Standardized Regulatory Impact Assessment: Electronic Logging Devices for Intrastate Motor Carriers and Drivers

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Abbreviations

AOBRD - Automatic on-board recording device
CGE – Computable General Equilibrium
CFR – Code of Federal Regulations
CHP – California Highway Patrol
CMV – Commercial Motor Vehicle
ELD – Electronic Logging Device
FMCSA – Federal Motor Carrier Safety Administration
FMS – Fleet Management Systems
FY – Fiscal Year
HOS – Hours of Service
LH - Long Haul
MCSAP – Motor Carrier Safety Assistance Program
PRS – Proposed Regulatory Scenario
RIA – Regulatory Impact Analysis
RODS – Records of Duty Status
SH – Short Haul
SRIA – Standardized Regulatory Impact Assessment

1. Introduction

The California Highway Patrol (CHP) is proposing to amend existing regulations to require intrastate drivers and the motor carriers that employ those individuals to use Electronic Logging Devices (ELD) to prepare drivers' Records of Duty Status (RODS).[1] Currently, the state's regulations do not require ELDs and are not compatible with federal regulations outlined in Title 49, Code of Federal Regulations (CFR), Part 395.8, which requires carriers and drivers to prepare RODS using ELDs. An ELD is a device or technology that automatically records a driver's driving time and facilitates the accurate recording of the driver's hours of service (HOS) and other categories of duty status. This system would replace an existing, paper-based system of HOS recording.

The intent of the proposed regulatory amendment is to improve commercial vehicle safety by reducing the number of HOS violations that contribute to fatigue-induced traffic accidents. However, because a significant share of intrastate carriers in California do not currently use an ELD system for preparing RODS[2], the CHP regulatory amendments are likely to impose additional compliance costs on regulated carriers and drivers. This document provides an economic impact assessment of the costs and benefits of the proposed ELD regulation.

1.1. Background of the Proposed Regulation

On July 6, 2012, President Barack Obama signed into law a new two-year transportation reauthorization bill, the Moving Ahead for Progress in the 21st Century Act (MAP-21). The law includes many important provisions intended to help the Federal Motor Carrier Safety Administration (FMCSA) fulfill its important mission to reduce crashes, injuries, and fatalities involving commercial vehicles. The Electronic Logging Device rule, congressionally mandated as a part of MAP-21, is intended to help create a safer work environment for drivers and make it easier and faster to accurately track and manage RODS data. The FMCSA established an implementation timeline for the mandatory use of ELDs to record driver's RODS. The implementation timeline began December 16, 2015, requiring all carriers and drivers, subject to the ELD rule, to use only manufacturer certified ELDs registered with the FMCSA to record driver's RODS. Full implementation of the federal ELD rule was completed in December 2019.

Section 2400 of the California Vehicle Code (CVC) authorizes the Commissioner of the California Highway Patrol to enforce laws regulating the safe operation of motor vehicles.

[1] Existing regulations for RODS are contained in the CHP Motor Carrier Safety Regulation (Title 13, California Code of Regulations, Division 2, Chapter 6.5), https://regulations.justia.com/states/california/title-13/division-2/chapter-6-5/

[2] We estimate that 197,632 of 366,800 affected drivers (53.9%) do not currently use any ELD technology.

Section 2402 CVC authorizes the Commissioner to make and enforce regulations as necessary to carry out the duties of the CHP. Sections 34501 and 34501.2 CVC allow the CHP to adopt reasonable rules and regulations, which are designed to promote the safe operation of vehicles described in Section 34500 CVC. The adopted regulations are contained in Title 13, California Code of Regulations (CCR).

Title 49, CFR, Part 350.303 establishes requirements for states to remain compatible with the Federal Motor Carrier Safety Regulations (FMCSR). Therefore, an amendment is needed to create consistency between state and federal regulations. Furthermore, the Motor Carrier Safety Assistance Program (MCSAP) requires states, under certain conditions, to adopt and enforce state Commercial Motor Vehicle (CMV) safety laws and regulations that are compatible with the FMCSRs. These include HOS rules. Currently, state regulations do not require an ELD as the method for preparing an intrastate driver's RODS and are subsequently not compatible with federal regulations. In order for the CHP to fulfill the mandate established in Section 34501(a) CVC and be in compliance with federal law, the CHP must amend intrastate RODS regulations. This rulemaking action will align state regulations with FMCSRs in Title 49, CFR, Part 395.8 by requiring carriers and drivers to record RODS using ELDs. Additionally, the use of ELDs will enhance commercial vehicle safety by improving compliance with the applicable HOS rules and reducing the overall paperwork burden for both motor carriers and drivers.

CHP's proposed regulatory amendment would apply to intrastate commercial vehicles operating in California. The California Department of Motor Vehicles defines intrastate commerce as operating a commercial vehicle within the state when the driver does NOT:[3]

- Cross the state line
- Transport cargo that originated from outside the state
- Transport cargo destined outside California, or
- Transport any hazardous substances or waste (as defined in CFR, Title 49 §171.8)

The timetable for implementation is as follows:

- CHP has been planning to publicly notice ("start") the rulemaking by December of 2021, with a currently projected effective date ("filing date") in regulation of October 1, 2022.

- From the latter date, immediate compliance (i.e. "full implementation") is expected and any violations will be subject to citation. Between the notice and effective

[3] https://www.dmv.ca.gov/web/eng_pdf/comlhdbk.pdf

dates, CHP will be advertising to ensure that operators are aware of the start date. Meanwhile, they have been advised that this regulation is coming for 3-4 years.

- The 12-month period following October 1, 2022, is therefore assumed to correspond to the basis for the major regulation determination.

1.2. Major Regulation Determination

California Code of Regulations (1 CCR Section 2000) defines "Major regulation" as any proposed rulemaking action adopting, amending, or repealing a regulation subject to review by OAL that will have an economic impact on California business enterprises and individuals in an amount exceeding fifty million dollars ($50,000,000) in any 12-month period between the date the major regulation is estimated to be fully implemented (as estimated by the agency), computed without regard to any offsetting benefits or costs that might result directly or indirectly from that adoption, amendment, or repeal. Direct compliance costs are estimated to average approximately $49 million per year over the next decade (2021-31), depending on various ELD cost assumptions (Table 7. Section 2 below). However, direct benefits of the proposed regulation are estimated to average about $306 million per year over the same period (Table 12 below). Therefore, combined direct costs and benefits, the metric for the SRIA threshold, significantly exceed $50 million per year. Thus, CHP implementation of the ELD rule qualifies as a major regulation, requiring a complete SRIA.

1.3. Public Outreach and Input

The California Highway Patrol has conducted three Commercial Vehicle Safety Summits (CVSS) in October of 2017, 2019, and 2021 where discussions and classes were held for the trucking industry. Additionally, CHP has fielded numerous questions and comments about the proposed regulations from interested stakeholders.

1.4. Regulatory Baseline

All economic impacts estimated in this SRIA are evaluated relative to a baseline scenario. This regulatory baseline is a counterfactual scenario that assumes that the proposed regulations were not implemented, and instead current intrastate commercial vehicle regulations remain as they are. Regulated carriers would not be required to utilize electronic logging devices for preparing RODS. It is further assumed in the regulatory baseline that even though the federal regulations do require ELDs for interstate carriers, there would be no spillover in the voluntary use of ELDs for intrastate carriers. This assumption is a necessary oversimplification due to a lack of data on the voluntary use of ELDs amongst intrastate carriers.

2. Impacts on California Businesses

2.1. Who is affected by the ELD rule?

The FMSCA estimates that there are approximately 2.8 million drivers that operate intrastate in the United States.[4] As a rough approximation of the number of these drivers in California, the total number of intrastate drivers are scaled by California's share of national transportation and warehousing output (13.1%).[5] Based on this approximation, there are 366,800 intrastate drivers in California that could be subject to the proposed regulations. This is likely to be a conservative estimate of the total number of intrastate drivers. The California DMV reports that there are 640,824 drivers with Class A and Class B licenses (not all of which are commercial licenses).[6] It is assumed, based on the FMCSA 2020 Pocket Guide to Large Truck and Bus Statistics, that 41.2% of commercial motor vehicles are involved in intrastate commerce, then this alternative method of calculating affected drivers suggests that are approximately 270,699 intrastate drivers in California.

As the HOS record-keeping requirements are less stringent for Short Haul (SH) drivers versus Long Haul (LH) drivers, there are different costs and benefits associated with the regulation depending on driver type. Therefore, total affected drivers are separated by driver type. Since data is not available at the California state level, are based on estimates from the federal Regulatory Impact Analysis (RIA). In the RIA, the FMCSA uses data from the Motor Carrier Management Information System (MCMIS) to estimate approximately 3.3 million drivers will be affected, roughly 800,000 of which are SH drivers. Based on this, it is assumed that a similar distribution of drivers in California, which implies 24% of affected drivers are SH and 76% are LH. Using the estimate of 366,800 affected drivers this suggests 88,032 SH and 278,692 LH affected drivers in California.

Additionally, estimates are needed for the number of drivers that already use ELDs. It is assumed that some CMV intrastate drivers in California voluntarily elect to use ELDs and regulatory costs should not be ascribed to these drivers as they would use ELDs in absence of the regulation. Lacking data on California ELD use, we rely on estimates at the federal level. However, the federal RIA does not estimate ELD usage explicitly. Instead, the RIA estimates two related, albeit different, pieces of technology; Fleet Management Systems (FMS) and Automatic On-Board Recording Devices (AOBRD).

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[4] 2020 Pocket Guide to Large Truck and Bus Statistics. Federal Motor Carrier Safety Administration.
[5] Bureau of Economic Analysis (2021), SQGDP2 Gross domestic product (GDP) by state accessed 12/20/21.
[6] California DMV Statistics, Available at https://www.dmv.ca.gov/portal/file/california-dmv-statistics-pdf/

Both FMS and AOBRDs are not ELDs but share similar characteristics. FMS allow CMV operators to track vehicles, monitor the truck, and send messages to the driver. Some FMS have the capacity for HOS recording, which are classified as AOBRDs. Thus, AOBRDs are a subset of FMS. ELDs are the technological successor to AOBRDs and have more sophisticated technology and features.

The RIA uses a combination of observed data in 2005 along with a forecasting model to estimate FMS and AOBRD usage among CMVs nationally in the absence of regulation. For the purposes of this study, FMS usage is considered as a proxy for ELD usage. Before the federal regulation was introduced, manufacturers made several tiers of FMS devices some of which lacked HOS monitoring or other ELD specific features. It is assumed that after the regulation took effect, the demand for FMS devices that lack ELD functionality would be severely reduced, and as a result FMS manufacturer were incentivized to ensure new devices would be ELD compliant. Furthermore, given that ELDs have FMS capabilities and are mandated federally, it is reasonable to anticipate that early technology adopters would select the more sophisticated device. Based on this, it is assumed the number of FMS users that lack ELD compatibility to be low and therefore FMS use represents a good proxy for ELD use.

The forecasting model estimates that by 2020, 55% of LH CMVs will have a FMS. It is therefore assumed that 55% of California intrastate LH CMVs will have an ELD in 2020. The RIA assumes that FMS usage of SH CMVs will be one-third that of LH, and thus it is assumed that 18% of California intrastate SH CMVs will have an ELD in 2020. Note that these forecasts are in absence of federal regulation, which took effect in 2017. It is assumed these estimates serve as lower bounds as federal regulation likely induced more voluntary usage at the state level. This suggests that voluntary ELD usage might be higher overall, and therefore our cost estimates should serve as an upper bound.

Table 1 below presents estimates on voluntary ELD use among LH and SH CMVs. In total, it is estimated that 197,043 (53.9%) of the 366,800 affected drivers will not use any existing ELD and therefore be affected by the regulation.

Table 1: Estimates of ELD Use (2020)

Category	Estimated ELD Use	Total Drivers	Drivers without ELD	Drivers with ELDs
LH	55%	278,768	125,446	153,322
SH	18%	88,032	72,186	15,846
Total		366,800	197,043	169,757

2.2. Labor Costs

Labor costs are an essential component of our analysis as they are used to inform direct impacts to California businesses and consumers. Labor costs are comprised of wages, fringe benefits and overhead. Fringe benefits include a variety of costs in addition to wages such as health insurance, retirement plans, paid leave, etc. Overhead are any costs to a firm that are related to labor but are outside wages and fringe benefits. These include the fixed costs of a firm that manages employees and include things such as human resource salaries, office overhead, and payroll services.

Wage estimates come from the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES). Mean wage estimates are used for four occupation types in California (May, 2020): Heavy and Tractor-Trailer Truck Drivers, Bus and Truck Mechanics and Diesel Engine Specialists, Information and Record Clerks, and Transportation Inspectors. The OES does not report on fringe benefits by occupation type. Instead fringe benefits are derived from the Employer Costs and Employee Compensation (ECEC) which reports wages and benefits for industry groups. Here estimates from the transportation and warehousing section are used which report average hourly wages of $26.97 and average hourly benefits of $13.80.[7] This implies a fringe benefit rate of 51%. With regard to overhead, estimates are not available from the BLS and this analysis instead uses numbers from in the federal RIA that derives estimates from research by North Dakota State University.[8] Industry data used in this research found an overhead rate of 27%.

