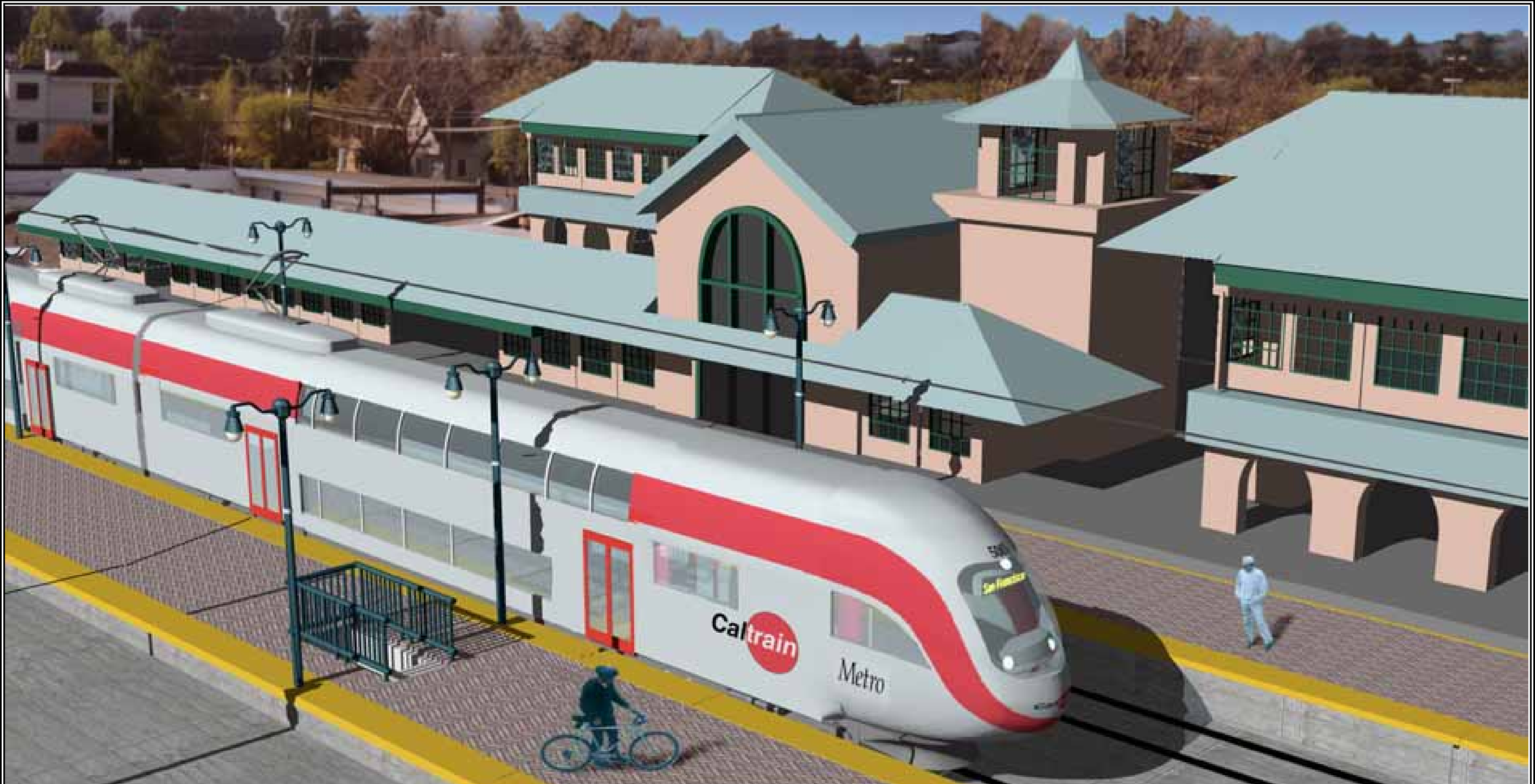

BAY AREA COUNCIL
ECONOMIC
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Connecting business, labor,
government and education

The Economic Impact of Caltrain Modernization

A Bay Area Council Economic Institute White Paper

June 2012

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Cover Illustration: San Jose Station Area

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Executive Summary

The Caltrain system is a vital part of the Bay Area's public transportation system. With service launched by Southern Pacific in 1863, this commuter railroad has connected communities and guided their growth and development for nearly 150 years. Today, Caltrain provides over 40,000 daily trips, a number that is growing rapidly along with the fast-growing technology companies of Silicon Valley, the Peninsula and San Francisco.

Caltrain has long recognized that its growing passenger levels cannot be efficiently or economically served with the conventional diesel equipment that it currently operates, and since 1999 Caltrain has had official plans to convert to electric power. With a new commitment of funding from the California High-Speed Rail Authority, Caltrain believes that by 2019 it can convert to electric power and install a new advanced train control system.[1] Together, these upgrades compose the Caltrain Modernization Program which enhances Caltrain service and supports high speed rail in the future.

Upgrading the system with electric power and an advanced train control system has both short-run and long-run economic implications:

- In the short run, the sizeable construction expenditures will provide a significant stimulus to the local economy.
- In the long run, the Modernization Program will allow Caltrain to offer faster trip times and/or more frequent service, which will have ongoing positive economic effects. These effects include shorter travel times for passengers, lessened traffic congestion on Highway 101, employer access to a larger labor pool, and increased real estate values near Caltrain stations.

This report addresses the short-term and the long-term economic implications of installing the upgraded power and communications systems. Taken together, the construction benefits along with the long-term benefits would provide mid-range economic benefits in the state by an estimated $2.0 billion. These estimates are reached by adding gross regional product, state and local taxes, increases in residential property values, increased property tax collections, and the value of time saved by Caltrain riders.

[1] This funding commitment is subject to legislative budget approval.

Among the specific benefits of the project are the following:

- Construction can be expected to add 9,581 full-time equivalent job-years to the state economy, with the vast majority (over 90%) being in the Bay Area.

- Construction will increase California's gross state product, or output, by $951 million.

- State and local tax collections will see an increase of $71 million during the construction phase.

- Property values near Caltrain can be expected to see an increase of as much as $1 billion.

These estimates reflect a considerable short-term economic benefit for the state and the region. Although the Bay Area economy is recovering better than most economies nation-wide, this project will directly benefit sectors of the economy that have been hardest hit by the recession—construction employment and real estate values.

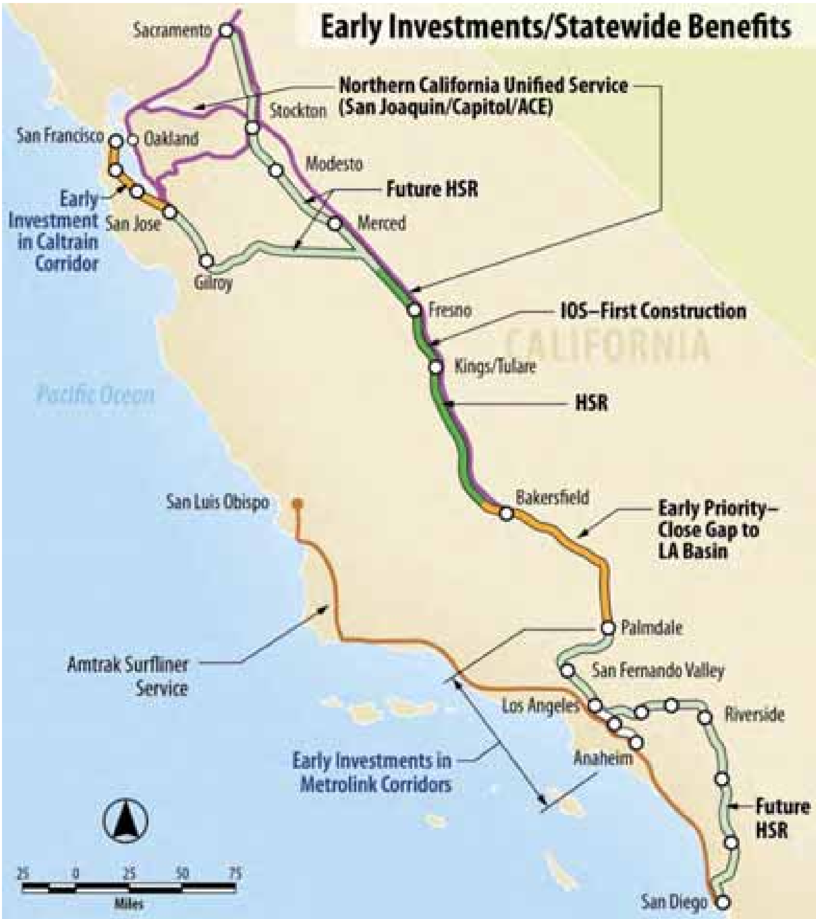
The long-term benefits are also considerable. The primary source of these benefits is from increases in residential property values. Estimates suggest that property values near Caltrain stations could be increased by as much as $1.0 billion, with accompanying increases in property taxes (over time) of up to $59 million over a 30 year timeframe. Accounting for the declines in pollution and noise, net benefits could be as high as $1.1 billion, including increases in property taxes.

Table 14: Summary Results ($ Millions)

	Estimate Range		
Economic Benefit	**Low**	**High**	**Middle**
Short-Term			
Value Added	950.6	950.6	950.6
State and Local Taxes	71.1	71.1	71.1
Long-Term			
Property Values	209.7	1,012.5	611.1
Property Taxes	12.3	59.1	35.7
Time Savings	185.3	370.5	277.9
Environmental Changes	15.5	15.5	15.5
Long-Term Total	422.8	1,457.6	
Overall Total	1,444.5	2,479.3	1,961.9

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

There will be further benefits; the Caltrain Modernization Program will act as a catalyst for local transit-oriented development and will facilitate the success of the region's priority development areas.



