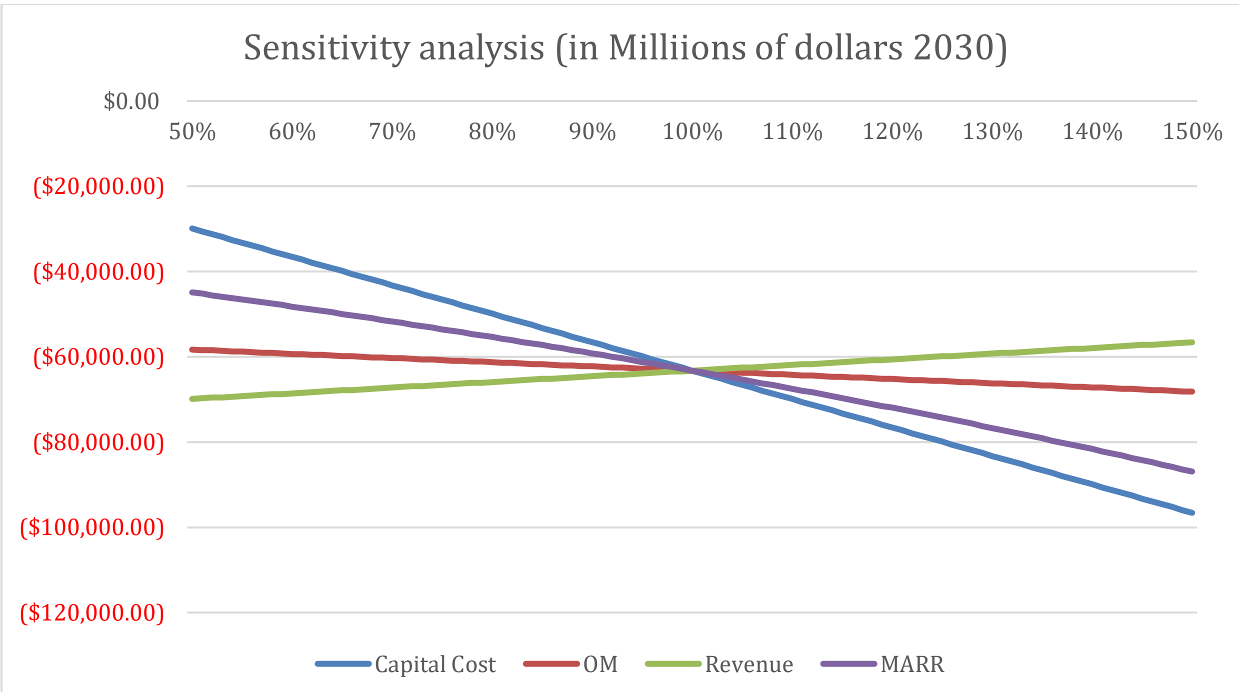


Figure 7: Spider Plot showing the sensitivity of each cashflow item.

Breakeven Point

Although based on current estimates, the project does not have a breakeven point in the analysis, so extending the cash flow into the future does not yield an economic breakeven point. In this case, looking at the B/C ratio will be much more critical.

DISCUSION

The California High Speed Rail, although an exceptional engineering design, exceeds the cost per mile ($210.5 million per mile or $130.8 million per kilometer) of other major high-speed rail lines for example, Spain's AVE rail system costing about 33 million USD per mile once converted to a USD/mile basis (INECO, 2023; Yahoo Finance, 2025). This makes the cost of the CHSR almost an order of magnitude higher than that of similar high-speed rail systems. There are a few reasons why this could be. California is an expensive place to build, and it has less public land than Spain, which results in higher costs. Additionally, despite the many "firsts" the CHSR has experienced, it has its fair share of delays and issues. Construction delays can lead to a higher cost. So ultimately, the combination of experimentation, geography, and political conditions makes it so that the CHSR is not directly comparable to another high-speed rail.

Although not comparable in cost per length to other rail systems, it's still important to draw attention to the funding, or lack thereof, of the current CHSR plan. The current plan has a 7-billion-dollar deficit. Because of this deficit, I hoped a sensitivity analysis would identify opportunities to reduce costs. However, the sensitivity analysis showed that the most critical parameter is the project's initial cost. This creates a situation in which the cost item with the greatest impact has also shown the greatest cost creep as the project progresses. Unfortunately, this has been the most influential factor in dragging the project's value into the negatives when benefits are not accounted for. Ultimately, I hoped the sensitivity analysis would show that revenue had the most significant impact on the project's value, as it's the only variable whose value increases as the base case increases. The idea being that if it is proven that the project will be relatively profitable, lenders could cover the initial 7 billion funding deficit. However, the solution that deviates the least from the base case is to ensure the project maintains or reduces its initial construction costs. Changing the base cases to “high” and “low” revenue and to “high” and “low” operation and maintenance costs did not have a big impact.

After listening to the presentations during the final week of classes, I briefly compared my work with Yağmur Bade Özel. In her report, she found that the CHSR breaks even in the same operating segment. However, unlike mine, her report uses YOE$ and is centered on the project’s completion date in 2030. This, along with subtle differences in our inclusion of revenue, operations, and maintenance, and a slightly different starting operating cost, means her project breaks even, while my cash flow does not. In Table 7, I was able to replicate the Benefit-Cost analysis closely. Ultimately, I believe our differences stem from nuances in how we structured our report. The official reports state that by 2040, the project will most likely have reached breakeven, as Yağmur had concluded. I believe some of the reasons mine did not reach breakeven were my nuances regarding the IOS and Valley-to-Valley ridership models, as shown in Table 5.

The residents of California initially seemed excited about the prospect of a solution to their notorious traffic. However, the funding required, the delays, and the political divide over large public infrastructure projects have tarnished the rail’s optimistic view. It still has a positive public view, though not by much; the drawbacks and issues that have arisen during construction have made residents skeptical of the train's success. Once completed, these views may change, but for now, everyone must wait until completion to know precisely how the numbers will look. (Benton G., 2025)

CONCLUSION:

The California Rail system, pioneering high-speed rail in the US and North America, has not done so without financial challenges. Today, the project remains highly beneficial to Californians, reducing traffic and providing not only economic benefits but also saving travel time on some of the most common routes in California by connecting major cities like San Francisco and Los Angeles. Like most major infrastructure projects, the project does not generate enough revenue to cover its costs. Still, the benefits of the section inspected, the IOS, outweigh the costs by a factor of 2, making it attractive to residents and government agencies. This report finds that, to alleviate its funding deficits, the most impactful way is to ensure the construction budget is not exceeded and/or reduce current expected construction spending. However, historically, this has not been the case. This complex financial image has shifted a California resident from a highly optimistic view to a more cautious one, and the analyses in this report support their reasons.