These fringe benefit and overhead estimates are used for mechanics and clerks, while only fringe benefit estimates are used for drivers. It is assumes overhead costs do not apply for drivers who do not work in offices and therefore do not have the related overhead costs. For roadside inspectors, different estimates are used for fringe benefits and overhead, derived from reported data to the FMCSA from roadside inspectors in 18

[7] https://www.bls.gov/news.release/pdf/ecec.pdf December, 2021 release.

[8] Mei, Qinfen, Mazen I. Hussein, and Alan J. Horowitz. "Establishing values of time for freight trucks for better understanding of impact of toll policies." Transportation research record 2344, no. 1 (2013): 135-143.

states. These estimates are used in the federal RIA and assume fringe benefits of 32% and overhead of 16%.

Table 2 summarizes our wage, fringe benefit, overhead, and hourly cost estimates. This analysis uses the following costs throughout the analysis: $38.30 per hour for driver labor costs, $53.14 per hour for truck and bus mechanic labor costs, $43.15 per hour for CMV clerical labor costs, and $58.39 per hour for roadside inspector labor costs.

Table 2: Wage, Time, and Labor Costs

Occupation	BLS Occupation Code	Mean Hourly Wage	Fringe Benefits	Overhead	Hourly Cost
Heavy and Tractor-Trailer Truck Drivers	53-3032	$24.71	51%	N/A	$37.31
Bus and Truck Mechanics and Diesel Engine Specialists	49-3031	$29.20	51%	27%	$51.98
Information and Record Clerks, All Other	43-4199	$23.71	51%	27%	$42.20
Transportation Inspectors	53-6051	$39.45	32%	16%	$58.39

Source: Bureau of Labor Statistics, https://www.bls.gov/oes/#data

2.3. Compliance Costs

2.3.1. ELD Device Costs

ELD device costs are the primary cost category associated with the regulation. As previously discussed, some CMV operators and drivers may already have compliant systems in place, and thus costs must be separated between drivers with voluntary ELD use.

New ELD

The first group considered are drivers with no existing ELD. To avoid citation, drivers in this group will need to purchase new ELDs to become compliant (in the same year the regulation is implemented), and these represent the bulk of costs to California businesses. The associated costs for this group are the hardware cost of the ELD as well as labor costs to install the device. In regard to hardware costs, both a low-cost and high-cost option are presented. As the ELD market has evolved significantly since the federal regulation was introduced, these options are considered to better represent the range of total costs.

Table 3: Top Selling ELD Solutions in 2020

Device Name	Initial Cost	Ongoing Fees (per Truck)	FMCSA Compliant
AT&T Fleet Complete	$0	35	Yes
BigRoad DashLink ELD	0	50	Yes
Blue Ink Technology ELD	$295	$0	Yes
CarrierWeb CarrierMate	$700	$30	Yes
EROAD Ehubo ELD	0	60	Yes
Ezlogz	0	35	Yes
Garmin ELD	$250	$0	Yes
Gorilla Safety ELD	$0	$10	Yes
J.J. KELLER Encompass	0	33	Yes
KeepTruckin ELD	$150	$35	Yes
Linxup	250	50	Yes
Omnitracs (IVG) Intelligent	800	35	Yes
Pedigree ELD Chrome	$499	$25	Yes
PeopleNet Display.4	240	*60*	Yes
Rand McNally – ELD 50	$149	30	Yes
Samsara	$99	$33	Yes
Stoneridge EZ-ELD	$169	$15	Yes
Teletrac Navman	$0	$45	Yes
Transflo ELD T7	$99	30	Yes
Verizon Connect	$0	$60	Yes
Average	$185	$34	
Standard Deviation	$236	$18	
Lower Bound	$0	$16	
Upper Bound	$421	$51	

Source: https://www.besteldevices.com/best-eld-guide/

Less expensive options leverage existing smart phone or tablet technology with a separate piece of hardware. The hardware is used to connect the diagnostic port of the vehicle while a smartphone app allows drivers to track driving hours. One of the leading manufacturers of this technology is KeepTruckin that offers the highest rated logbook app. The KeepTruckin ELD costs $150 and requires a $20/month software service. It is assumed that drivers will use their existing smartphone to use the ELD.

More expensive options represent ELD devices that are self-contained pieces of hardware that require no additional smartphones or tablets. These are specialized devices that often include touchscreens and are manufactured for the sole use of ELDs.

Omnitracs is a leading manufacturer of such devices, and our estimates are based on the IVP model which retails for $800 and requires a $23/month software service.[9]

Regardless of the device used, it is assumed that an average lifetime of 5 years before being replaced.[10] Current offerings of ELD solutions are quite diverse and, while underlying technology costs have declined, features (including emergency contact, 2-way communication, mobile phone implementation, etc.) have expanded to offset significant price declines in many cases. The authors surveyed the 20 top selling ELD devices in 2020, considering average fleet size and freight size vehicles and revised estimates (Table 3) accordingly.

Thus, for the lower-cost device over a ten-year span this assumes year 0 costs of $150, year 5 costs of $150, and year 10 costs of $150. A similar distribution of costs would hold for the more expensive device. Additionally, growth in the sector is accounted for by assuming a 5% growth rate in the heavy and tractor-trailer truck driver sector, based on BLS projections from 2018 – 2028.[11] For the first 5 years each new driver that enters the sector will require an ELD. In year 5, the analysis also accounts for the cohort replacement costs and each year between 5 and 10 has both replacement and new driver costs. Replacement cost by pre-compliant drivers is again considered part of the SRIA Baseline, and not factored into the regulatory impact. New drivers (i.e. those in the 5% growth category) are all assumed (for convenience only) to be adopting because of the regulation, making their costs incremental.

New ELD purchases will also have installation costs. It is assumed that the device will need to be installed in the first year and removed and reinstalled in subsequent years. The length of time for installation varies depending on the type of device. The lower cost device requires a quick installation which it is assumed will take 0.5 hours. It is assumed that removal will take half the time therefore removal and reinstallation in future years takes 0.75 hours. For the more expensive ELD option, it is assumed that a more involved installation that will take 2 hours to install and 3 hours to remove and install. With an estimated labor rate of $54 of truck mechanics, this implies a new installation labor cost of $27 and a replacement labor cost of $40 for the less expensive device. For the more expensive device, new installation labor costs are $108 and replacement labor costs are $162. Costs are summarized below in Table 4.

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[9] The IVP is the successor to the model used in the federal RIA. That model, the Omnitracs MCP50 was discontinued and replaced by the IVP.

[10] Based on IRS guidance of depreciating computer equipment where full depreciation is reached in year 5. This falls outside of the manufacture warranty of three years, so we assume hardware will need replacement every 5 years. https://www.irs.gov/pub/irs-pdf/i4562.pdf. Accessed May, 2021.

[11] See https://data.bls.gov/projections/nationalMatrix?queryParams=53-3032&ioType=o. Accessed July 2021.

Table 4: Costs of ELDs, 10-year horizon, (2020 $)

	Hardware Costs	New Installation Labor	Replacement Installation Labor	Monthly Fees	Total Annualized Costs (0% discount rate)
Lower Bound ELD	$0	$26.97	$40.45	$16	$198.74
Upper Bound ELD	$421	$107.87	$161.81	$51	$723.17

Given the stream of future costs associated with new ELD purchases and installation, it is appropriate to annualize costs in order to estimate the approximate yearly costs. To do so, calculate the total stream of future costs from which an annualized cost can be derived. Costs are annualized over a 10-year time frame with a 0% discount rate. In each year the total cost of new ELDs are calculated multiplying the hardware costs (both device and annual subscription) by the number of new drivers. Beginning in year 5, replacement costs are considered as the old cohort of drivers must begin replacing devices. Total costs are then combined across each unique year and annualized to estimate yearly costs across the 10-year forecast. With an estimated 226,771 drivers needing new ELDs during the first year of regulation, and the sector growing at 5% annually over the 10-year forecast, annualized costs are estimated between $15 and $55 million depending on device type (Table 6).

Drivers with Existing ELDs

We anticipate drivers with an existing ELD will incur no additional costs from the regulation. Given these drivers voluntarily elected to purchase and install ELDs in the absence of the regulation, their costs are part of the policy Baseline and not incremental from the perspective of the SRIA. Taken together, the assumptions of the above narrative yield the patterns of ELD adoption and commensurate cost are presented in Tables 5 and 6, respectively. As noted, an annual growth rate for the statewide CMV fleet of 5% is assume.

Table 5: Aggregate ELD Adoption Patterns (5yr product life)

	Total CMVs		Long Haul		Short Haul		Replacements		New ELDs	
Year	CMVs	ELDs	CMVs	ELDs	CMVs	ELDs	Pre-SRIA	SRIA		Total SRIA
2020	366,800	169,168	278,768	153,322	88,032	15,846				
2021	385,140	177,626	292,706	160,988	92,434	16,638				
2022	404,397	404,397	307,342		97,055		35,525		226,771	226,771
2023	424,617	424,617	322,709		101,908		35,525		20,220	20,220
2024	445,848	445,848	338,844		107,003		35,525		21,231	21,231
2025	468,140	468,140	355,786		112,354		35,525		22,292	22,292
2026	491,547	491,547	373,576		117,971		35,525		23,407	23,407
2027	516,124	516,124	392,255		123,870		35,525	226,771	24,577	251,348
2028	541,931	541,931	411,867		130,063		35,525	20,220	25,806	46,026
2029	569,027	569,027	432,461		136,567		35,525	21,231	27,097	48,327
2030	597,479	597,479	454,084		143,395		35,525	22,292	28,451	50,744
2031	627,352	627,352	476,788		150,565		35,525	23,407	29,874	53,281

Table 6: Aggregate ELD Costs under High and Low Hardware Cost Assumptions

	ELD Purchases (units)			Adoption Costs (million$)			
				Unit Cost:	$ 198.74	Unit Cost:	$ 723.17
	New SRIA	Replace SRIA	Replace Existing	SRIA	ELD	SRIA	ELD
2022	226,771	-	35,525	$ 45.068	$ 7.060	$ 163.994	$ 25.691
2023	20,220	-	35,525	$ 4.018	$ 7.060	$ 14.622	$ 25.691
2024	21,231	-	35,525	$ 4.219	$ 7.060	$ 15.354	$ 25.691
2025	22,292	-	35,525	$ 4.430	$ 7.060	$ 16.121	$ 25.691
2026	23,407	-	35,525	$ 4.652	$ 7.060	$ 16.927	$ 25.691
2027	24,577	226,771	35,525	$ 49.953	$ 7.060	$ 181.767	$ 25.691
2028	25,806	20,220	35,525	$ 9.147	$ 7.060	$ 33.285	$ 25.691
2029	27,097	21,231	35,525	$ 9.605	$ 7.060	$ 34.949	$ 25.691
2030	28,451	22,292	35,525	$ 10.085	$ 7.060	$ 36.696	$ 25.691
2031	29,874	23,407	35,525	$ 10.589	$ 7.060	$ 38.531	$ 25.691
Decadal	449,726	313,921	355,253	$ 151.767	$ 70.603	$ 552.246	$ 256.908
Annual	44,973	31,392	35,525	$ 15.177	$ 7.060	$ 55.225	$ 25.691

2.3.2. New Equipment for Roadside Inspectors

Equipment for roadside inspectors was a major cost category for the federal regulation but will not be significant for California. The federal RIA assumed that roadside inspectors would interact with ELD data via Bluetooth adapter and a USB flash drive. However, due to security concerns this method of transfer was never used and instead the FMCSA created a software program and server system to transmit data securely. California roadside inspectors can access this software using existing computers and therefore we assign no costs to this category.

2.3.3. Training Costs

Training costs are another significant cost category. The primary costs related to this category come from the lost productivity from completing training. The opportunity cost of this lost productivity can be measured by the relevant labor costs and the number of hours of training required.

Driver Training

Drivers that receive new ELDs will be expected to understand how to use them. Although this might not represent a formal training session, the learning curve will still incur some costs. We relate these costs to the opportunity cost of foregone productivity as measured by wages and time. We assume that it will take drivers on average 0.5 hours to become familiar with new ELDs and an average hourly driver labor cost of $35. Total costs per affected drivers would be approximately $18.

There are ongoing training costs for drivers as well. Once drivers are familiarized with ELDs we assume this knowledge will carryover if they work for a different CMV operator. Therefore, turnover is not a relevant parameter to measure ongoing costs. However, as new drivers are hired and become CMVs drivers for the first time they will need to familiarize themselves with ELD use. Therefore, the relevant parameter to measure ongoing driver training costs is the growth rate in the sector opposed to the separation rate. We assume a 5% growth rate in the heavy and tractor-trailer truck driver sector. Once again, the future steam of costs has been "levelized" with annual averages. Total costs are found by multiplying the number of drivers who require new ELDs by the annualized training costs. In total, we find an annualized cost of approximately $809,507 for driver training programs.

Roadside Inspector Training

For roadside inspectors we assume no additional training will be required. After the federal regulation went into effect, roadside inspectors completed training for interstate ELDs. As the underlying technology is the same for interstate and intrastate, we assume inspectors are therefore familiar with ELDs and there will be no additional training costs.

2.3.4. HOS Compliance Costs

The final cost category we consider represents the additional labor costs arising from hiring drivers to ensure HOS compliance. The increased usage of ELDs is expected to reduce HOS violations, and this in turn means additional drivers will be needed to fill the gap between prior HOS overage and compliance. In absence of the regulation, drivers violate HOS by driving beyond legal amounts. As ELDs bring violations down, the hours of driving that occur beyond the legal limit will be driven by new drivers.