Introduction

Caltrain provides the primary means of traveling the length of the San Francisco Peninsula by public transportation. It is a key component of the Bay Area's transportation infrastructure, linking San Francisco and Silicon Valley. Its ridership is forecast to increase by 75% over the next 25 years, and it is destined to play a central role in key regional plans for transit, sustainability or urbanism.[2]

Caltrain currently provides commuter rail service using conventional diesel locomotives pulling unpowered passenger cars. By modifying the system to run on electric current and by upgrading the signal system, the Caltrain Modernization Program will improve the system's performance, operating efficiency, capacity, safety and reliability. These improvements will allow Caltrain to provide an improved passenger experience with faster trip times and/or more frequent service.
The project will also improve air quality, reduce some noise disturbances and lower vibration levels near the tracks.

[2] For ridership forecast details see U.S. Department of Transportation, Federal Transit Administration, Caltrain Electrification Program, Environmental Assessment/Final Environmental Impact Report (July 2009) 1:3–159.

Based on the California High-Speed Rail Authority (CHSRA) Business Plan (April 2012), the Metropolitan Transportation Commission has developed an MOU reflecting regional agreement on leveraging Proposition 1A funding for high-speed rail with local, state and federal funding to implement Caltrain's advanced signal system and electrification projects. This is the first time that a realistic funding strategy has been defined for the modernization program envisioned in the Caltrain 1999 and 2004 strategic plans.

The overall intent of the MOU is to jointly support and pursue the implementation of a statewide high-speed rail system that utilizes a blended system and operational model on the peninsula corridor to support a one-seat ride between San Francisco's Transbay Transit Center and Southern California.

The MOU applies specifically to project investments that upgrade existing rail service and prepare for a future high-speed train project that is limited to infrastructure necessary to support a blended system, which will be primarily a two-track system shared by both Caltrain and high-speed rail as well as other passenger and freight services.

The blended system comprises several interrelated capital projects. The early investment projects are the Caltrain Electrification Infrastructure and Advanced Signal System projects.

The remaining interrelated capital projects are the Downtown Extension (DTX) project, the San Jose Diridon Station, the Millbrae BART/Caltrain Station, and Core Capacity Upgrades to stations, tunnels, bridges and passing tracks (to be determined), in addition to other track modifications and rail crossing improvements, including grade separations (to be determined).

The funding plan included in the MOU is for the Caltrain Electrification Infrastructure and Advanced Signal System projects only. Together these projects make up the Caltrain Modernization Program, and it is these projects that form the basis for the analysis of economic impacts in this report.

The economic impacts of the Caltrain Modernization Program broadly fall into three categories:

- local jobs and capital inflows during construction,
- changes in real property values, and
- the economic value associated with improved service.

Following a brief description of the Caltrain corridor and the Modernization Program, this report provides estimates of the economic impact of construction and the effect on real estate property values, as well as the economic benefits of improved service.

About the Caltrain Corridor

Built during the peak of the California Gold Rush, the railroad that is today's Caltrain serves one of the world's most economically productive regions. From its northern terminus in San Francisco, Caltrain carries over 40,000 passengers daily through the heart of Silicon Valley to its southern terminus in Gilroy. Along its 77-mile route, Caltrain serves some of the world's most iconic companies, institutions and communities.

The Caltrain corridor stands out for its exceptional economic strength. Companies along the corridor account for approximately one-third of all venture capital investment in the United States, bringing $11.6 billion to the region in 2011. The region has the highest concentration of high-tech workers and the highest average high-tech salaries of any metropolitan area on earth. Of the Bay Area's 30 Fortune 500 companies, 24 are located along the Caltrain corridor, including Apple, Google, and Intel.

Caltrain serves one of the most diverse and well-educated populations in the world. Passing through 17 cities across three counties, Caltrain's total service area features over 3 million residents and scores of world-class universities and community colleges in a temperate Mediterranean climate. These and other factors have incubated businesses, contributing to the creation and growth of the region's economic clusters in high-tech, biotech, and green energy, keeping unemployment levels along the corridor at 6.75%, significantly below the regional rate (7.93%), and far below state levels (11%).

Utilizing fossil fuel locomotives, rail service along the Caltrain corridor has remained fundamentally unchanged since it first opened in 1863. Caltrain operators officially proposed electrifying the line in 1999, but the project was delayed indefinitely for lack of funding. Caltrain estimates that electrified service will reduce air pollutants by 90%, lower energy consumption by 64%, reduce congestion along Highway 101, stabilize operating expenses and push ridership past 70,000 per day.

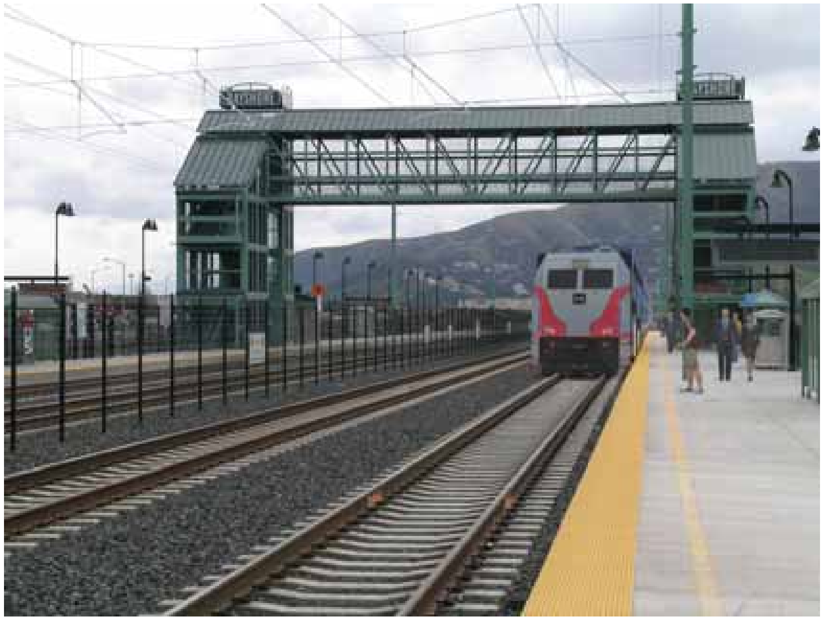
Project Description

The primary components of the Caltrain Modernization Program are the replacement of the existing train equipment with Electric Multiple Unit (EMU) trains, the construction of the associated power infrastructure and the installation of a new advanced signal system.

With these investments, Caltrain will have the ability to provide faster trip times and/or more frequent service. This is primarily because EMU trains can accelerate and decelerate more quickly than the existing diesel-powered trains. Because a substantial portion of each trip is spent accelerating and decelerating between nearby stations, electrification can result in reductions in travel time and/or increased service. The new signal system permits shorter separation between trains, enabling Caltrain to support higher levels of service in the corridor.

Caltrain is planning to increase service from the current 5 trains to 6 trains per peak hour per direction. With the increased service level plus the enhanced attributes of the modernized system and the EMU capabilities of accelerating and decelerating faster than diesel powered trains, Caltrain will be able to reduce travel time and/or increase service to stations.

The infrastructure associated with the advanced signal system is a series of communication equipment installations throughout the right of way. The overhead contact system (OCS) is composed of two electric conductors above each track, hanging from poles 30 to 50 feet tall and positioned every 180 to 200 feet. Overbridge barriers will be placed to protect the OCS from objects thrown off of bridges. The power facilities along the route include two primary substations, one switching station and seven paralleling stations. The primary substations are approximately 200 feet by 150 feet in size, the switching station is approximately 160 feet by 80 feet and the paralleling stations approximately 80 feet by 40 feet. Power facilities will be placed mostly within the railroad right-of-way and will be located in spots that minimize their impact on surrounding land uses.



Construction Impacts

Costs

The Caltrain Modernization Program is estimated to cost approximately $1.456 billion.[3] Of this amount, roughly $785 million will go toward constructing the infrastructure needed for electrification, approximately $440 million will fund the new electric trains and related services, and the remaining $231 million will go toward installing the new advanced signal system (Table 1).

Table 1: Breakdown of Costs (in Year-of-Expenditure Dollars)

Project Component	Estimated Cost ($ Millions)
Electrification Infrastructure	785
Advanced Signal System	231
EMU Trains	440
Total	1,456

Source: Bay Area Council Economic Institute calculations based on Caltrain data.

[3] This figure is expressed in year-of-expenditure dollars.

Of the $1.456 billion total project cost, the majority will be spent within the Bay Area and will generate local economic benefits, but a portion is anticipated to be spent outside of the region. For example, the new EMU trains are unlikely to be constructed in the Bay Area because there are no American companies that produce EMU trains. Accordingly, our analysis begins by deducting from the total project expenditures the amount that will be spent outside of the Bay Area. The result—$1.11 billion in year-of-expenditure dollars—is the estimated amount that will impact the Bay Area and California economies.

This $1.11 billion expenditure will be spread over several years, but a complete accounting of these expenditures according to the year in which they may potentially be made is excessively complex for this analysis. Instead, we assume that the expenditures occur in 2014. This assumption will cause the impact of expenditures made before 2014 to be understated and will cause the impact of expenditures made after 2014 to be overstated.[4]

[4] 2014 seems a reasonable estimate of the mid-point. See the “Estimated Construction Phasing” table in the U.S. Department of Transportation, Caltrain Electrification Program, Environmental Impact Report, 4-5.

Estimated Impacts

The economic impacts of construction are estimated using a standard input-output model, which estimates the short-run impacts of changes in the economy through the use of multipliers.[5] In essence, this model takes the average characteristics of the construction industry and estimates the increased use of resources that the industry would absorb in the event that there were more demand for construction services. The estimated impacts of construction are reported below in terms of employment and output.

[5] Specifically, the estimates are derived using the IMPLAN Professional® 3.0 software package. See Appendix A for more information on the IMPLAN model and its assumptions.

Overall, the economic impacts of the Caltrain Modernization Program are described using three estimate types:

- Resulting employment impacts are measured in terms of full-time equivalent (FTE) job-years generated.[6]
- Resulting output impacts are measured in terms of dollar value added (a measure of regional gross state product, similar to national GDP). This value added measurement is a good reflection of the overall benefits to the local and state economies.
- Resulting economic activity is a representation of the aggregate expenditures generated by the Modernization Program.

The implementation of the Caltrain Modernization Program does not occur in a vacuum. Rather, each aspect of the Modernization Program has a ripple effect within the regional and state economies. These effects are commonly referred to as "multipliers." The additional funds that will flow to design specialists and construction workers will allow them to buy more equipment; the makers of construction equipment pay salaries to their employees; and these employees purchase goods from businesses in their hometowns. Thus the initial injection

[6] An FTE job-year is 2,080 hours' worth of work. Job-years do not represent the number of people a project will employ. One FTE job-year could represent one person employed for 2,080 hours, or two people employed for 1,040 hours each, etc.

of funds circulates throughout the economy. *Direct impacts* in this context refer to jobs and output generated directly by the Caltrain Modernization Program; *indirect impacts* refer to jobs and output generated by the Modernization Program's input suppliers; and *induced impacts* refer to all further removed jobs and output generated by those directly and indirectly employed due to their spending on other things like food and housing.

Accordingly, our estimates of the three types of economic effects—employment, output (value added), and economic activity—are broken down into direct, indirect and induced impacts. The employment impacts of construction are further broken down by region as shown in Table 2. The direct impacts are assumed to be confined to the nine Bay Area counties,[7] but the indirect and induced impacts spill over into the rest of California.

[7] These counties include San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Sonoma, Napa and Marin.

Employment Impacts

Overall, modernization can be expected to add over 9,500 FTE job-years to the state economy, with the vast majority (8,809) being in the Bay Area. Benefits to other counties in the rest of the state amount to 772 FTE job-years, or 8.1% of the total. Altogether, this represents about 2,400 FTE job-years in each of the four years of construction.

Table 2: Resulting Employment Impact in California

Region	Direct	Indirect	Induced	Total
The Bay Area	4,702	1,315	2,793	8,809
Rest of California	0	333	439	772
All of California	4,702	1,648	3,232	9,581

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Notes: Employment is measured in full time equivalent (FTE) job-years (2,080 hours per year) and not in specific numbers of positions added to the economy. Rows may not sum to exact totals due to rounding.

The following table breaks down the employment impacts by project component.

Table 3: Resulting Employment Impact by Project Component (FTE Job-Years)

Project Component	Direct	Indirect	Induced	Total
Electrification Infrastructure	3,249	1,148	2,207	6,604
Advanced Signal System	1,220	431	829	2,480
EMU Trains	232	69	195	496
Total	4,702	1,648	3,232	9,581

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Note: Rows and columns may not sum to exact totals due to rounding.

Table 4 breaks down the construction impacts by industry, using 2-digit North American Industrial Classification System (NAICS) categories. The largest impacts are for the industries that are directly affected by the project, namely the construction industry and the professional, scientific and technical services industry. The indirect and induced impacts are more spread out across the spectrum of local industries, but continue to show a degree of concentration within the two directly impacted industries.

Table 4: Resulting Employment Impact by Industry

Industry	Direct	Indirect	Induced	Total
Ag., Forestry, Fishing and Hunting	0	25	21	45
Mining	0	34	5	39
Utilities	0	4	9	12
Construction	4,469	16	23	4,508
Manufacturing	0	232	82	314
Wholesale Trade	0	79	96	174
Retail Trade	0	174	531	705
Transportation and Warehousing	0	117	89	206
Information	0	36	60	95
Finance and Insurance	0	84	309	392
Real Estate and Rental and Leasing	0	85	164	249
Prof., Sci., and Tech. Services	232	413	150	796
Management of Companies and Enterprises	0	15	19	34

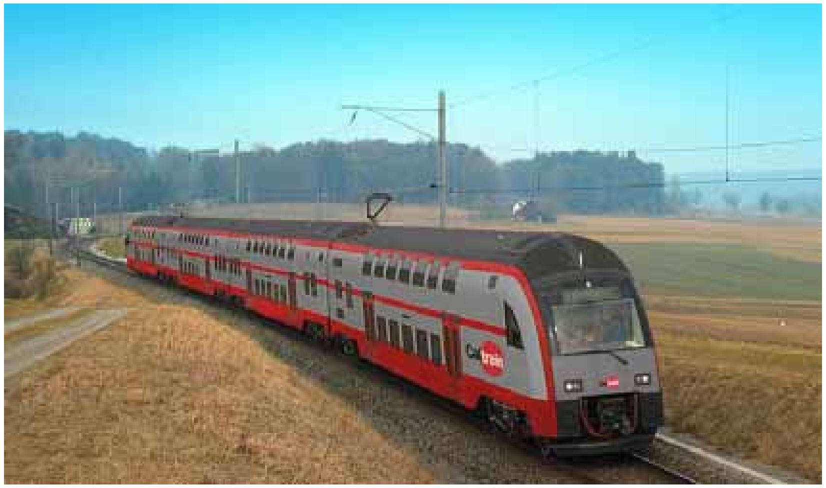
Admin. Support and Waste Management Services	0	152	153	305
Educational Services	0	1	149	150
Health Care and Social Assistance	0	0	540	540
Arts, Entertainment, and Recreation	0	16	123	139
Accommodation and Food Services	0	52	351	403
Other Services (except Public Administration)	0	100	312	413
Public Administration	0	15	46	61
Total	4,702	1,648	3,232	9,581

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Notes: Employment is measured in full time equivalent (FTE) job-years (2,080 hours per year) and not in specific numbers of positions added to the economy. Rows and columns may not sum to exact totals due to rounding.

Job creation stemming from the Modernization Program is most heavily concentrated in the construction sector. In all, some 4,500 FTE job-years will be generated in the construction sector. While this sounds like a large number of workers along the 51-mile corridor, it is worth noting the proportion of the created jobs that are likely to be behind the scenes. A break-down of the Bay Area's construction sector shows about two-thirds of the workers in Construction and Extraction trades. More than 11% are in Management, 6% are in Office and Administrative Support, and another 3.4% are in Business and Financial Operations.

Many jobs are also created in other sectors due to the ripple effect in which the construction spending makes its way through the broader economy. Construction companies purchase intermediate inputs from other suppliers, creating jobs in Manufacturing and Wholesale Trade, for example. At the same time, the incomes of those in the Construction industry are spent more broadly in other sectors—in particular, Retail Trade, Health Care and Social Assistance, and Accommodation and Food Services. Each of these sectors will experience an increase in employment as a result of the economic activity generated by the Caltrain Modernization Program. The figures for Health Care are surprisingly high, but merely reflect the fact that spending in this sector is equal to one-fifth of U.S. GDP and it is very labor intensive.



Economic Output Impacts

The output impacts of the Caltrain Modernization Program are also broken down by region, as shown in Table 5. The output and employment impacts reflect a similar pattern, with the Bay Area reaping most of the output benefits and roughly 8% of the benefits accruing to the rest of the state. It should be noted that the figures in Table 5 are for a measure of output that is equivalent to U.S. gross domestic product and that measures the increase in value added to the economy. This is roughly the value of increased economic activity that results from the project less the purchases of intermediate inputs from outside of the region. While output, or value added, in the region increases by nearly $951 million, the increase in aggregate economic activity, the value of all economic transactions associated with the project, is $1.6 billion.

Table 5: Resulting Output Impact in California ($ Thousands)

Region	Direct	Indirect	Induced	Total
The Bay Area	448,894	142,253	287,266	878,413
Rest of California	0	32,548	39,595	72,143
All of California	448,894	174,801	326,861	950,556

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Table 6: Resulting Economic Activity in California ($ Thousands)

Region	Direct	Indirect	Induced	Total
The Bay Area	779,791	243,637	444,087	1,467,515
Rest of California	0	66,536	68,072	134,608
All of California	779,791	310,173	512,160	1,602,123

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

The following two tables show the economic output and activity effects broken down by project component rather than by region. The economic activity benefits are naturally highly correlated with the expenditure levels for each component presented in Table 1.

Table 7: Resulting Output Impact by Project Component ($ Millions)

Project Component	Direct	Indirect	Induced	Total
Electrification Infrastructure	308	122	223	653
Advanced Signal System	116	46	84	245
EMU Trains	25	8	20	53
Total	449	175	327	951

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.
Note: Rows and columns may not sum to exact totals due to rounding.

Table 8: Resulting Economic Activity by Project Component ($ Millions)

Project Component	Direct	Indirect	Induced	Total
Electrification Infrastructure	541	217	350	1,108
Advanced Signal System	203	82	131	416
EMU Trains	36	11	31	78
Total	780	310	512	1,602

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Impact on State and Local Tax Revenue

Table 9 summarizes the multiplier effects of each project component in terms of state and local taxes. The construction firm hired to carry out the work is subject to a variety of taxes, the income received by workers is taxed and households pay a variety of taxes. In total, the Caltrain Modernization Program will generate in excess of $71 million in state and local taxes, to some extent offsetting the overall cost of the project.