In order to estimate these costs, we rely on work from the federal RIA. In that document, the FMCSA estimates the full cost of HOS compliance per new ELD. This is done in several steps (see Appendix 2 for details). First, the RIA calls on estimated effects from changes in the federal HOS rules from 2013. During this regulatory change, the FMSCA considered survey data on driver schedules to estimate how well the industry was complying and how future rule changes would affect compliance. In the analysis of that regulation, the FMSCA estimated the number of new drivers and CMVs that would be needed to redistribute the workload so that no driver would have HOS violations.

These costs serve as the baseline and are adjusted to estimate the impacts to the federal ELD regulation. First, the costs are adjusted for inflation from year 2000 dollars to year 2020 dollars. Second, the costs are adjusted for increases to CMV vehicle miles traveled as a proxy for industry growth. Third, costs are adjusted to account for observed HOS compliance as measured by roadside inspectors.

Adjusted total compliance costs are then downscaled to a weighted average compliance cost per CMV. Costs per CMV represent a move to full compliance from a baseline that includes CMV operators that already use ELDs. To isolate the compliance cost attributed only to new ELDs, we assume that ELDs are effective in reducing HOS violations by 33%. With this assumption the compliance costs per CMV for each new ELD are estimated.

Ultimately, the RIA estimates a compliance cost per new ELD of $286 for LH and $193 for SH (as SH CMV operators have less HOS violations, costs are lower). The Department of Transportation has not found it necessary to update these estimates, but we have adjusted them for inflation. In particular we estimate that the annual cost for increased HOS compliance from ELD use is $315 for LH and

$213 for SH in year 2020 dollars. Total costs for this category are then estimated by multiplying the number of anticipated new ELDs (LH and SH drivers without ELD or FMS) by this cost. Overall, we estimate total costs for this category to be $4.3 million, the second largest cost category. Annualized total direct costs specific of the regulation are summarized below in Table 7.

Table 7: Total Regulatory Costs (million $, annualized)

	Low Cost	High Cost	Average
New ELD Hardware	$15.177	$55.225	$35.201
Training	$0.810	$0.600	$0.705
HOS Compliance	$13.070	$13.070	$13.070
Total	$29.057	$68.895	$48.976

2.4. Incentives for Innovation

The mandated use of a new piece of technology inherently implies the sector is strong candidate for innovation. Indeed, in the years following the federal ELD mandate, previously dominate manufacturers such as Omnitracs have seen their market share fall as new start-ups have entered the market. Companies such as KeepTruckin, Samsara, and BigRoad have all taken market share by offering low-cost models leveraging apps and smartphones. These start-ups have been especially effective of gaining market share in the small fleet segment and have seen their valuations and market share grow significantly in past years.

2.5. Small Business Impacts

Understanding the differential impacts between small and large businesses are important given the cost structure of the regulation. In general, smaller businesses may may find it harder to fund the new costs, especially when such a large percentage are driven by an upfront hardware cost. To estimate the differential impacts, we first must estimate the number of small business employees in California. According to the U.S. Small Business Administration, 32.6% of Transportation and Warehousing employees worked for a small business.[12]

[12] Source, US Census Bureau, release 5/28/2021, https://www.census.gov/data/tables/2018/econ/susb/2018-susb-annual.html

We use this percentage to share out the number of affected drivers and estimate impacts to small businesses. As roadside inspectors are government employees the small business designation would not apply to them and these costs are not considered in our estimates. Estimates for small businesses by cost category and provided below in Table 8.

Table 8: Total Regulatory Costs for Small Business (million 2020$, annualized)

	Low Cost	High Cost	Average
New ELD Hardware	$3.907	$14.217	$9.062
Training	$0.196	$0.196	$0.196
HOS Compliance	$1.402	$1.402	$1.402
Total	$5.505	$15.815	$10.660

Estimating the incidence of these aggregate costs on individual enterprises, especially how they affect market entry and exit, is quite difficult because of the heterogeneity of the small business community in this sector.[13] The extent of financial impact for each enterprise will depend on their fleet characteristics such as number of vehicles, prior ELD adoption, and general profitability. No reliable data is available on the size distribution of enterprises providing CMV services eligible for ELD regulation. Having said this, direct costs and benefits per vehicle are measured in hundreds rather than thousands of dollars, making it unlikely that compliance with this regulation will trigger significant market entry or exit for small enterprises.

2.6. Competitive Advantage/Disadvantages for California Businesses

California businesses likely face a competitive disadvantage as this regulation follows federal regulation. Thus, federal CMV operators have experience using ELDs while some California operators do not. There will be a learning curve and adjustment period as California businesses adapt to the new regulation that federal carriers have already overcome. We anticipate any disadvantage to be small because paper recording is an established practice in the state and adoption costs for the next technology are quite low compared to other operating expenses. Many

[13] At the time of this report's preparation, there were no reliable statistics on the size distribution of CMV ownership in California, let alone their individual cost of profitability characteristics.

CMV operators in California are familiar with ELD technology already and the learning curve for the rest will not be steep.

Although many of the new FMS and ELD start-ups are based in California, it is hard to argue for any competitive advantage based on their location. These companies are national in scale, and any advantage due to this regulation would already be captured by compliance with the federal regulation. It is conceivable that smaller, pre-ELD California companies may face intensified competition from those who are already Federally compliant, but again the modest technology adoption and learning costs are unlikely to pose an existential threat.

3. Benefits to California Businesses and Consumers

The proposed regulation is expected to generate benefits in the form of avoided costs. These avoided costs can be broadly divided into two categories: (1) savings from reduced paperwork and (2) savings from avoided accidents. Savings from reduced paperwork can be further divided into personnel time saving from avoided paperwork and materials cost savings from reduction in the number of paper logbooks purchased. Savings from avoided accidents arise because adoption of ELDs is expected to reduce HOS violations and, through a reduction in the number of these violations, reduce the risk of accidents caused by tired drivers. The following section examines each of these benefits separately and estimates total expected benefits from the proposed regulation.

3.1. Savings from Reduced Paperwork

Absent ELDs, drivers are required to record their HOS on paper logs. Completed logs are then submitted to clerical office staff for processing. ELDs eliminate most of the time associated with this process as well as the cost of the paper logs. Table 8 shows estimated paperwork savings per driver from ELD use in year 1. Derivations of these estimates are shown in the following sections.

Table 9: Paperwork Savings per Driver (2020 $)

Driver Filling out RODS	Driver Submitting RODS	Clerk Filing RODS	Elimination of Paper Log Books	Total Paperwork Savings
$646.37	**$74.82**	$177.92	$64.35	$952.22

3.1.1. Driver Savings

ELDs reduce the time drivers spend logging their HOS, however, they do not eliminate it completely. Use of ELDs still requires drivers to login, logout, and change duty status but it eliminates the requirement to manually log hours and to submit the logged hours to the home office. The FMCSA estimates that, absent ELDs, drivers spend 4.5 minutes per RODS and that they fill out an average of 240 RODS per year (FMCSA 2015) for a total of 1,080 minutes (18 hours) of savings per year. In addition, ELDs eliminate the need for drivers to forward their completed RODS to the home office. The FMCSA estimates that this process takes 5 minutes and occurs 25 times per year (FMCSA 2015) for a total of 125 minutes (2.08 hours) per year. Drivers of heavy and tractor-trailer trucks have an average hourly wage of $23.10 per hour in California (BLS 2021[14]) and employers are assumed to pay an average of 55% for fringe benefits (FMCSA 2015) leading to an estimated cost of $35.80 per driver's hour in current dollars. Multiplying the time saved from drivers not filling out RODS and the time saved by drivers not submitting RODS by the cost of a driver-hour leads to estimates of $636.30 and $73.65 in savings per driver per year, respectively.

3.1.2. Clerk Savings

ELDs reduce the time clerical staff spends logging RODS. The FMCSA estimates that it takes 1 minute for clerical staff to process each RODS and that clerical staff process 240 RODS per driver per year (FMCSA 2015) leading to a time saving of 240 minutes (4 hours) per year. Clerical staff in California have an average hourly wage of $22.53 (BLS 2019[15]). Following the approach in the Federal ELD RIA, we assume the same fringe benefits for clerical staff (55%) as well as an additional 27% cost for overhead (office space, etc.), which leads to an estimated cost of $44.58 per clerical hour. Multiplying hours saved by hourly cost of clerical work leads to an estimate of $177.92 saved on clerical employee costs per driver per year.

3.1.3. Paper Savings

Drivers operating vehicles equipped with ELDs are not required to purchase logbooks to regularly record their HOS. Drivers are, however, required to keep at least one paper logbook in case the ELD malfunctions. Following FMCSA (2015) we estimate that drivers without ELDs purchase one paper logbook per month. Once ELDs are adopted we assume only one logbook needs to be purchased per year to serve as an ELD backup. Therefore the need to purchase eleven logbooks per year is eliminated. One of the leading vendors of paper logbooks has a list

[14] , https://www.bls.gov/oes/current/oes_ca.htm#00-0000
[15] , https://www.bls.gov/oes/current/oes_ca.htm#00-0000

price of $5.85 per book as of January 1, 2020.[16] Multiplying eleven logbooks saved by $5.85 results in $64.35 in savings on paper costs per driver per year.

3.1.4. Total Paperwork Savings

Combining the savings from reduction in driver time filling out and submitting RODS, clerical staff processing RODS, and the cost of paper logbooks, we estimate a total paperwork saving of $952.22 per driver in year 1. Applying this benefit to the drivers adopting new ELDs because of the regulation (See Table 5, column 2) implies savings of $216M in year 1. Accounting for the increase in drivers associated with 5% annual sector growth, and with a discount rate of 0%, annualized benefits from paperwork savings over the 10-year period are estimated to be $272M (Table 10).

3.2. Savings from Avoided Accidents

Each year traffic accidents involving large trucks result in billions of dollars of damages across the United States. In California, over the period 2017-2020, there were an average of 395 fatal crashes and 11,789 non-fatal injury accidents involving large trucks each year.[17] FMCSA estimates that risk of accidents increases when drivers exceed their maximum hours of service limits. One measure of the frequency of tired driving is the number of instances of HOS violations. In the past five years there were an average of 37,094 HOS violations cited per year in California[18]. This number underestimates the total number of times drivers exceeded legal HOS limits because it only represents the times drivers were inspected and cited. One of the motivations for requiring ELDs is to reduce these HOS violations with the hope that this will in turn reduce the number of accidents caused by tired drivers. While there is some evidence that ELD adoption does in fact lead to a reduction in HOS violations and to a reduction in the number of accidents,[19] data limitations make it difficult to precisely measure the effect of HOS violations on crash risk. We therefore follow the approach utilized in the Federal RIA (FMCSA 2020) and estimate a reduction in crashes with FMCSA's crash reduction model[20] parameterized to California data (see Appendix 2 for details).

[16] https://www.jjkeller.com
[17] FMCSA MCMIS: https://ai.fmcsa.dot.gov/CrashStatistics/rptSummary.aspx
[18] FMCSA MCMIS: https://ai.fmcsa.dot.gov/SafetyProgram/RoadsideInspections.aspx
[19] Hickman, et al. *Evaluating the Potential Safety Benefits of Electronic Hours-of-Service Recorders.* Final Report. April 2014.
[20] U.S. Department of Transportation. FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model, Version 1.2—Report for FY 2013 Interventions (2015).

Table 10 shows an overview of the crash savings estimates and subsequent sections detail the calculations. Overall, it is estimated that the proposed regulation would reduce the number of HOS violations by 2,568, and that this would lead to approximately 83 fewer crashes per year. Valued at $292,000 per crash, this leads to an overall estimate of $24.3M saved from avoided crashes in year 1. Accounting for sector growth this translates to $34.7M in annualized savings over 10 years.

Table 10: Savings from Crash Reduction (2020 $)

Period	Number of avoided HOS violations	Number of avoided crashes	Average cost per crash	Total Savings from avoided crashes
Year 1	2,568	83	$292,000	$24.3M
Annualized	-	-	-	$34.7M

3.2.1. Estimating the number of avoided crashes from ELD adoption

FMCSA's crash reduction model is utilized in conjunction with data on the number of HOS violations in California[21] and estimates of the reduction of HOS violations associated with ELD adoption[22] in order to estimate the effect of ELD adoption on HOS violations and, in turn, on crash risk reduction. Crash reduction is estimated in three steps: (1) estimate the number of HOS violations in California among drivers that currently do not use ELDs but would use ELDs under the proposed regulation (2) estimate the number of HOS violations that would be avoided under the proposed regulation (3) use the crash reduction model to estimate the number of avoided crashes associated with the HOS violation reduction estimated in 2. The following sections describe these steps in detail.

(1) Estimate the number of current HOS violations among drivers not currently covered by the federal regulation but who would be required to adopt ELDs under the proposed regulation

Data are available from the FMCSA Motor Carrier Management Information System (MCMIS) on the number of HOS violations by type and by year for California. Data include the number of inspections and the number of violations by large trucks in California for 151 different HOS violation codes. We utilize data for 2015-2019 fiscal years and take the average number of violations by violation type

[21] FMCSA MCMIS: https://ai.fmcsa.dot.gov/SafetyProgram/RoadsideInspections.aspx
[22] FMCSA (2015) Tables 27-28

across years. This gives an estimate of the average number of HOS violations by large trucks in California per year.