Table 9: Changes in State and Local Business Taxes ($ Thousands)

Project Com-ponent	Employee Compen-sation	Indirect Business Taxes	House-hold Taxes	Corp-orate Taxes	Total
Electrifi-cation Infra-structure	1,302	27,144	17,037	3,158	48,641
Advanced Signal System	489	10,207	6,406	1,187	18,289
EMU Trains	110	2,312	1,527	179	4,128
Total	1,901	39,663	24,970	4,524	71,058

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Real Property Value Impacts

The Caltrain Modernization Program is likely to affect property values and property taxes near Caltrain:

- Enhanced service in the form of faster trip times and/or more frequent service will affect the desirability of properties near Caltrain stations.
- Environmental factors such as improved air quality, reduced vibration levels and altered noise patterns will affect properties near the tracks, and new power facilities may aesthetically impact adjacent properties.
- Increases in property values will also have an effect on overall property tax collections.

These three impacts are discussed in turn in the rest of this section.

The Impact of Enhanced Service on Property Values Near Stations

The Caltrain Modernization Program has the potential to increase property values through the effect of enhanced service to nearby residences. Because of the faster trip times and/or more frequent Caltrain service, the homes of nearby residents will have an improved amenity—the Modernization Program essentially brings any destination on the Caltrain route a little bit closer.

The largest effect on property values is estimated to occur for properties near Caltrain stations; these are the properties where the residents can most effectively exploit the reduced travel time or expanded service levels. There is scant literature providing a reasonable guide as to what might be expected in terms of changes in property values. The influence of infrastructure improvements on residential properties is very dependent on the nature of the infrastructure and the nature of the local real estate market. Fortunately, the introduction of the Baby Bullet service in 2004 provides a natural experiment. The Baby Bullet service introduced express Caltrain service to a subset of stations along the line. Analyzing differences in the appreciation of property values near different stations permits an assessment of the abnormal increase in property values that accrued to stations with access to Baby Bullet service.[8]

From this analysis, it appears that a 1 minute reduction in expected travel time resulting from the introduction of Baby Bullet service caused assessed property values within 0.25 miles of a Caltrain station to increase by 1.5% to 2.4%. Below, we evaluate the change in property values assuming an increase of 1.5%, the lower bound of possible effects. Because of this

[8] See Appendix B for an extended discussion of the methodology.

choice, the estimates presented below also represent a lower bound on the effect—this is one of several steps we take to keep our estimate conservative (in the sense of underestimating any positive impacts).

We assume that travel time will be reduced by between 5 and 10 minutes along the full length of the impacted route. Precise calculation of the expected travel-time reduction at each station hinges upon the details of Caltrain's new service schedule, which has yet to be established. In the absence of this information, we allocated the expected travel-time reduction in proportion to each station's distance from San Francisco, with the exception of San Francisco's 4th and King St., 22nd St. and Bayshore stations, which were assigned a travel-time reduction equal to half of the overall reduction.[9]

Applying the conservative 1.5% gain in property value per minute of travel-time reduction to the 2011 assessed values of all residential properties within 0.25 miles of an impacted Caltrain station, and scaling the effect by the estimated expected travel-time reductions, we conservatively estimate that following the Caltrain Modernization Program, assessed property values will increase by $209.6 million with a 5 minute time savings and $419.3 million with a 10 minute time savings.

[9] Passengers leaving 4th and King are assumed to travel half the length of the corridor on average, yielding a 2.5 to 5 minute time benefit.

Table 10 breaks down the estimated increase in assessed property values by county.[10]

Table 10: Estimated Increase in Residential Property Values ($ Millions)

	Estimated Increase in Assessed Value					
	5 Minute Reduction in Travel Time			10 Minute Reduction in Travel Time		
County	0 – 0.25 miles	0.25 – 0.5 miles	Total	0 – 0.25 miles	0.25 – 0.5 miles	Total
San Francisco	31.3	38.8	70.1	62.6	77.5	140.1
San Mateo	89.3	128.9	218.2	178.5	257.9	436.4
Santa Clara	89.1	128.9	218.0	178.1	257.9	436.0
Total	209.7	296.6	506.3	419.2	593.3	1,012.5

Source: Bay Area Council Economic Institute calculations using county assessor data from various sources.

There are three additional factors that make our estimate more conservative. First, the 0.25-mile radius around Caltrain stations that bounds our estimate is an imposed one. Within the

[10] College Park station was omitted from the estimate, as it is currently only served by a single train during each weekday rush hour.

range of distances considered in previous studies of the effect of proximity to rail transit on residential property values, 0.25 miles is at the lower end.[11] Choosing a 0.25-mile radius reduces our estimate of positive impacts because it carries the implicit assumption that changes in expected travel time do not affect the value of properties beyond this distance. As it is likely that the value of properties beyond this distance will also be positively affected by travel-time reductions, the choice of a 0.25-mile radius makes our estimate more conservative.

The effect on property values between 0.25 and 0.5 miles from the station was also evaluated. In general, the effect was lower than for those properties within the 0.25-mile radius. It seems implausible that the effects would cease at 0.25 miles but likely that they would decline significantly beyond that range. In order to get a sense of the understatement of the effects on property values by excluding properties between 0.25 and 0.5 miles from stations, we assume that the effect on property values in this range is half that of the inner circle range. With this assumption, given the significantly larger inventory of housing in this outer range, despite the smaller effect, assessed values have the potential to increase by up to $593 million. Combining the inner and outer circles, the overall

[11] A survey of previous literature on the topic can be found in Daniel B. Hess and Tangerine M. Almeida, “Impact of Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York," Urban Studies (2007), 44:1041.

increase in residential real estate values is plausibly in excess of $1.0 billion.

Second, our estimate is limited to the effect of travel-time reduction on residential properties. In a 2002 study, Berkeley researchers Robert Cervero and Michael Duncan estimated the impact of VTA and Caltrain rail services on Santa Clara County commercial property values.[12] They found that being within 0.25 miles of a VTA stop was associated with a 23% increase in the value of a typical commercial property, and that the corresponding figure for a Caltrain station was a whopping 120%. These findings suggest that our estimate with respect to residential properties alone is an underestimate of the joint impact on residential and commercial property values near Caltrain stations.

Third, using the introduction of Caltrain's Baby Bullet service in 2004 as a means of obtaining our estimate suggests that it holds in the context of Caltrain ridership around that time. Caltrain has estimated ridership in 2007 at approximately 33,420 passengers per day and has forecast ridership in 2035 to reach 71,000 passengers per day, conditional on the

[12] Robert Cervero and Michael Duncan, “Transit's Value-Added Effects: Light and Commuter Rail Services and Commercial Land Values,” Transportation Research Record 1805, paper no. 02-2273 (2002).

Caltrain Modernization Program.[13] Inasmuch as travel-time reductions are linked to assessed property values via the probability that potential homebuyers are Caltrain riders, greater ridership in the future implies an even stronger effect on property values than the one we have estimated. By not incorporating Caltrain's forecast of greater future ridership—due to either general increases in ridership or the induced increase due to Modernization—into our estimate, we are yet again ensuring a more conservative estimate.

It is important to note that in California, unless a property changes ownership, its assessed value can only increase by up to 2% a year because of Proposition 13. This means that the estimated impacts will not be realized immediately, but only gradually, as properties change hands. Market values, on the other hand, may be affected as soon as homebuyers become aware of travel-time reductions.

The most closely related study to ours was produced in June 2011 by Economic & Planning Systems, Inc. (EPS), which was retained by the City of Palo Alto to estimate the economic impacts of the Caltrain Modernization Program within the city. Their study puts the impact of improved travel times on the assessed value of residential properties in Palo Alto at $34 million, in contrast to the more conservative figure of $6.4 million that our estimates suggest. The difference between the estimates stems in part from our stricter assumption that the impacts of travel-time reduction only accrue to properties within 0.25 miles of a Caltrain station, as opposed to the assumption of a 0.5-mile radius used by EPS. Allowing the range to expand out to the 0.5 mile radius, our estimates suggest a potential increase in assessed values of $43 million using their 8 minute assumption, an effect that is larger than the EPS estimate. The difference also emerges from the fact that our estimate relies on econometric identification of the effects of the Caltrain Modernization Program using data from the Bay Area, whereas the EPS estimate relies on cited estimates of train station effects estimated using data from New Jersey.[14]

The estimated increases in property values also have implications for property tax collections. As indicated, the estimated increases in assessed property values would not all be realized upon completion of the Modernization Program. Assessed property values would only be affected as properties turn over. In time, the increase in values will be reflected in assessed values, and the 1.25% California property tax rate will apply.

[13] U.S. Department of Transportation, Federal Transit Administration, Caltrain Electrification Program, Environmental Assessment / Final Environmental Impact Report (July 2009) I: table 3.15-5.

[14] The EPS study cites “The ARC Effect: How Better Transit Boosts Home Values and Local Economies,” Regional Plan Association (2010).

Were the increases in place in 2011, property taxes would have been between $4.3 million and $10.0 million higher than was observed.

The Impact of Environmental Changes on Real Property Values

The Caltrain Modernization Program will affect the route's immediate environment in several ways. Replacing diesel with electric locomotion will prevent direct emissions from the trains, thereby improving air quality near Caltrain tracks. It will also reduce vibration levels and reduce engine noise. On the other hand, the increase in service frequency will cause safety horns and crossing signal bells to be heard more frequently. In addition, new power facilities may aesthetically affect adjacent properties.