However, these numbers include violations by drivers in all types of vehicles regardless of whether they are equipped with ELDs. We therefore make adjustments in order to better estimate the number of HOS violations by vehicles and drivers that do not currently use ELDs but that would be required to adopt them under the proposed state regulation. It is not possible to identify this group from the data, however. Some of the violations may be incurred by drivers and vehicles already equipped with ELDs. Moreover, it is also possible that some of the violations may be incurred by drivers that are neither equipped with ELDs nor would they be required to use ELDs by the proposed California regulation. In order to limit the over-counting of violations we first omit any violations related to onboarding recording devices (e.g., 395.13B). We do not have sufficient information to divide the data further so we scale the number of violations by the share of trucks without ELDs. We then assume that all remaining violations were incurred by vehicles and drivers that would adopt ELDs as a result of the proposed regulation. In total we estimate there were an average of 7,782 HOS violations per year among vehicles in CA that have not yet adopted ELDs but would be required to do so under the proposed regulation (Table A1).

(2) Estimate the reduction in HOS violations under the proposed regulation

FMCSA used data from five motor carriers that voluntarily adopted ELDs to estimate the rate of HOS violation reduction by violation type following ELD adoption. We rely on their numbers[23] along with data on the average number of HOS violations in California to estimate the reduction in violations that would be achieved under the proposed regulation (Table A2). For each violation we multiply the estimated percent share in violation type by the number of violations of that type estimated in step 1 above. In total we estimate that the proposed regulation would help avoid 2,568 of the 7,782 violations estimated in the previous step, a reduction of 33%. The reduction estimated here for California is smaller than the 45% reduction estimated in the federal RIA and the difference is due to differences in the pre-regulation rate and type of HOS violations observed in California compared to the U.S. overall.

(3) Estimate the number of avoided crashes under the proposed regulation

Following the federal RIA (FMCSA 2015) we rely on the *FMCSA Safety Program Effectiveness Measure: Intervention Model Fiscal Year 2009* to estimate a crash

[23] FMCSA (2015) Tables 27-28

reduction associated with elimination of each HOS violation type. Estimated crash reductions for each violation type are shown in Table A3. The numbers represent the annual number of crash reductions for each violation assuming 240 working days per driver. The maximum crash reduction can be achieved by reducing the number of violations for driving after being declared out of service because this violation has been found to be associated with the highest number of crashes. For most violations 1 crash is avoided for every approximately 40 avoided violations.

Each of the crash risk reductions in this step is matched to the estimated change in violations in California by violation type estimated in the previous step. Crash risk is then summed up across violation types to estimate total reduction in crashes. In total we estimate an average reduction of 83 crashes associated with the proposed regulation in year 1.

3.2.2. Valuing avoided crashes

Data on the cost of crashes of different severities[24] was translated into 2020$ and used to value crashes that result in no injury, non-fatal injury, and fatal injuries, respectively. These costs include medical costs, emergency services, property damages, lost productivity from road congestion, emission and additional fuel from road congestion, and the cost of injuries/fatalities. Data on the frequency and severity of different crash types is available from the National Highway Transportation Safety Administration's (NHTSA) General Estimates System and Fatality Analysis Reporting System. The average cost of crashes, weighted by frequency of crash severity, is estimated to be $292,000.

This number comes from national data and is assumed to be representative of the costs of a crash in California. On average, California is more expensive than other states, so this is likely an underestimate of crash cost in California. However, state specific data on crash cost was not available.

Multiplying the number of avoided crashes (83) by the weighted average cost per crash ($292,000) gives us an estimated benefit of $24.3M from avoided crashes in year 1. Following the assumptions on industry growth detailed in the costs section above results in a 10-year annualized saving of $34.7M.

3.2.3. Caveats

There has been some debate on the extent to which ELD adoption reduces crash risk. If ELDs enforce strict HOS limits that drivers may be incentivized to drive more

[24] Zaloshnja, E. and Miller, T. (2006). Unit Costs of Medium and Heavy Truck Crashes. Final Report for the Federal Motor Carrier Safety Administration (FMCSA) and the Federal Highway Administration

aggressively when they are close to reaching their HOS limit in an effort to reach their destination prior to being forced to stop driving. This response could potentially work to offset the effect of reducing the number of tired drivers on the road leaving an overall ambiguous effect of ELD adoption on crash risk. Absent conclusive studies on ELD adoption and crash risk we follow the Federal RIA, acknowledge there is substantial uncertainty surrounding this issue, and present total benefits with and without benefits from crash risk reduction.

3.3. Total Benefits

Annualized paperwork savings over the 10-year period were estimated to be $272M and annualized savings from crash cost reduction were estimated to be $35M. With 5% growth of the sector and recurrent savings for adopters, this leads to annualized benefits of $306M from the proposed regulation.

Table 11: Total Savings from New ELD Adoption (2020 $ millions)

Period	Paperwork Savings	Avoided Crash Savings	Total Savings
Year 1	$ 216	$ 24	$ 240
Annualized	$ 272	$ 35	$ 306

Note: Annualized benefits are estimated over a 10-year period with a 0% discount rate.

4. Macroeconomic Impacts

4.1. Methodology

The economy-wide impacts of the proposed ELD regulation will be evaluated using the BEAR forecasting model. The BEAR model is a dynamic computable general equilibrium (CGE) model of the California economy. The model explicitly represents demand, supply, and resource allocation across the California economy, estimating economic outcomes over the period 2022-2031. For this SRIA, the BEAR model is aggregated to 60 economic sectors, with detailed representation of the construction sectors most likely affected by the ELD rule.

The current version of the BEAR model is calibrated using 2018 IMPLAN data for the California economy (BEAR: 2016b). Both the baseline and policy scenarios use the Department of Finance conforming forecast from June 2021 (see Appendix

1). The conforming forecast provides assumptions on GDP growth projections for the State and population forecasts.

4.2. Scenarios

The macroeconomic impact results are based on the expected changes in compliance costs attributable to the *regulatory implementation of* the ELD requirements. The main scenario, *Proposed*, represents the expected impact on the overall California economy of this compliance, and includes both the costs and benefits of the proposed ELD rule.

4.3. Inputs to the Assessment

In addition to the BEAR model's detailed database on the Baseline structure of the California economy, the macroeconomic assessment is calibrated to incremental, sector specific ELD compliance costs and cost reductions as the primary inputs for the impact assessment. Note that positive costs are associated with additional costs from compliance, such as purchasing and installing the ELD devices, while negative costs represent any savings attributable to reduced administrative and paperwork costs. Details of how these costs are calculated are discussed in previous sections, but it should be emphasized that the general equilibrium nature of the BEAR assessment tool takes as inputs the estimated private and public costs and benefits set forth in Section 3 above, applying them as direct (not net) costs and benefits and deriving indirect and induced costs and benefits that will be passed through markets (via prices) and institutional transfers across the state economy. All three forms of cost and benefit impacts are captured by this model and then aggregated into net economic impacts, annually over the period 2022-2031.

Incremental compliance costs are broken into two general categories: the increase in labor costs and the increase in material input costs. Labor costs, as detailed above, include any costs associated with hiring additional workers. Material input costs primarily consist of the purchase costs of ELDs. Incremental savings of the proposed ELD rule are also broken into two categories for the macroeconomic assessment: the savings to firms associated with reduced demand for labor as the time required to fill out paper logs declines and the reduction in intermediate firm demand for office supplies associated with paper logs. The annualized costs associated with these four categories are summarized in Table 12.

Table 12: Annualized Aggregate DIrect Costs and Benefits (million $)

Direct Costs	
ELD Technology	35.201
Driver Training	0.705
HOS Compliance	13.070
Direct Benefits	
Driver Time	203.305
Clerical Time	50.156
Supplies	18.140
Crash Avoidance	34.700
Net Direct Benefit	**257.325**
Benefit-Cost Ratio	**6.25**

4.4. Results

4.4.1. Overall Economy Response

For the *Proposed* intrastate ELD scenario, Table 13 presents impacts on the overall California economy over the period 2022-2031. A variety of macroeconomic metrics are listed, including level and percentage changes in real Gross State Product (GSP)[25], total Full Time Equivalent (FTE) state employment, gross state Output and Investment, and total Household Real Consumption. All monetary indicators are adjusted for inflation to a 2020 base year but not discounted. It is further assumed that in the first year of enactment (2022, Q4), direct impacts are half of what they would be on an annual average basis (Table 12). This allows for pre-emptive adoption beginning in Q3 before mandatory, universal compliance begins in Q4.

Although the magnitude of impacts varies over time and across comparison cases (see regulatory alternatives below), the salient macroeconomic finding is that the intrastate ELD rule will result in positive but relatively small net impacts on the state economy, as measured through these macroeconomic indicators. The simple reason for this is that estimated benefits for this regulation, including reduced labor costs from automated and real time monitoring, significantly outweigh incremental technology costs. As Table 12 indicates, net benefits average about $250M per year, and these (largely direct cost savings) begin to enter Investment from the

[25] GSP is the state-level counterpart of GDP, or the total value added of all formal sector activities in the state economy.

first year, contributing to compounded growth and modest job creation for the state economy.

Table 13: Economy-Wide Impacts of Intrastate ELD Regulations

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
Gross State Product	71	122	187	266	357	461	577	704	842	989	548
Employment (FTE)	1,802	2,894	4,083	5,356	6,714	8,156	9,677	11,275	12,946	14,687	9,112
Real Output	461	742	1,065	1,418	1,809	2,237	2,704	3,208	3,750	4,330	2,565
Investment	118	182	249	314	378	442	504	564	622	676	469
Household Consumption	(8)	3	27	66	118	185	267	363	473	598	262

Percent Differences	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	Average
Gross State Product ($M)	.00%	.00%	.00%	.01%	.01%	.01%	.01%	.02%	.02%	.02%	.01%
Employment (FTE)	.01%	.01%	.02%	.03%	.03%	.04%	.04%	.05%	.06%	.06%	.04%
Real Output	.01%	.01%	.02%	.02%	.03%	.04%	.04%	.05%	.05%	.06%	.04%
Investment	.03%	.04%	.05%	.06%	.07%	.08%	.08%	.09%	.10%	.10%	.08%
Household Consumption	.00%	.00%	.00%	.00%	.01%	.01%	.01%	.02%	.02%	.03%	.01%

Note: All results are annual average differences from Baseline over 2024-2031. All figures in 2020 $ millions or Full-time Equivalent (FTE) employment headcounts.

In this general equilibrium framework, incremental technology and training costs are offset by combined direct, indirect, and induced benefits of time savings and improved safety. In this way (combined with investment), $257M in annual direct savings is more than doubled on an average basis ($258M) across the decade following enactment. Thus, the majority of net adjustments arise from so-called “multiplier” or spillover effects from improved efficiency and the savings it confers on carriers and their clients. Extensive indirect and induced effects would of course be expected from a pervasive service like transportation, and these linkages are captured in the CGE assessment model. In addition to improvements in current indicators, rising income increases state savings and investment, offering growth leverage for the economy and sustaining increases in the same aggregates. Simply put, the proposed regulation improves regulatory and transport efficiency via technology adoption, contributing to a virtuous cycle of higher productivity and broad-based incremental economic growth.

4.4.2. Creation or Elimination of Jobs within California

As noted above, job creation is positive but modest, as would be expected by the small percentage changes in the aggregates. Most of the direct employment gains (about half the total) can be expected in the regulated industry since it enjoys the efficiency gains, followed by supply chain partners and of course ELD manufacturers. The magnitude of averted crash costs suggests that some downward pressure might be exerted on vehicle repair and medical services, although these will be very small demand shifts in percentage terms.

The employment effect of efficiency gains on the trucking sector itself will depend on the degree to which efficiency gains are reinvested technology or employment. Similarly, real wages could rise in the sector because of higher productivity, but this depends on bargaining characteristics that are not captured in the assessment model. For the majority of the aggregate aggregate stimulus following from this regulation, job creation will be dispersed across the economy through indirect and induced impacts.

4.4.3. Creation of New Businesses or the Elimination of Existing Businesses within California

There is no reliable data on transport trucking business entry into and exit from the Californa economy. Registration and licensing do exist, but lack of detailed interstate carriage data makes it impossible to identify individual fleet capacity adjustments that are confined to the state market. Many carriers “bridge” their fleets across state lines, and it is not feasible to disentangle their individual entry or exit from a single state market. Only time will tell how this adjustment plays out at the firm level, where the impact of the regulatory change will depend upon many sources of uncertainty.

4.4.4. Competitive Advantages or Disadvantages for Businesses Currently Doing Business within California

Although we lack the ability to consistently identify enterprise level market entry and exit, the ten-year trend net efficiency gains this regulation will improve competitiveness for California trucking services in their own state and other markets. Of course, this benefit will arouse competitive interest from out of state enterprises, but as many of these are already compliant they are unlikely to be moved to enter the state for this reason alone. In this way, the regulation offers a competitive advantage only to in-state operators.[26]

4.4.5. Increase or Decrease of Investment in California

Because the net benefits of the regulation are driven primarily by operating efficiency gains, the California trucking industry enjoys substantial savings that have been assumed to be reinvested in the state. Taking account of results in Tables 12, this can be expected to comprise about half of the estimated growth of induced investment over time (Table 13).