To estimate these impacts, we adopt a conservative set of assumptions put forth by Economic & Planning Systems, Inc. (EPS) in June 2011, when estimating the economic impacts of Caltrain Modernization in the city of Palo Alto. The assumptions are as follows:

- **Air quality:** Reduced emissions will increase the assessed values of residential properties within 100 feet of the tracks by 0.5%.
- **Noise:** Reduced engine noise will increase the assessed values of residential properties within 100 feet of the tracks by 0.65%, but more frequent horn and signal noise will roughly offset this impact, yielding a net zero impact.
- **Vibration:** Reduced vibration will increase the assessed values of residential properties within 100 feet of the tracks by 1%.
- **Aesthetics:** The assessed values of residential properties whose view will span new power facilities will be reduced by 5%. We apply this assumption to all residential properties within 250 feet of a new power facility.[15]

[15] In instances where there remain several possible alternatives for a power facility's location, we take the average of the effect across the alternative sites.

Our estimates of the impact of environmental changes on the assessed value of residential properties are given in Table 11. The total estimated impact is a gain of roughly $15.5 million in assessed values for residential properties. The gain will mostly accrue to properties in San Mateo and Santa Clara counties.

Table 11: Estimated Impact of Environmental Changes on Assessed Value of Residential Properties ($ Thousands)

	Air Quality	Noise	Vibration	Aesthetics	Total
San Francisco County	361	0	722	-119	964
San Mateo County	2,388	0	4,776	-231	6,933
Santa Clara County	2,626	0	5,251	-282	7,595
Total	5,375	0	10,749	-632	15,492

Source: Bay Area Council Economic Institute.

Property Tax Increases

With a projected increase in property values, there will also be an increase in property tax revenues. Property in California is taxed at a base rate of 1.25% of the assessed value of the property. Assessed values in the region will not reflect the increase in market value of the residences due to the Modernization Program until the residences are sold. It is at that time that the assessed values are adjusted upward to reflect the market value of the property at the time of the sale.

The analysis in the preceding sections suggests that there will be a significant increase in market values of between $225 million and $1.04 billion, depending on the extent of the time savings and the range of residences that experience an increase in value. Accordingly, were all of the residences to change hands immediately, there would be an increase in property taxes of between $2.7 million and $13.1 million in the first year of service, and over a 30-year timeframe.

However, not all properties will sell in the first year, nor during a 30-year timeframe for the elements of the Modernization Program. Assuming that just 2.5% of properties turn over in an average year, which implies that 72.5% of the properties will turnover in 30 years, it is possible to project the present discounted value of future property tax receipts associated with the project.

Table 12 provides such estimates. Between 2014 and 2044, the assumed effective capital life of the project, property taxes will increase between $12.3 million and $59.1 million.[16] These revenues reflect increases in property taxes that would not be collected, but for the implementation of the Modernization Program.

Table 12: Estimates of Property Tax Revenues Associated with the Modernization Plan ($ Millions)

	Minimum	Maximum
5 Minute Travel Time Reduction	12.3	24.0
10 minute Travel Time Reduction	29.5	59.1

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

Note: Estimates in the Minimum column include only increased values for properties within 0.25 miles of a Caltrain station. The Maximum column includes increases for properties up to 0.5 miles from a Caltrain station.

[16] A relatively aggressive discount factor of 7.5% has been used in developing these estimates. Given the low interest rates on current U.S. Treasuries, it would be reasonable to argue for a lower discount rate. However, 30 years is a long time horizon and current interest rates are not likely to persist indefinitely. This assumption serves to render the estimates in Table 12 quite conservative. These estimates are also based on the figures in Table 10, which are increases applied to 2011 property values. Property values in the year that service begins will likely be higher, as will the accompanying increases as a result of the Modernization Program. This, again, renders the estimate conservative.

Direct Travel-Time Impacts

The Modernization Program will have a direct effect on travel times for commuter travel and road travel.

- **Commuter Travel:** Faster trip times and/or more frequent service can reduce wait or travel times for Caltrain passengers.
- **Road Travel:** Enhanced Caltrain service and greater frequencies can impose costs on road traffic through increased crossing frequencies. At the same time, increased Caltrain ridership can reduce traffic, reducing traffic congestion.

Commuter Travel-Time Impacts

Not only will those who own residential real estate in the vicinity of Caltrain stations benefit from the Modernization Program, but those riding Caltrain will experience reduced waits and shorter travel times. These gains can be estimated by valuing the potential time savings of passengers. This is accomplished by developing an estimate of the value of time for passengers and an estimate of the amount of time saved.

There are a variety of strategies for estimating the value of time for passengers. The approach taken here is to limit time-savings benefits to weekday travelers and to use an estimate of average wages for those both working full-time and living in one of the three counties served by Caltrain. The logic behind this statistic as an estimate is that for each minute the individual waits, he or she could either be working or engaged in an activity that has approximately the same value per minute as a minute spent working. For this group, average wages in 2008–2010 were just over $68,000.[17] However, a 2010 survey of Caltrain riders implies that the average Caltrain passenger has a household income of in excess of $104 thousand and is of significantly higher average education than is the population as a whole.[18] We have opted to use the average of these two figures, or $86,000. This implies an average value of a single minute of just under $0.70.

The amount of time saved can also be estimated, but the process is more complicated. The first step is to estimate the level of ridership on an average weekday. For this, data is taken from a recent report on Caltrain passenger counts.[19] From this report, we have estimates of boardings and alightings at each station between the 4th and King St. station and the Tamien station. Data is not available on specific trips taken, so it is not possible to count the number of trips between any two stations. Instead, the boardings at any one station are assumed to turn into alightings at other stations along the route in proportion to each station's overall share of alightings. This process will overestimate the length of many trips, but will also understate the length of others. This procedure provides a synthetic set of distinct trips taken on Caltrain on an average weekday.

The time savings on each trip are then estimated by assuming a savings of 5 to 10 minutes between the 4th and King St. and Tamien stations (as was done above). The time savings are assumed to be distributed evenly along each mile of track between the two stations. Each trip is then shortened by a share of the 5 or 10 minutes that is equivalent to the share of the distance traveled between 4th and King and Tamien stations.

Combining the estimates of the value of a minute saved and the estimate of the time saved for each trip, it is possible to estimate the total value of time saved for Caltrain passengers. Estimates suggest that were the elements of the Modernization Program in place in 2011, and were the time saved to have been 5 or 10 minutes along the length of the upgrade,

[17] Calculation by the Bay Area Council Economic Institute from the 2010 American Community Survey 3-Year Estimates.

[18] Corey, Canapary & Galanis Research, "October 2010 Caltrain Onboard Study, Supplemental Reports, Ridership Segmentation Report (Peak & Weekend Customers" (March 2011).

[19] U.S. Department of Transportation, "Caltrain Annual Passenger Counts: Key Findings" (February 2011), at http://www.caltrain.com/Assets/Stats+and+Reports/Ridership/2011+Caltrain+Ridership+Counts+FINAL.pdf

passengers would have valued the time savings at between $7.6 million and $15.2 million (Table 13).[20]

Table 13: Estimated Value of Commuter Time Savings ($ Millions)

	Assumed Reduction in Travel Time			
	5 Minutes		10 Minutes	
	2011	Present Discounted Value over 30 years	2011	Present Discounted Value over 30 years
Value	7.6	185.3	15.2	370.5

Source: Bay Area Council Economic Institute calculations using county Assessor data from various sources.

As was done with property taxes above, we can estimate the total value of these benefits over the course of a 30-year time-frame. Allowing ridership to grow as projected in the Electrification EIR, discounting the future at a 7.5% discount rate, we can generate a present discounted value of the commuter time savings. As presented in the table, these benefits would exceed $185 million with a 5-minute time savings along the line and $370 million with a 10-minute time savings along the line.

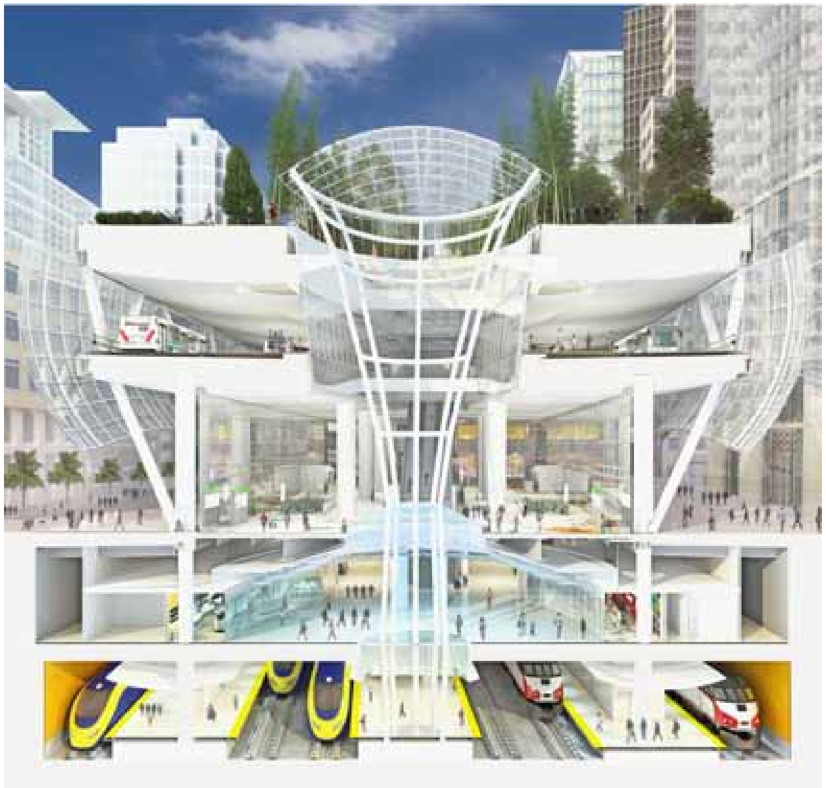
[20] The benefits accrue to counties according to the station of boarding.