4.4.6. Incentives for Innovation in Products, Materials, or Processes

As noted in Section 2.4 above, California's trucking services industry has a long history of innovation for competitiveness, and this can be expected to continue. The regulation offers direct efficiency gains that firms can reinvest in new technologies, skills, and practices, but predicting these behavioral adjustments is beyond the scope of this study.

Thus innovation is likely to continue in the sector, and firms "behind the curve" of Federal standards will have strong incentives to adapt for national competitiveness. For the rest, many of the gains may have already been achieved through the federal regulation. In other words, because the California regulation succeeds the federal regulation, the incentives for innovation may have largely been realized.

4.4.7. Benefits to California Businesses and Consumers

While we have not addressed the social benefits of safer roadways for everyone in the state, this was a primary impetus for the regulation. Our estimates of the economic benefits of reduced crashes do take account of direct property and personal losses, but as noted these estimates rely on national data and are likely to be lower than California numbers, were the latter available. Also, benefits of a less risky transport environment might include less costly insurance options and other market responses outside the scope of this study. Broader measures of social welfare are not accounted for explicitly in this assessment.

Because of its extensive linkages to the rest of the economy, most businesses and households will benefit from a more efficient trucking industry. We have only

[26] It should be noted that this discussion does not address foreign (e.g. Canadian and Mexican) competitors.

captured the transmission of cost savings, but reliability and other features, including unforeseen complementary/induced innovations, can improve services to the majority of California enterprises and households. Contending with the recent COVID public health crisis has put unprecedented pressure on state supply chains to adapt and innovate. Cost savings from this regulation will facilitate progress in this essential process.

5. Fiscal Impacts

5.1. Revenue Implications

Our estimates of the public sector costs and benefits of the regulation are negligible in the aggregate, not a surprising result since none of the specific compliance actions has a direct fiscal component. Of course, aggregate economic growth can be expected to swell federal, state, and local public coffers, but the economic aggregates are moving less than 1/10th of one percent annually.

5.2. Public Sector Costs

At a more detailed level, costs and benefits for detailed CMV related regulatory/enforcement activity are very small compared to the overall industry savings and attendant multiplier effects. To take one example, roadside inspectors who are government employees are a potential fiscal impact. Whether the workload of inspectors increases or decreases depends both on the time allocated per citation as well as the number of citations issued. While ELDs help inspectors flag potential HOS violations, additional time is required to verify violations on the devices themselves and to identify supporting evidence of non-compliance. The time spent per citation is therefore expected to remain consistent with current practices. The number of citation issues depends on multiple factors.

As discussed above the proposed regulation is expected to result in a reduction in HOS violations overall (including both detected and undetected violations). On one hand this could reduce inspector workload because less violations imply less citations would be issued. However, ELDs are also expected to make it easier to identify potential violations, thereby increasing the share of violations detected, which could increase the number of citations issued for a given violation rate. While data required to quantify changes in the violation detection rate are unavailable, these two counteracting forces suggest a small change in workload is possible, although whether it would be an increase or decrease remains ambiguous.

Looked at from another perspective, ELDs have been around for many years now and have been part of CHP's inspection process for at least 4 years. No additional training will be required for CHP with intrastate adoption. ELDs are a method for drivers to keep track of their own hours. Currently, the Intrastate drivers are allowed to use paper logs to keep their time.

To compare:

- Current record of duty status (RODS) with paper logs are similar to a person at a meeting making handwritten notes of the minutes. Those notes may be difficult to read due to poor penmanship and may have missing items due to the note taker not hearing something said. This is what inspectors run into with drivers who maintain paper RODs - missing locations, dates, status, incorrect calculations.
- ELDs are an electronic version of the paper RODS. The person at the meeting now has a tablet and records it. The program on the tablet converts the conversation into transcribed minutes. The minutes are now easy to read and include the entire conversation. The ELDs are similar in how it records the miles, locations, and status of the driver automatically and transcribes that data into an easy-to-read, error-free format with negligible access costs.

These considerations explain why the regulation is not officially expected add time CHP inspections. Indeed, it will more likely save a minute or two since the electronic RODs will be more accurate and communicable. The RODs portion of the inspection only takes a few minutes in the vast majority of cases.

The net change in traffic incidents is more difficult to quantify. The drivers who would be subject to ELDs (electronic RODs) are the same ones currently required to maintain paper RODs. As in the example above, the person now required to keep the notes on the tablet was the same person required to keep the notes on paper before. The fixed cost of recording went up a bit, but their job is now easier on the administrative side once they learn the new system.

Meanwhile, the intrastate ELD requirement does not affect any CMV operators who are currently exempt from paper RODs. Thus, any local truck driver who is exempt from maintaining paper RODs will still be exempt from the new ELD RODs. Only drivers currently required to maintain paper RODs will now be required to adopt the new technology and more automated recording practices.

For these reasons, the proposed ELD regulation is not expected to have a significant measurable impact on other local and state government entities.

Because the net cost to intrastate carriers is not expected to increase, government agencies relying on private carriers are not likely to see increased transportation service prices.

5.3. Other Public Finance Issues

Based on current practice and understanding, there will be no Federal funding to reimburse the state's cost for enforcing this regulation. To this extent, increased enforcement cost could exert fiscal pressure on CHP's budget or be transmitted to other resources like the General Fund. There is currently no formal determination about dedicated financing for this aspect of regulatory implementation, but as noted above these incremental costs are assumed to be negligible. Finally, it is assumed that changes in citation fees would impact state, county, and local budgets according to the established revenue sharing rule: The state receives roughly 50 percent of traffic fine revenue, the county gets 40 percent, and cities and other collection programs receive 10 percent.

With respect to local governments, this regulation imposes a mandate which falls in the purview of Sec 6 of Article XIII B of the California Constitution. Although, it has a statutory exception under GC 17566 subdivision A, and has a fiscal impact, this is NOT a state reimbursable mandate. Having noted that, this assessment was not able to identify or estimate any non-reimbursable local costs that would arise from this regulation. To the extent that local governments might bear any part of emergency costs for crashes, these would yield some local savings.

6. Economic Impacts of the Regulatory Alternatives

As required for major regulations, this SRIA considers two regulatory alternatives to the Proposed Regulatory Scenario (PRS). For this analysis, the proposed scenario reflects results assuming DOF's projected growth rates for all relevant sectors.

6.1. More Stringent Regulatory Alternative

The current version of the PRS does not consider specific financial penalties for noncompliance. Such fines are typical of so called "moving violations", so it is reasonable to consider how the net benefits of the policy might be affected by adding a significant fine to PRS. In law enforcement, the theory for financial penalties is based on two principles: deterrence and compensation. Deterrence is a behavioral impact, where loss aversion makes individuals more reluctant to break rules. This effect is simple to understand but quite difficult to estimate. The principle of compensation has two components, enforcement cost recovery and social compensation for damage. In the present case, it is possible to estimate both, but with respect to the former CHP does not collect revenue for its citations – they are credited to local law enforcement agencies in the localities where citations are written. Fines based on the social cost of an infraction (without a crash) implicate a driver in damages caused by other people in other circumstances, but this is inconsistent with American jurisprudence. For actual damages attributable to HOS negligence, US civil liability and insurance provide appropriate remedies.

Assuming a deterrent fine is added to infractions, it is possible to compare this to the PRS and see the overall impact a more stringent regulation of this kind. This requires assuming a degree of deterrent “responsiveness”, essentially the percent change in violations for a given increase in the fine. There is some criminology literature on this subject, examining recidivism among traffic offenders, but it is far from conclusive.[27] Generally speaking, this evidence suggests that substantial increases in fines and license disqualifications have quite limited potential in deterring offenders, and the most consistent predictors of returning to court are the individual attributes of offenders.

In any case, the magnitude of the fine impact (uncertain) is less important to the present assessment than its direction (negative, higher fine implies lower infraction rate). Making the simple assumption that a significant fine ($1,000) reduces infractions by a modest amount will reveal how net macroeconomic benefits compare to the PRS. For example, assuming that a fine of $1,000 reduces infractions 10% would increase private cost of the regulation by $4.19M (90% of initial infractions times the individual fine). While this would generate citation revenue this would not accrue to state agencies. Thus, the public benefit does not offset the incremental private cost of the incremental fine.

It is not known how many additional carriers would adopt the technology in the presence of the fine, but assuming the same percentage would yield an additional $2.87M in technology adoption costs. Benefits, on the other hand would include

[27] See e.g. Tavares, António F., Sílvia M. Mendes, and Cláudia S. Costa. "The impact of deterrence policies on reckless driving: the case of Portugal." European journal on criminal policy and research 14, no. 4 (2008): 417-429.
Moffatt, Steve, and Suzanne Poynton. "Deterrent Effect of Higher Fines on Recidivism: Driving Offences, The." BOCSAR NSW Crime and Justice Bulletins (2007): 15.
Bar-Ilan, Avner, and Bruce Sacerdote. "The response of criminals and noncriminals to fines." The Journal of Law and Economics 47, no. 1 (2004): 1-17.

paperwork savings for the new adopters that is nearly equal to the fine ($952/carrier). If averted crashes due to deterrence were the same magnitude as the reduction in violations, this benefit have about the same value ($2.34M) as the ELD adoption cost for the newly compliant ($2.57M). Taken together, these components indicate that the more stringent policy would only have positive net economic benefits if the deterrent effect were so strong that it compelled adoption, reduced infractions, and achieved improved driving safety, all by significant and comparable amounts. According to the literature cited above, these effects may be uncertain, but they are very unlikely to be so great in any of these components. Thus, the private cost of increasing baseline fines for all violations ($4.19M) can be expected to dominate and reduce the state-wide economic benefits below those of the PRS. This argument supports the choice of the Proposed regulation.

6.2. Less Stringent Regulatory Alternative

Recognizing the fact that many carriers adopt ELD without be required to do so, a less stringent regulatory alternative would be voluntary adoption with supplemental public information on EDL benefits to users, insurers, and the general public. one that advises all commercial drivers to use ELDs instead of requiring their use. This approach could also encourage private sector support, such as insurance companies offering discounts for adoption.

The detailed scope of such a program is less important than understanding how it compares to the PRS, i.e. ascertaining if it be expected to yield larger or smaller net benefits for the California economy. To establish this, Less Stringent Regulatory Alternative is specified that assumes the same initial conditions, but implementation of a voluntary adoption standard that enjoys 50% uptake. In other words, this assumes that industry incurs half the aggregate adoption cost ($49M) it would in the mandatory PRS.

On the benefit side, this would also offer only half the paperwork savings. Applying this benefit to the 77,893 drivers, with total annualized benefits (at 5% annual sector growth) from paperwork savings over the 10-year period estimated to be $476.11M. The second main benefit, reducing the number of current HOS violations among drivers not currently covered, is assumed to fall half as much. In total, this estimates that the proposed regulation would help avoid 1,284 of the 7,782 violations estimated in the Baseline, a reduction of 16.5%. Avoided crashes are also assumed to fall by only half as much. Multiplying the number of avoided crashes (41.7) by the weighted average cost per crash ($292,000) gives us an estimated benefit of $12.2M from avoided crashes in year 1. Following the assumptions for industry growth detailed in the costs section above results in a 10-year annualized saving of $17.35M.

Since both costs and benefits decline by the same proportions in this scenario, the net benefit to the overall economy remains positive but falls by about half.[28] We do not have data to precisely estimate the actual “compliance gap” that would result from making the ELD program voluntary (with more emphatic public information), but two considerations lead is to conclude that the PRS is better for the California economy. Firstly, our simple 50% example indicates improved compliance short of the mandatory level would yield lower net macroeconomic benefits. Secondly, even this is an optimistic scenario because it assumes that those electing not to adopt present the same accident risks as those who are voluntarily compliant. In reality, it is more likely that higher risk drivers would opt out of ELD surveillance, meaning that averted losses from accidents in this scenario, as well as net benefits, could be much smaller. This reasoning is strongly supported by actuarial evidence in vehicle sector, which has shown across countries, vehicle type, age groups, etc., that uninsured drivers have significantly greater odds of causing crashes compared to insured drivers.[29] For this reason, the less stringent regulatory alternative can be expected to lead to lower net benefits.

[28] Technically, the assessment model is not linear (like many multiplier models) because economic behavior does not generally conform to such simple relationships, especially over time.

[29] See, e.g. Donaldson, James H. "Uninsured Motorist Coverage." Ins. Counsel J. 36 (1969): 397.

6.1. Macroeconomic Impacts

The regulatory alternatives are compared with the Proposed ELD regulation in Table 14, comparing the macroeconomic impacts in 2031, understanding that these two scenarios would trend like the Proposed Regulation scenario because that have qualitatively similar trends of positive annual net direct benefits over the assessment decade. Because the baseline California economy is growing over this period, all scenarios would be rising over time and qualitative differences between alternative regulatory impacts will be same in each year.

These results are fully consistent with the narrative interpretation above. The less stringent alternative offers about half the net economic benefits of the PRS, and the disadvantage would remain essentially proportional to lack of voluntary compliance. Again, compliance assumptions are quite optimistic in this case, but anything less than what would be achieved under the PRS will reduce net economic benefits.

Table 14: Macroeconomic Impacts of ELD Regulatory Alternatives

	Proposed	Less Stringent	More Stringent
Gross State Product ($M)	989	547	830
Employment (FTE)	14,687	7,313	14,343
Real Output	4,330	2,169	4,155
Investment	676	371	631
Household Consumption	598	309	519

Note: Difference from Baseline scenario in year indicated. All figures in 2020 $ millions or Full Time Equivalent (FTE) jobs.