Road Travel-Time Impacts

The Caltrain Modernization Program may affect road travel times in several ways. First, in the event that service frequency is increased, the number of cars delayed at crossing signals will similarly increase. Second, enhanced service (either increased frequency or reduced travel times) will have the effect of increasing ridership, or of inducing more demand for services. At the same time, increased ridership implies a reduction in the number of vehicles on roads, both city streets and highways.

Providing a valuation for increased delays at crossings is possible, and our calculations suggest that these costs would likely be reasonably modest. Valuing the time savings from generally reduced vehicular traffic is much more complicated. As a result, both calculations are omitted from the results presented below. For our purposes, it is acknowledged that there are effects on those in passenger vehicles, but that the pair of most significant effects likely cancel each other out.[21]

[21] Caltrain is currently undertaking a detailed analysis of the impact of the upgrades on traffic flows in the region.



Transbay Terminal cross-section.
Project Architect: Pelli Clarke Pelli.
Rendering courtesy of the Transbay Joint Powers Authority.

Findings

The Caltrain Modernization Program is a significant project, with estimated local expenditures of $1.11 billion in year-of-expenditure dollars. Accordingly, the expected benefits are also significant. These benefits come in both the short run—those associated with the installation and design of the program's components—and the long run—those associated with improved service provided by Caltrain.

In the short run, the expected employment and output effects are quite large. Over the course of the four-year project, more than 9,500 full-time equivalent job-years will be added to the state economy. Though these jobs are concentrated in the Construction sector, the demand for products in other sectors, both through the purchase of construction-related materials and through the expenditures of the construction workers, will also increase. Notable among the other industries that benefit are Retail Trade and Health Care and Social Assistance.

Carrying out the Caltrain Modernization Program would provide some much-needed relief to local construction workers. Over the course of the recession, construction employment in the nine-county Bay Area fell by more than 30%, or roughly 60,000 jobs. Job opportunities in the three Caltrain counties fell by a similar percentage. It is worth noting that although job opportunities fell relatively uniformly across the region, construction workers are extremely mobile. In an average year, one-third of all workers employed in construction in the three Caltrain counties live in some other Bay Area county. Accordingly, it could be anticipated that up to one-third of the construction jobs generated in the three counties will benefit workers somewhere in the rest of the Bay Area, most likely in Alameda and Contra Costa counties.

It should be noted that the results here are smaller than many guideline job generation figures. In particular, American Public Transportation Association (APTA) reports indicate that $1 billion in increased construction or infrastructure spending is likely to create roughly 24,000 jobs. The difference here is in large part due to the notion of "leakage."[22] The APTA figures are based on the economic impacts nationwide, while our numbers are for California alone. Some of the economic activity resulting from the Caltrain Modernization Program will be the purchase of materials by those directly involved in implementing the program. Many of these materials will be produced outside of California and are hence not included in the economic impact analysis presented in this report. Were we to report benefits for the nation as a whole, we would see job gains that are more comparable to the APTA guidelines.

[22] See Appendix A for more on the concept of leakage in this context.

Nonetheless, the implementation of the Caltrain Modernization Program will result in significant economic benefits for the state: the generation of more than 9,500 full-time equivalent job-years, an addition of nearly $1 billion to gross state product in California, $1.6 billion in increased economic activity, and $71 million in state and local taxes.

In the long run, once these upgrades have been installed, there are significant benefits both to homeowners near the Caltrain stations and to those who ride Caltrain. Although there are also potential negative implications from the visual effects of the new infrastructure and from increased wait times at rail crossings, these are more than offset by the positive economic benefits.

In all, our very conservative estimate of these benefits indicates an additional $423 million in long-run benefits. The actual benefits are likely much larger: this figure could plausibly be as high as $1.5 billion, in particular, allowing for the very real possibility that properties further away from stations would see some appreciation with improved service. Further, this study has only analyzed the impact on residential properties. Were commercial properties to be included, the overall benefits would likely be significantly higher.

Taken together, the quantifiable short-run and long-run benefits resulting from the Caltrain Modernization Program are significant. With expenditures of $1.11 billion, the following benefits are likely:

- 9,581 full-time equivalent job-years of work will be generated.
- An infusion of $1.6 billion worth of increased economic activity will be generated statewide, with most of the activity occurring in the Bay Area.
- Gross state product will be increased in the State of California by $951 million in construction-related economic benefits.
- Improvements in residential real estate values will lead to at least $210 million, but possibly as much as $1.0 billion.
- As much as $71 million in short-run state and local taxes and as much as $59 million in additional property tax revenues will be generated.
- As much as $370.5 million will be realized in the value of time savings for Caltrain passengers.

These benefits are substantial, resulting in between $1.4 and $2.5 billion in economic gain. Where in this range the benefits lie depends on the extent of time savings for Caltrain passengers (estimated to be between 5 and 10 minutes for the entire route) and the distance across which improved service affects property values. A conservative, yet very reasonable estimate of the overall benefits is $2.0 billion. Accordingly, the cost of the upgrades will be more than offset by gains in the California economy.

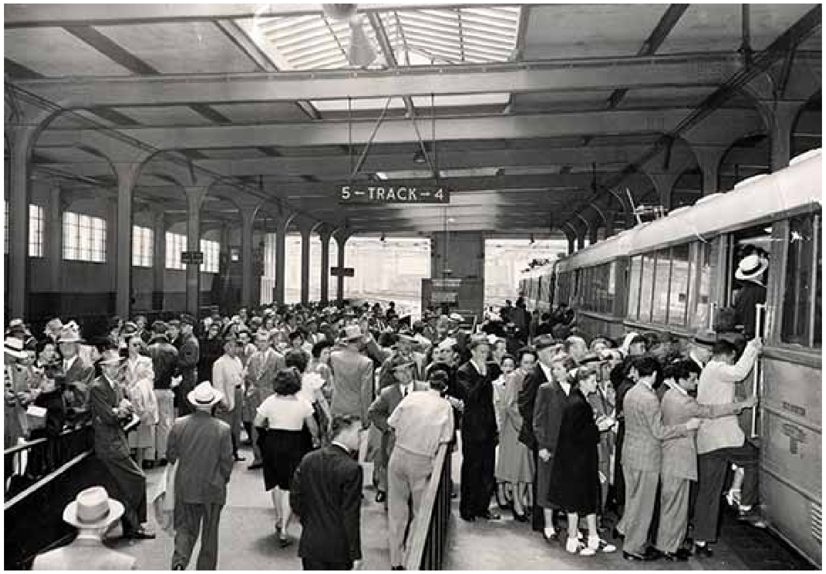
Table 14: Summary Results ($ Millions)

	Estimate Range		
Economic Benefit	**Low**	**High**	**Middle**
Short-Term			
Value Added	950.6	950.6	950.6
State and Local Taxes	71.1	71.1	71.1
Long-Term			
Property Values	209.7	1,012.5	611.1
Property Taxes	12.3	59.1	35.7
Time Savings	185.3	370.5	277.9
Environmental Changes	15.5	15.5	15.5
Long-Term Total	422.8	1,457.6	
Overall Total	1,444.5	2,479.3	1,961.9

Source: Bay Area Council Economic Institute calculations using IMPLAN system analysis.

There are further benefits that will result from upgrading Caltrain, not the least of which is facilitating growth of transit-oriented development and facilitating the success of designated priority development areas. It is widely accepted that improved public transportation can result in higher density development near transit stations. There is no reason to expect the effects of the Caltrain Modernization Program to be any different.

Transbay Terminal 1939



Appendix A: IMPLAN Input-Output Methodology

The IMPLAN modeling system combines the Input-Output Benchmarks from the U.S. Bureau of Economic Analysis with other data to construct quantitative models of trade-flow relationships between businesses, and between businesses and final consumers. From this data, we can examine the effects of a change in one or several economic activities in order to predict its effect on a specific state, regional or local economy (impact analysis). The IMPLAN input-output accounts capture all monetary market transactions for consumption in a given time period. The IMPLAN input-output accounts are based on industry survey data collected periodically by the U.S. Bureau of Economic Analysis, and they follow a balanced account format recommended by the United Nations.

IMPLAN's Regional Economic Accounts and the Social Accounting Matrices were used to construct region-level multipliers that describe the response of the relevant regional economy to a change in demand or production as a result of the activities and expenditures related to the Caltrain Modernization Program. Each industry that produces goods or services generates demand for other goods and services, and this demand is multiplied through a particular economy until it dissipates through “leakage” to economies outside the specified area.

IMPLAN models discern and calculate leakage from local, regional and state economic areas based on workforce configuration, the inputs required by specific types of businesses and the availability of both inputs to production (intermediate products and labor) in the economic area. Consequently, economic impacts that accrue to other regions or states as a consequence of a change in demand are not counted as impacts within the particular economic area. This concept of leakage is central to understanding why estimated economic impacts per $1 billion might be lower when produced for a regional economy than is often reported for nationwide studies.

The model accounts for substitution and displacement effects by deflating industry-specific multipliers to levels well below those recommended by the U.S. Bureau of Economic Analysis. In addition, multipliers are applied only to personal disposable income to obtain a more realistic estimate of the multiplier effects from increased demand. Importantly, IMPLAN's Regional Economic Accounts exclude imports to an economic area so the calculation of economic impacts identifies only those impacts specific to the particular economic area, in this case as determined and defined by Caltrain. IMPLAN calculates this distinction by applying the area's economic characteristics described in terms of actual trade flows within the area.