Because of the imperfect deterrent effect of realistic fines, the more stringent alternative offers less economic benefit than the Proposed regulation, by all the metrics considered. A fairly close substitute was considered in this case, with the private fine just about equal to the benefit of compliance. Because of heterogeneity in the population, however, a uniform penalty is unlikely to achieve proportionate compliance, so even these inferior outcomes are unduly optimistic. Much stiffer penalties would add two important risks, encouraging evasion and discriminating against smaller carrier enterprises. Considering this and the greater complexity of implementing a more stringent enforcement mechanism, the PRS would be preferred to this alternative on economic and equity grounds.

For all the reasons discussed, the Proposed regulation is most beneficial on macroeconomic grounds.

7. Summary of Economic Results

The California Highway Patrol's proposal to modify its Record of Duty Status regulations to require the use of electronic logging devices for intrastate carriers is expected to result in both increased compliance costs for regulated carriers, a reduction in time and expenses related to paperwork for these same carriers, and benefits arising from fewer traffic accidents. The overall results suggest that the proposed regulatory action has a consistently favorable benefit cost ratio, depending on assumptions used for calculating compliance costs. In the main case considered, the ratio was 6.25=$306M/$49M (Table 12). The majority of direct cost and benefit fall on sectors that utilize intrastate carriers. All compliance costs calculated in this SRIA are attributable to these carriers and approximately 8% of the calculated benefits are attributable to time and material savings for regulated carriers. The remainder of the benefit incidence is incurred by carriers and the driving public, including substantial regulatory and transportation service efficiency gains that propagate across the California economy over space and time.

Empirical comparison with more and less restrictive regulatory alternatives (Section 6) reveals that the Proposed regulation is preferred on economic grounds. In the less restrictive case, realistic compliance assumptions led to lower net benefits, mainly because of lower averted damages and information cost savings. In the more stringent alternative, higher penalties for noncompliance imposed private economic costs without offsetting benefits because of limited deterrence potential.

While direct economic impacts are likely to be concentrated amongst regulated carriers, macroeconomic results suggest that the proposed ELD rule will have a negligible impact on the overall California economy. All required macroeconomic SRIA indicators, such as Gross State Product, employment, real business output, and household income show indiscernible impacts, compounded by extensive multiplier spillovers and growth dividends from reinvested efficiency savings.

8. References

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9. Appendix 1 - Department of Finance Compliant Baseline Calibration

9.1. Introduction

The following document provides background information on the baseline scenario calibration for the Berkeley Energy and Resources (BEAR) Model, conforming its macroeconomic projections to those of the California Department of Finance (DOF). [30, 31, 32] As a condition for implementation in Standardized Regulatory Impact Assessment (SRIA) analysis, economywide models must provide accurate reference baselines for comparison to their own SRIA regulatory scenarios as well as other state economic assessment.[33]

9.2. Macroeconomic Baseline Forecasts

There are three fundamental macroeconomic series of importance for baseline calibration: Population, Employment, and Personal Income. The following three figures compare forecasts for these series between DOF and BEAR. As it happens, population is exogenous (input) to the BEAR model, to these two series are identical. In the case of Personal Income, DOF forecasts only extend to 2019, but BEAR tracks these exactly through the calibration mechanism described in Section 9.5 below.

[30] California Code of Regulations, title 1, section 2003(b)

[31] https://www.dof.ca.gov/forecasting/demographics/projections/

[32] https://www.dof.ca.gov/Forecasting/Economics/

[33] We would like to express our thanks to the DOF Chief Economist and her staff for their cooperation and data sharing to support this calibration exercise. Any errors implementing these inputs are solely the responsibility of the authors.

Figure 9.1

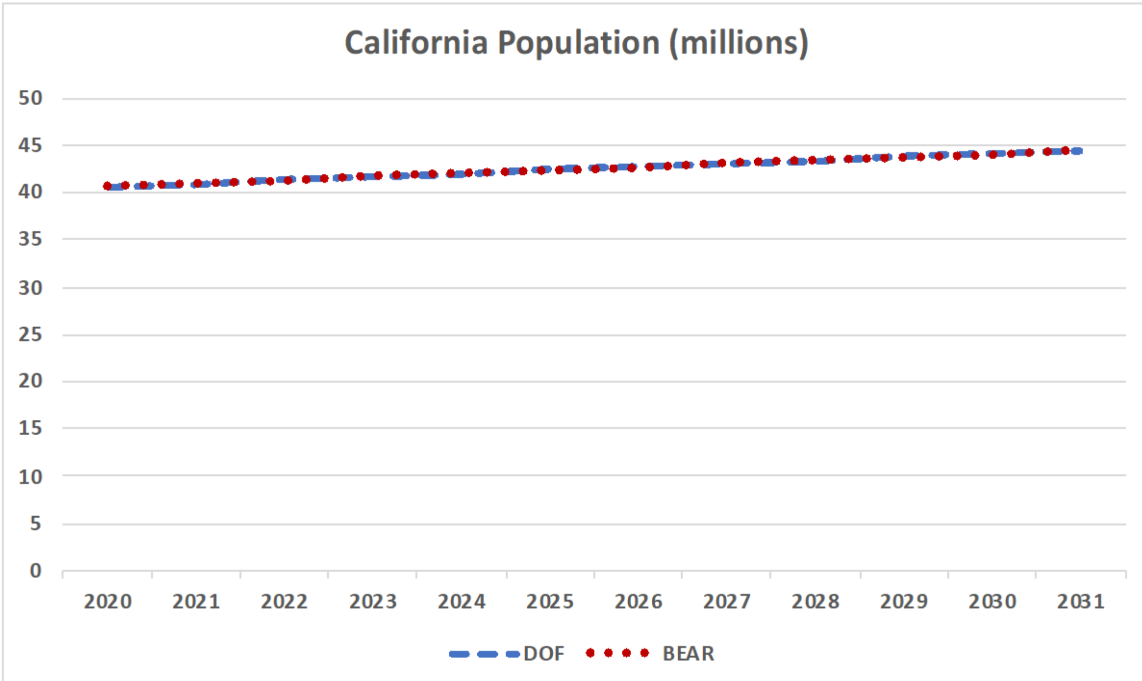
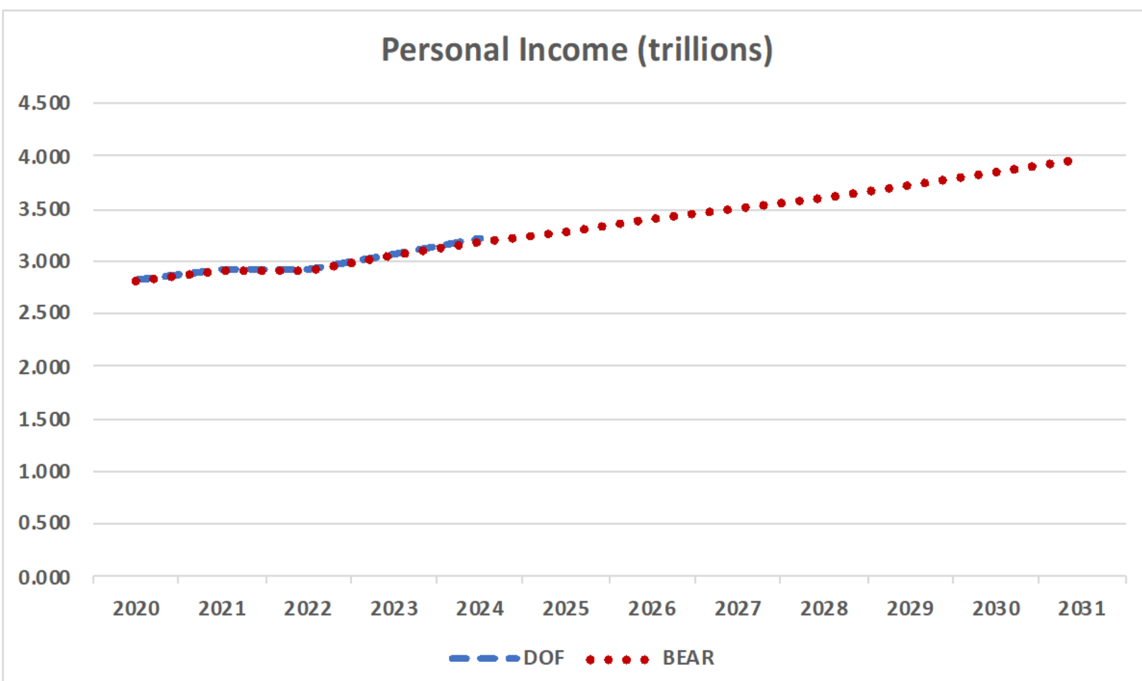


Figure 9.2



Beyond 2019, BEAR's aggregate Personal Income growth is calibrated to an average (2013-2019) of 4.5%. Finally, DOF and BEAR projections of Total Wages and Salaries and Employment are compared in Figures 2.4 and 2.5.

Figure 9.3

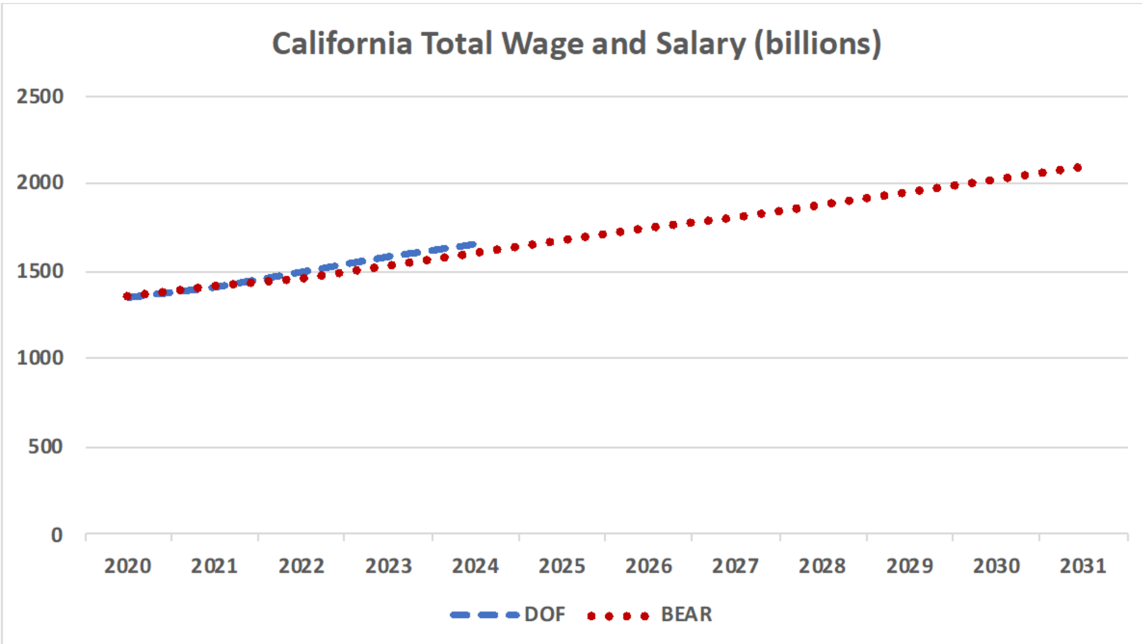
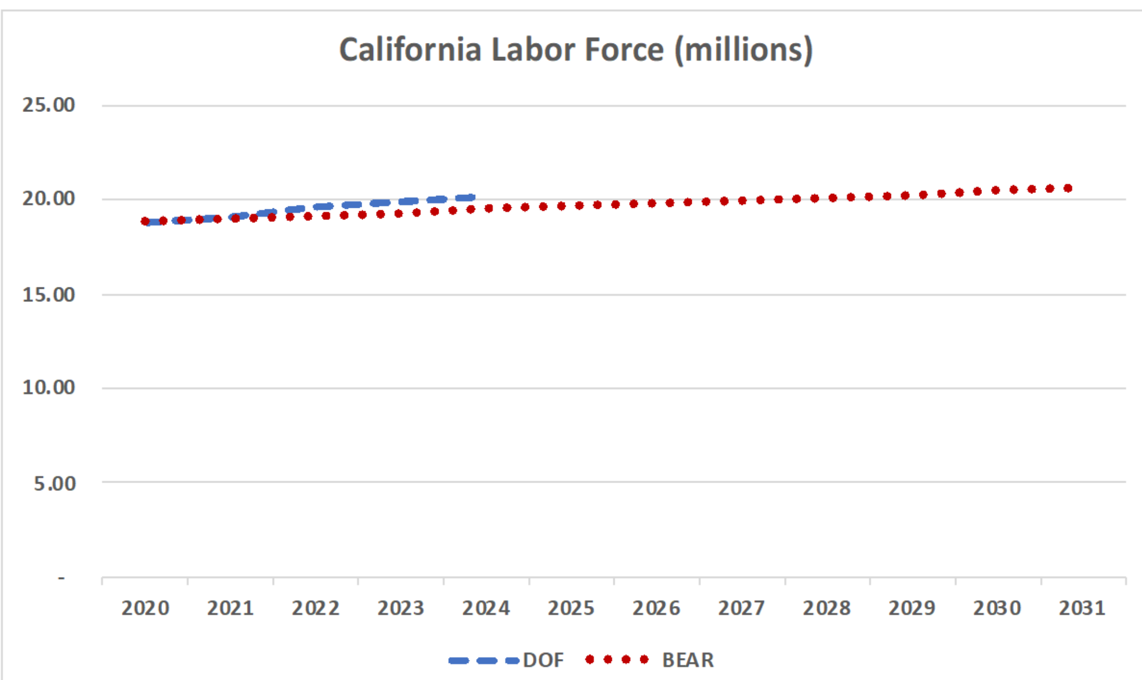


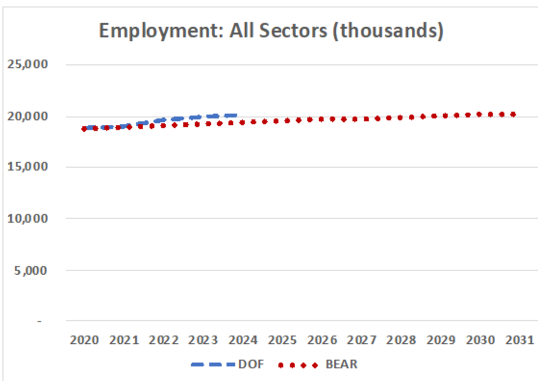
Figure 9.4



9.3. Sectoral Baseline Forecasts

The following figures summarize the results of the BEAR baseline calibration for a 12 sector aggregation compatible with published DOF forecasts. The latter projections (blue dashed series) are for the years 2020-2024 only, while BEAR extrapolates these annually to 2031.

Figure 9.5



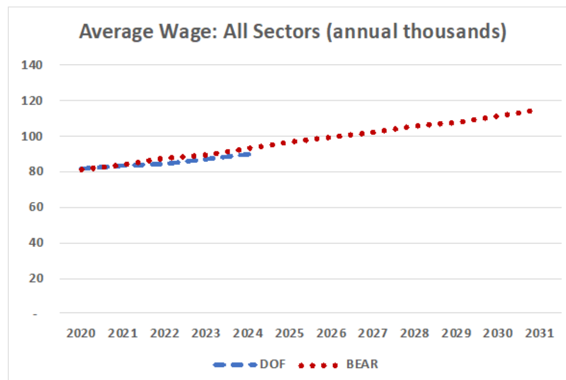
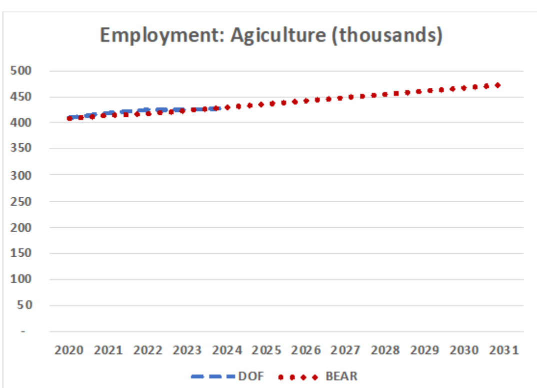