Impact studies operate under the basic assumption that any increase in spending in an industry sector has three effects. First, there is a direct effect on that industry itself. Second, there is a chain of indirect effects on all the industries whose outputs are used by the industry under observation. Third, there are induced effects that arise when employment increases and household spending patterns are expanded.

Overall economic impact has several aspects. First, there is an effect on value added—the take-home pay of all the people affected will be supplemented by that amount. Second, there is an employment effect, with some jobs created in the industry itself and the others spread throughout the California economy. Third, there is the output, where the difference between value added and output is that the former concentrates on people's paychecks, whereas the latter includes the costs of intermediate inputs. National income accounting avoids double counting by excluding the costs of intermediate inputs.

In sum, our analysis using IMPLAN input-output accounts is based on three important assumptions. First, there are constant returns to scale. This means that a 10% cut in spending will be ten times as severe—across every sector in the economy—as a 1% cut. Second, there are no supply constraints. This means that any marginal increase in output can be produced without having to worry about bottlenecks in labor markets, commodity markets or necessary imports. This assumption is quite realistic in a free-market economy like California's where there is some unemployment. It is even more reasonable in times of high unemployment, such as the present economic environment, because there are many under- and un-utilized resources that can be activated without detracting from other industries. Third, the flow of commodities between industries is fixed. This means that it is not possible to substitute in the short run the many different inputs that go into the industry in question.

In addition to the fundamental economic effects, the IMPLAN model also produces estimates of the state and local taxes that are generated by a project. The following list outlines the types of taxes generated.

- **Employee Compensation:** Employee Compensation in the IMPLAN model is the total payroll cost of the employee paid by the employer. This includes wage and salary, all benefits (e.g., healthcare and retirement) and employer-paid payroll taxes (e.g., the employer side of social security and unemployment taxes).

- **Indirect Business Taxes (IBT):** Prior to the 2003 comprehensive National Income and Product Accounts (NIPA) table revisions, IBT was the name of one of the three components of value added. IBT consists of tax and nontax liabilities that are chargeable to business expenses when calculating profit-type incomes and certain other business liabilities to government agencies that are treated like taxes. Thus, IBT includes taxes on sales, property and production, but it excludes employer contributions for social insurance and taxes on income. As part of the NIPA revision, this component was modified and termed "taxes on production and imports less subsidies." The major differences between the two are attributable to the treatments of subsidies and non-taxes by the Bureau of Economic Analysis (BEA). In more general terms, IBT can currently be considered the combination of excise, sales and property taxes, as well as fees, fines, licenses and permits.

- **Household Taxes:** This category is the combination of excise, sales and property taxes, as well as fees, fines, licenses and permits levied on final users of nondurable goods and services.

- **Corporate Taxes:** The Corporate Taxes category is the combination of excise, sales and property taxes, as well as fees, fines, licenses and permits levied on corporations. A corporation is a legal entity, created for the purpose of producing goods or services for the market, that may be a source of profit or other financial gain to its owner(s); it is collectively owned by shareholders who have the authority to appoint directors responsible for its general management.

Appendix B: Empirical Strategy for Estimating the Impact of Reduced Travel Times on Property Values Near Stations

The Difference in Differences (DD) and Triple Difference in Differences (DDD) Methods

The two simplest approaches to estimating the impact of travel-time changes on property values use either differences in property values across space or differences in property values over time.

The first approach is to compare the value of properties near stations that experienced a change in travel time with properties near stations that experienced a different change in travel time (or none at all). Whether the difference in average property values between these two sets of properties is in fact *caused* by the difference in travel-time changes is far from certain. Any other difference between the two sets of properties—for example, the fact that travel-time reductions happened to be greater in areas that also happened to be more expensive to begin with—could also explain the difference in property values. Put simply, any difference between the properties around each station could be responsible for the difference in their property values, and attributing this difference solely to their having different travel-time changes requires ruling out an exhaustive list of alternative explanations. Adequately controlling for such an exhaustive list is almost never feasible, so when studies use this approach to infer a causal effect, they can never quite escape the shadow of doubt.[23]

The second approach is to compare the value of properties near stations that experienced a change in travel time before and after the change occurred. Unfortunately, this approach suffers from a similar problem, because we can almost never rule out that some other change that occurred between our before and after observations is in fact causing the observed change in property values. For example, if the school district to which the properties belong improved its record over this period, this improvement may be responsible for some or all of the change in property values.[24] Put simply, property values near the different stations may have evolved differently between our before and after observations. Attributing the different local property value trajectories solely to the difference in travel-time changes is difficult to justify.

[23] Despite incorporating data from before and after travel-time changes occurred, the method used in the New Jersey study cited by EPS essentially belongs to this approach, and despite including an admirable set of relevant control variables in its regression, the study is still subject to this critique.

[24] Even if average test scores adequately capture school district quality and can be controlled for, ruling out an exhaustive list of any other such concurrent changes is almost never feasible.

One way of getting around these problems and plausibly arguing that travel-time changes are causing the change in property values is to combine the two approaches. The hybrid approach compares the *change* in property values near stations that experienced a change in travel time, before and after the change occurred, with the corresponding change in property values near stations that experienced a different change in travel time (or none at all). This approach is referred to as a "difference in differences" (DD) approach. As long as all other changes that may have affected property values concurrently with the travel-time changes were *similar* for properties near all the stations, then the effect of all such "other changes" cancels out, and the difference in differences approach yields an estimate that plausibly captures the causal effect of travel-time changes on property values. In practical terms, this means that if we are willing to assume that property values near the different stations would have evolved along similar trajectories in the absence of a change in travel times, then we can attribute any difference in trajectories of property values to the difference in travel-time changes. Unfortunately, such an assumption can never be verified, because we cannot observe the counterfactual world in which travel times did not change.

Of course, it need not be the case that all other changes affecting property values concurrently with travel-time changes were similar near the different stations. Reverting to the school district example, what if properties near stations experiencing different travel-time changes also belong to different school districts? In this case, the difference in differences approach captures both the effect on property values of the difference in travel-time changes between the stations *and* of any difference in the development of the school districts' influence on property values. Fortunately, the difference in differences approach can be modified to handle this difficulty, albeit at the cost of added complexity. The modified approach is referred to as a "triple difference in differences" (DDD) approach.

Even if we are uncomfortable with the difference in differences assumption that property values near the different stations would have evolved along similar trajectories in the absence of a change in travel times, we still have hope. For the set of properties near each station, we can locate a set of placebo properties that evolved similarly between our before and after observations. In this study, for example, we define the set of properties near each station as those properties within 0.25 miles of the station and we define properties within 0.5 to 0.75 miles of the same station as the corresponding set of placebo properties. What distinguishes each original set of properties from its placebo counterpart is that travel time only affects property values in the original set, and not in the placebo set (hence the term placebo).[25]

If we are uncomfortable with the difference in differences assumption, then we believe that using a difference in differences approach on the original sets of properties near each station yields an estimate that reflects both the effect of different travel-time changes on property values across stations, as well as the confounding effect (read "misleading effect") of any other developments that affected property values and that evolved differently across stations—a wanted and an unwanted component. In contrast, using the exact same difference in difference approach *on the placebo sets* of properties near each station yields an estimate that reflects only the unwanted component. Here comes the crux: suppose that in the absence of a change in travel times the property value trajectories of each original set of properties and its corresponding placebo set would have evolved similarly—we ought to be comfortable making this assumption if we have selected our placebo sets adequately—then the *difference* between the difference in differences estimate for the original sets of properties and the difference in differences estimate for the placebo sets of properties should reflect only the wanted component. Because the unwanted component appears in both difference in differences estimates, it cancels out when we take the difference between the two, leaving us only with what we want: the causal effect of travel-time changes on property values.

[25] In a softer version of this condition, property values in the placebo set may also be affected by travel time, but to a *lesser degree* than in the original set of properties. Using the softer condition ultimately causes the triple difference in differences approach to underestimate the effect of travel-time changes on property values, making our estimates yet another step more conservative.

Application

In this study we estimate the effect of travel-time reductions on residential property values within 0.25 miles of Caltrain stations using both the difference in difference (DD) and triple difference in difference (DDD) methods. In particular, we use the introduction of Caltrain's Baby Bullet service in June 2004 as source of variation in travel time, and (indirectly) observe the freshly assessed values of residential properties sold at arm's length in 2002 and in 2006. We chose the year 2002 because it precedes 2004 but is sufficiently prior to the introduction of the Baby Bullet service that anticipatory effects on property values are unlikely to be a serious concern. We chose 2006 because following the initial introduction of the Baby Bullet service, the frequency of service was increased several times and the timetables repeatedly updated, with the last update taking place in August 2005.

Formally, we applied the DD method by running the following linear regression on the full universe of residential properties within 0.25 miles of a Caltrain station that were last sold in either 2002 or 2006.

$$\log AV_{it} = \alpha + \beta_1 After_t + \beta_2 TTC_i + \beta_3 After_t TTC_i + X'_{it}\,\delta + \varepsilon_{it}$$

Here, AV_{it} is the assessed value of residential property i at time t. $After_t$ is an indicator variable that equals 1 if t equals 2006 and 0 otherwise (i.e., if t equals 2002). TTC_i is the expected travel-time change, in minutes, at the Caltrain station nearest property i given the relevant timetables for time 2002 and 2006. X_{it} is a vector of observed property attributes and ε_{it} is an error term.[26] The coefficient of interest is β_3, the DD coefficient, which measures the difference in before and after differences between properties near stations with different expected travel-time changes.

We applied the DDD method by running the closely related following regression on the same population of residential properties, expanding the area to include properties within a ring with a radius of 0.5 to 0.75 miles around each Caltrain station.

[26] Travel-time changes are measured in expectation because arrival time at the train station is taken to be random, thereby affecting wait time at the station, which is included in travel time.

$$\log AV_{it} = \beta_0 + \beta_1 After_t + \beta_2 TTC_i + \beta_3 After_t TTC_i + (1 - Placebo_i) \bullet (Y_0 + Y_1 After_t + Y_2 TTC_i + Y3 After_i TTC_i) + X'it\,\delta + \varepsilon_{it}$$

Here, $Placebo_i$ is an indicator variable that equals 1 if property i is within the 0.5-mile to 0.75-mile ring, and 0 otherwise (i.e., if it is within 0.25 miles of a Caltrain station). The coefficient of interest is γ_3, the DDD coefficient, which measures the *difference* in the difference in before and after differences between properties near stations with different expected travel-time changes, between properties within 0.25 miles of a Caltrain station and properties within the placebo 0.5-mile to 0.75-mile ring around the same Caltrain station. Inasmuch as travel-time changes affect property values in the placebo rings, the DDD coefficient picks up an underestimate of the true effect of travel-time changes within the 0.25-mile radius around the stations.[27]

Assessed values of residential properties sold at arm's length in 2002 and 2006 were not directly observed in our data. We could, however, directly observe the 2011 assessed value of all properties in our data. For San Francisco and Santa Clara counties we could also observe the date of the last arm's length transfer of ownership, and for San Mateo County we

[27] It is for this reason that the 0.5- to 0.75-mile ring was selected, rather than the closer 0.25- to 0.5-mile ring. The latter would have led to extreme underestimation.

could observe the last date of any transfer of ownership and a descriptor of the transaction, which we used to identify in which cases the last transfer of ownership was an arm's length one. The arm's length distinction is important, because it implies that the next assessment of that property's value was unconstrained. Because of California's historical Proposition 13, assessed property values can increase by no more than 2% per year, unless an arm's length transfer of ownership takes place. In order to back out the 2002 and 2006 assessed values of properties sold at arm's length in those years, we took the 2011 assessed values, assumed they had been constant since 2007 and that they increased by exactly 2% each year before then. Imputing lagged values this way roughly captures the evolution of assessed residential property values in California over those years.[28] Because we only observe the *last* arm's length sale for each property, any single property is only observed transacting once, either in 2002 or 2006, but not in both years, so our data consists of repeated cross sections rather than true panel data.

[28] Ignoring any decreases in assessed property values since the onset of the housing crisis in mid-2006 implies that we are underestimating home values in 2002 and in 2006, and therefore any positive effects of travel-time reductions, too, making our estimates more conservative yet again.

Expected travel-time changes were computed using Caltrain's schedules from April 2001 and August 2005, each of which spanned (at least) the subsequent calendar year, under several assumptions. In particular, expected travel-time changes were calculated for northbound passengers traveling to the 4th and King St. station who randomly arrive at their departure stations with uniform probability between 6:00 a.m. and 9:00 a.m. on a weekday morning and unconditionally board the next train. The exceptions to this rule were passengers traveling from 4th and King St., 22nd St. and Bayshore stations, who were assumed to be traveling southbound to the Palo Alto station under otherwise unchanged assumptions. Thus, expected travel times include both time spent waiting at the station for the next train and time spent on the train traveling. Table B.1 reports the expected travel times[29] before and after the introduction of Baby Bullet trains, as well as the expected travel-time change.[30] As shown by the table, the introduction of bullet train service in 2004 generated substantial variation across stations in travel-time change. It is this variation that allows us

[29] Passengers' expected travel times are their average travel times if they have an equal probability of arriving at the given station at any minute between 6:00 and 9:00am on a weekday. Passengers are assumed to board the next available train to their destination.

[30] Atherton, Broadway and Paul Ave. stations were active in 2002, but not in 2006. Expected 2006 travel times for these stations were obtained by adding the commute time by car from each of these stations to the nearest Caltrain station active in 2006 to the expected travel times calculated for these active nearby stations.

to estimate the impact of changes in service on local real estate values.

Table B.1: Expected Travel Time Changes by Station (Minutes, on an Average Weekday)

Station	Expected Travel Time 2002	Expected Travel Time 2006	Expected Travel Time Changes
4th & King	74	51	-23
22nd St.	71	49	-22
Paul Ave.	–	–	–
South San Francisco	33	37	4
Bayshore	39	50	11
San Bruno	43	35	-8
Millbrae	38	35	-3
Broadway	–	–	–
Burlingame	39	44	5
San Mateo	49	43	-6
Hayward Park	55	71	16
Hillsdale	48	40	-8
Belmont	61	73	12
San Carlos	55	57	2
Redwood City	64	62	-2
Atherton	–	–	–
Menlo Park	71	65	-6
Palo Alto	71	54	-17
California Ave.	73	67	-6
San Antonio	79	77	-2
Mountain View	77	71	-6
Sunnyvale	97	79	-18
Lawrence	101	91	-10
Santa Clara	105	92	-13
College Park	116	89	-27
San Jose Diridon	98	84	-14
Tamien	103	107	4

Source: Bay Area Council Economic Institute calculations based on Caltrain data.

Regression results are reported in the following table.

Table B.2: Difference in Differences (DD) and Triple Difference in Difference (DDD Estimates

	DD			DDD		
	(1)	(2)	(3)	(4)	(5)	(6)
DD or DDD coef. (β_3 or γ_3)	-0.0151***	-0.0202***	-0.0235***	-0.0182***	-0.0189***	-0.0157
	-0.0048	-0.005	-0.0058	-0.0052	-0.0055	-0.0065
Unreported β and γ coefs. county-specific	–	+	+	–	+	+
Controls for property attributes included	–	–	+	–	–	+
San Francisco County	+	+	+	+	+	+
San Mateo County	+	+	–	+	+	–
Santa Clara County	+	+	+	+	+	+
R^2	0.997	0.997	0.998	0.996	0.997	0.998
Number of observations	879	879	341	4,765	4,765	2,078

Source: Bay Area Council Economic Institute

Notes: Controls for property attributes include indicators for single family residences, condominiums and apartments, square footage, number of bedrooms, number of baths rounded up to the nearest integer and the lower of years elapsed since construction or since last renovation requiring a permit. Heteroskedasticity robust standard errors in parentheses.
***p<0.01, **p<0.05, *<0.1

As the outcome variable is the *log* of the assessed property value, the DD and DDD coefficients can be interpreted as being approximately percentage changes in assessed property values. The estimate of the basic DD coefficient (β_3) reported in Column (1) indicates that one added minute of expected travel time reduces assessed property values by 1.51%, or conversely that a one minute reduction in expected travel time increases property values by that amount. Column (2) reports the estimate from a specification similar to (1), in which the coefficients on β_0, β_1 and β_2 are allowed to vary by county. In Column (3), controls are added for property attributes (X_{it} in equation (1)). Unfortunately, our data does not include these variables for San Mateo County, so this specification is estimated with only San Francisco and Santa Clara County observations. It is reassuring that these controls do not drastically alter the results.

Column (4) reports the estimate of the DDD coefficient (γ_3), which is not significantly different from the estimate of the DD coefficient in Column 1, suggesting that property-value trajectories near the various Caltrain stations are not extremely different. Nevertheless, the DDD exercise is reassuring, and we take this to be our most preferred point estimate. Allowing all β and γ coefficients except γ_3 to vary by county in Column 5 hardly alters the results. As in Column 3, running a specification of (2) that includes controls for property attributes and is limited to San Francisco and Santa Clara County observations in Column 6 does not significantly alter results, either. To summarize, it appears safe to say that, on average, the effect of travel-time reduction on assessed property values within 0.25 miles of impacted Caltrain stations lies between 1.5% and 2% of assessed property value.

Several remaining comments are in order:

- Our estimate in no way accounts for new residential (or other) construction for which reduced travel times may be pivotal. Once again, avoiding this facet of the subject renders our estimates a shade more conservative, because the assessed value of properties is implicitly zero until they are observed.

- Our specifications all impose homogeneity of the effect of travel-time reductions on assessed property values. It is plausible that this effect varies along the impacted Caltrain route—for example, it could be different in northern San Mateo County, in which travel times are relatively short, compared to Santa Clara County, in which travel times are substantially longer. Unfortunately, our limited number of observations does not provide sufficient power to allow the estimates to vary flexibly by distance from San Francisco or any related variable. Moreover, imposing this homogeneity can be viewed as a (very indirect) way of taking into account that not all travel is in fact to San Francisco, but that some of it can be local, too, which weakens the motivation for allowing the effect to vary by distance to San Francisco.

- The number of observations within 0.25 miles of a Caltrain station may appear very small, but one must recall that only residential properties last sold at arm's length in either 2002 or 2006 enter the regression. Most residential properties within this radius were not sold (let alone at arm's length) in those years, or have been sold again since then. The number of observations increases substantially when the 0.5 to 0.75 ring is added because these rings have a larger area than a 0.25-mile circle, and also because the properties closer to Caltrain stations are more likely to be commercial.

- The high levels of explanation (R^2) in these regressions stems from the extremely sharp appreciation of property values in California between 2002 and 2006, which causes the $After_t$ variable to capture an unusually large share of the variation in assessed values.

- Finally, given the structure of our data, our estimates apply to the assessed value of the subset of properties not sold since 2006.[31] If not having been sold since that time is correlated with certain property characteristics, our estimate applies to properties of that characterization. This is unlikely to be a matter of any significance.

[31] The $After_t$ variable captures the difference in average assessed property values for the sets of properties sold in 2002 and 2006, including any part of this difference that stems from them being different in their average characteristics.

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