Figure 9.6



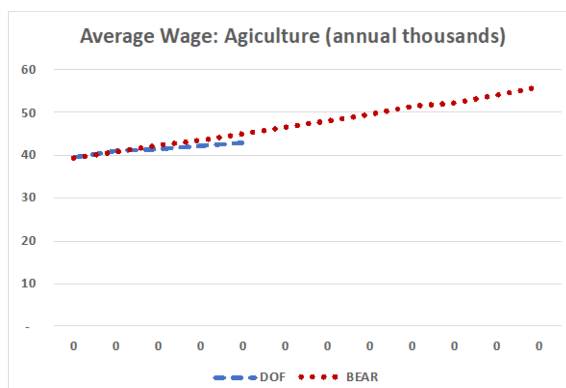


Figure 9.7

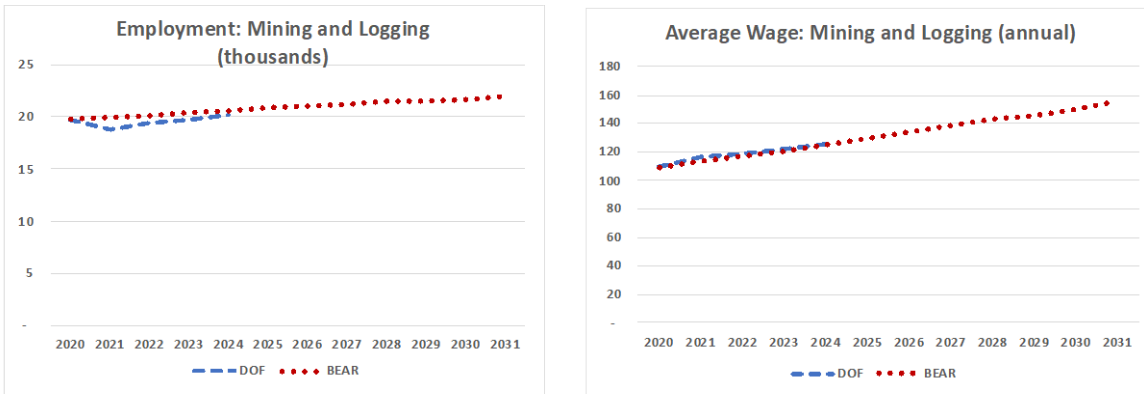


Figure 9.8

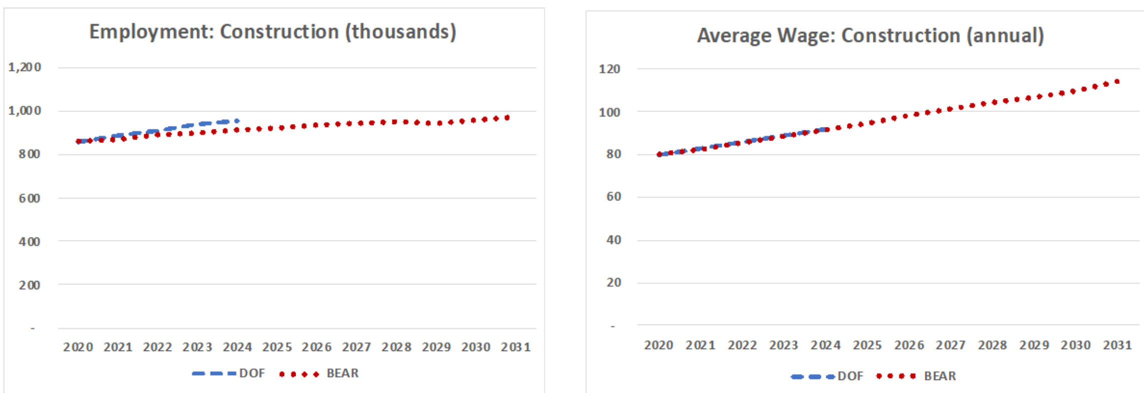


Figure 9.9

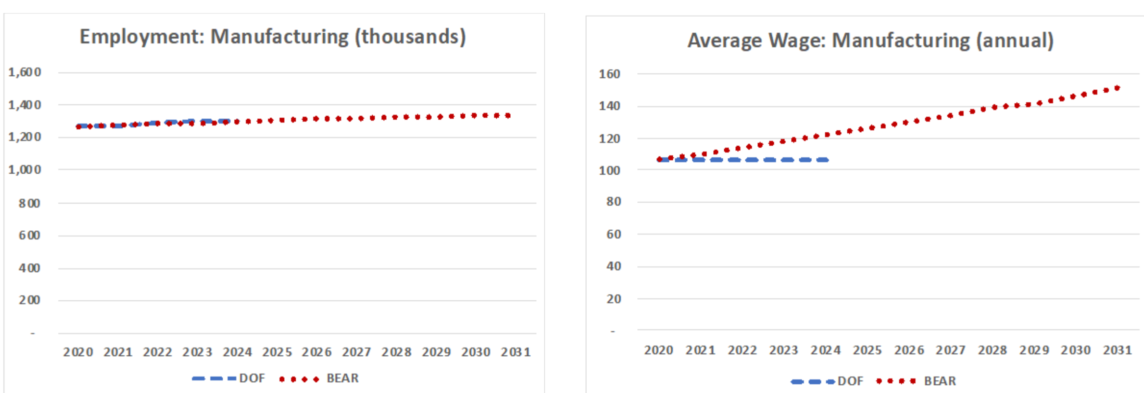


Figure 9.10

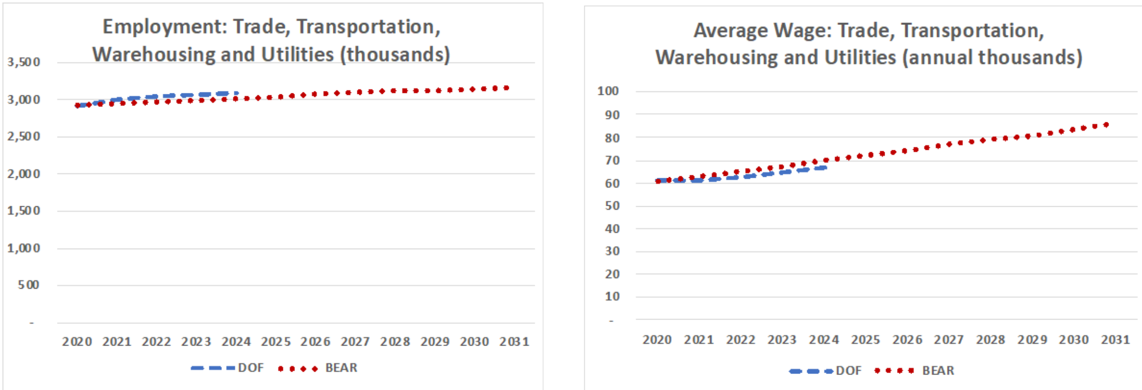


Figure 9.11

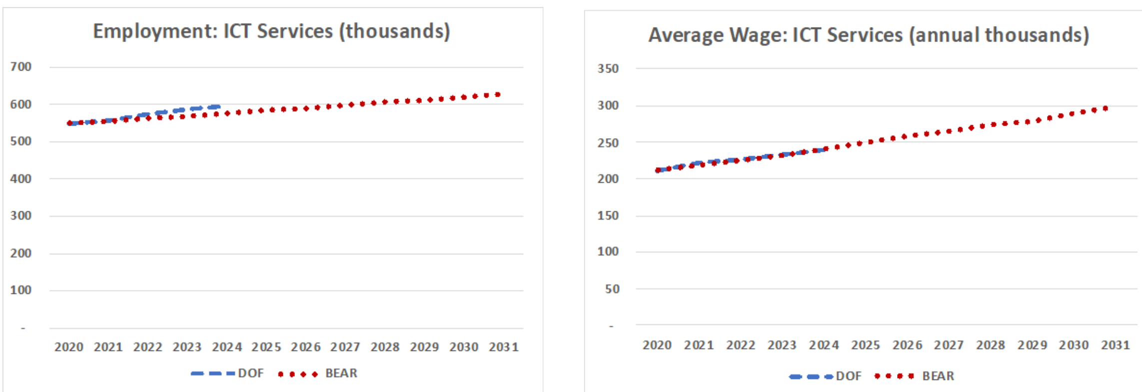


Figure 9.13

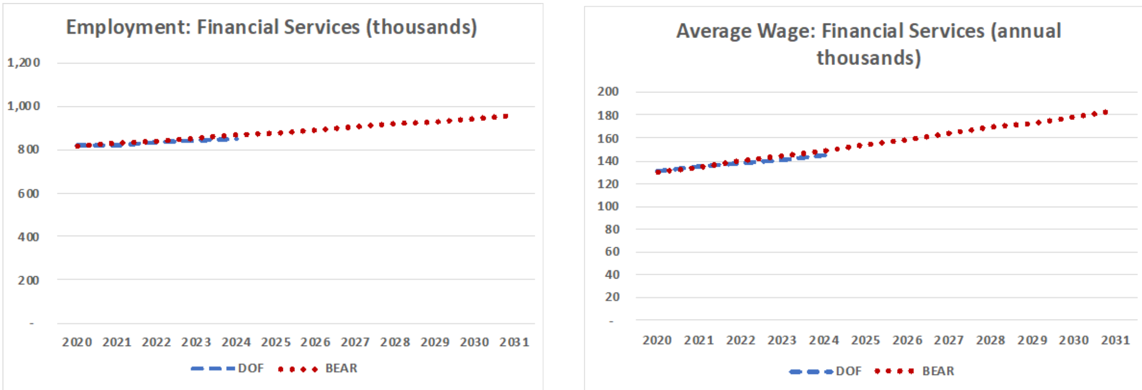


Figure 9.14

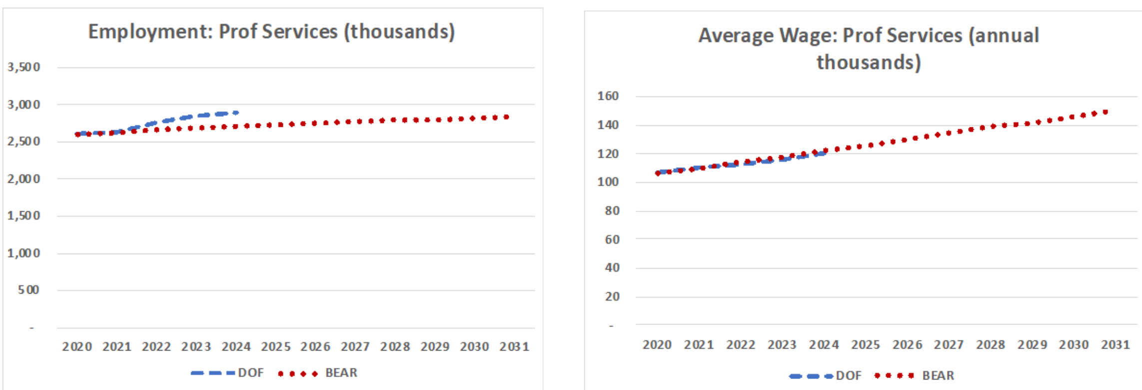


Figure 9.15

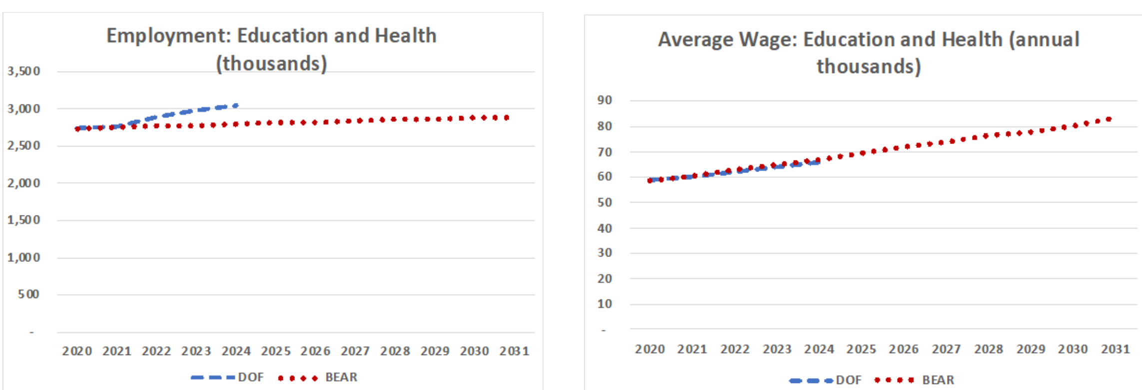
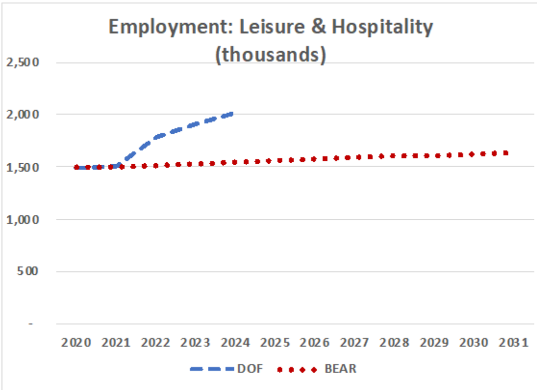


Figure 9.16



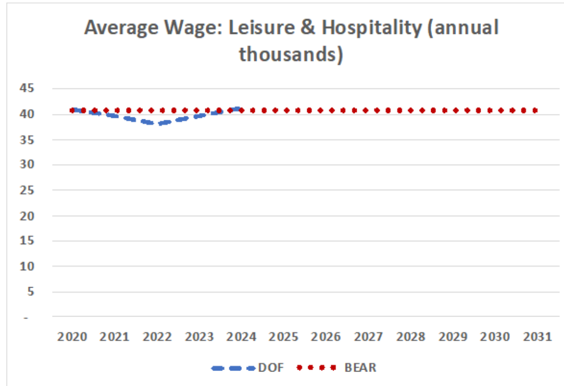
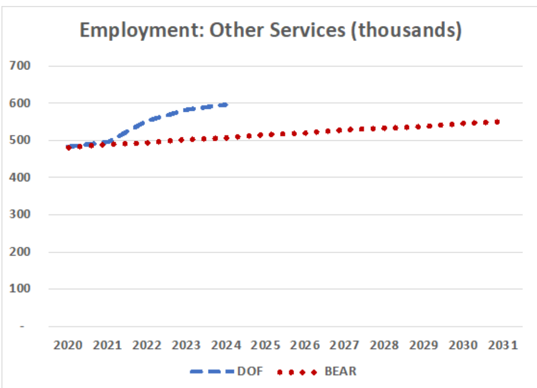


Figure 9.17



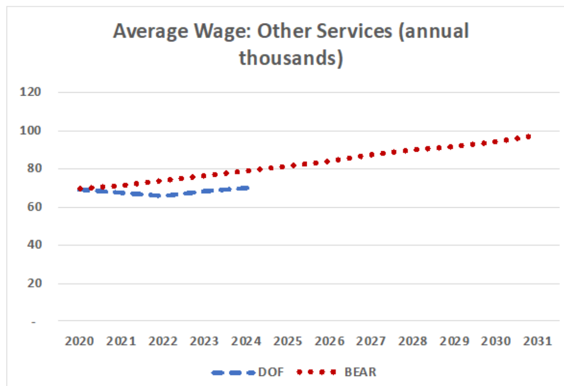
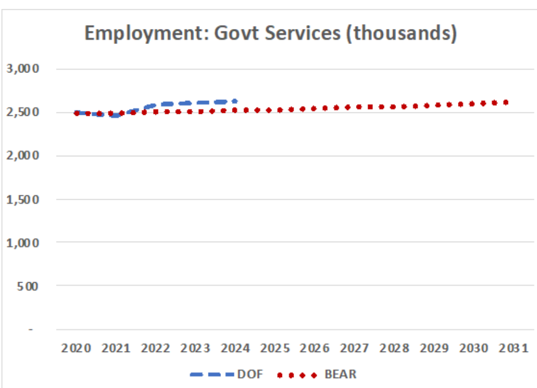
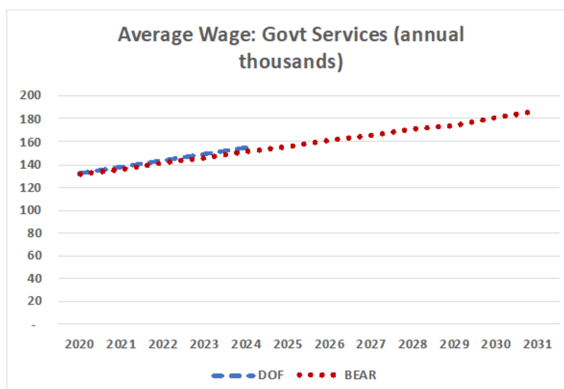


Figure 9.18





9.4. Detailed Macroeconomic Projections

As part of its regular reporting, DOF published twice-yearly forecasts of macroeconomic statistics on income and employment. In the following tables, we reproduce these estimates and their BEAR baseline counterparts for the years 2020-2024.

Table 9.1: California Labor Force Forecasts – DOF Projections

California Labor Force & Employment (Thousands) *	2017	2018	2019	2020	2021	2022	2023	2024	2017	2018	2019
Civilian Labor Force	19,172.1	19,263.5	19,353.5	18,819.5	19,017.9	19,596.7	19,884.2	20,096.7	0.8	0.5	0.5
Civilian Employment	18,244.7	18,440.7	18,551.7	16,906.7	17,566.1	18,462.3	18,936.8	19,238.1	1.6	1.1	0.6
Civilian Unemployment	927.4	822.8	801.8	1,912.8	1,451.8	1,134.3	947.3	858.6	-11.6	-11.3	-2.6
Civilian Unemployment Rate	4.8	4.3	4.2	10.2	7.6	5.8	4.8	4.3	NA	NA	NA
Farm Employment	422.0	421.6	422.1	408.0	419.4	424.2	425.9	426.9	-0.8	-0.1	0.1
Non-Farm Payroll Employment	16,826.0	17,172.1	17,430.0	16,216.2	16,403.8	17,206.9	17,664.1	17,959.8	2.1	2.1	1.5
Year-to-Year Change	345.9	346.1	257.8	-1,213.8	187.6	803.2	457.2	295.7	NA	NA	NA
Goods Producing	2,144.6	2,206.6	2,234.4	2,148.1	2,176.2	2,220.0	2,251.2	2,270.4	1.7	2.9	1.3
Mining and Logging	21.9	22.4	22.5	19.7	18.8	19.3	19.7	20.1	-1.8	2.7	0.2
Construction	810.1	860.2	885.1	858.8	884.0	910.2	934.6	951.1	4.4	6.2	2.9
Manufacturing	1,312.6	1,324.0	1,326.8	1,269.6	1,273.4	1,290.5	1,296.8	1,299.3	0.2	0.9	0.2
Machinery, Computers and Transportation	772.3	787.4	791.5	767.9	770.8	784.7	791.2	794.6	0.6	1.9	0.5
Food, Textiles and Other Manufacturing	540.3	536.6	535.3	501.7	502.6	505.8	505.7	504.7	-0.4	-0.7	-0.2
Service Providing	14,681.4	14,965.6	15,195.6	14,068.1	14,227.6	14,987.0	15,412.9	15,689.3	2.2	1.9	1.5
Trade, Transportation, Warehousing and Utilities	3,015.8	3,046.8	3,053.4	2,913.3	2,994.4	3,037.4	3,071.1	3,088.8	1.7	1.0	0.2
Retail, Wholesale Trade and Utilities	2,442.1	2,438.9	2,406.1	2,237.0	2,298.7	2,324.1	2,336.9	2,342.6	0.5	-0.1	-1.3
Retail Trade	1,688.9	1,684.4	1,657.8	1,532.3	1,581.3	1,592.5	1,595.1	1,593.3	0.6	-0.3	-1.6
Wholesale Trade and Utilities	753.2	754.6	748.3	704.7	717.5	731.6	741.8	749.3	0.2	0.2	-0.8
Transport and Warehousing	573.6	607.8	647.3	676.3	695.7	713.3	734.2	746.2	7.2	6.0	6.5
Information	529.4	543.2	562.1	547.9	555.8	574.1	587.2	593.3	0.5	2.6	3.5
Financial Activities	832.6	837.9	841.1	815.7	817.0	834.9	844.0	848.3	1.1	0.6	0.4
Professional and Business Services	2,582.1	2,669.2	2,721.7	2,604.5	2,638.2	2,749.3	2,841.3	2,891.0	2.0	3.4	2.0
Professional, Scientific, Tech Services & Mgt.	1,485.0	1,537.9	1,587.7	1,552.0	1,565.8	1,634.1	1,692.4	1,727.8	2.5	3.6	3.2
Administrative, Waste Mgt and Remediation	1,097.1	1,131.2	1,133.9	1,052.6	1,072.4	1,115.1	1,148.9	1,163.2	1.3	3.1	0.2
Educational and Health Services	2,650.2	2,722.1	2,807.1	2,726.3	2,766.8	2,877.9	2,965.8	3,032.3	3.8	2.7	3.1
Educational Services	363.6	373.6	383.1	352.2	354.1	380.4	387.7	389.4	2.5	2.8	2.5
Health Services	2,286.7	2,348.5	2,424.0	2,374.1	2,412.7	2,497.5	2,578.0	2,642.9	4.0	2.7	3.2
Ambulatory Services	813.6	839.1	872.3	849.4	875.3	903.8	934.1	956.0	3.5	3.1	4.0
Social Assistance	778.7	806.9	840.4	824.3	835.6	872.9	907.4	939.3	6.5	3.6	4.2
Other Health Care Services	694.3	702.6	711.3	700.4	701.7	720.8	736.6	747.6	2.0	1.2	1.2
Leisure and Hospitality	1,953.5	1,993.1	2,036.3	1,491.8	1,498.5	1,778.3	1,912.9	2,014.8	2.7	2.0	2.2
Other Services	563.7	571.7	576.2	481.8	495.1	552.6	580.5	596.6	1.8	1.4	0.8
Government	2,554.1	2,581.6	2,597.8	2,486.6	2,461.8	2,582.5	2,610.2	2,624.1	1.5	1.1	0.6
Federal	248.2	246.2	248.2	260.7	254.1	254.3	255.8	257.0	0.3	-0.8	0.8
Civilian	187.4	185.2	185.5	195.9	187.7	186.6	187.3	187.8	0.2	-1.2	0.2
Defense	60.8	61.1	62.7	64.8	66.4	67.7	68.5	69.1	0.5	0.5	2.7
State & Local	2,305.9	2,335.3	2,349.6	2,225.9	2,207.8	2,328.2	2,354.4	2,367.2	1.7	1.3	0.6
State	527.9	534.0	533.3	521.4	516.4	541.5	547.8	551.3	1.6	1.2	-0.1
Local	1,778.0	1,801.4	1,816.3	1,704.5	1,691.4	1,786.7	1,806.6	1,815.9	1.7	1.3	0.8

Table 9.2: California Personal Income – DOF Projections

California Personal Income ~ (Billion Current Dollars)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2017**	**2018**	**2019**
Total Personal Income	2,383	2,515	2,632	2,814	2,922	2,922	3,055	3,201	4.8	5.5	4.7
Taxable Personal Income	1,704	1,805	1,892	1,910	1,983	1,983	2,074	2,173	6.2	5.9	4.8
Total Wages and Salaries	1,190	1,259	1,333	1,354	1,406	1,406	1,470	1,541	6.5	5.8	5.9
Supplements to Wages and Salaries	270	281	291	292	304	304	317	333	4.0	4.0	3.4
Proprietors' Income	233	240	253	257	266	266	279	292	1.1	3.0	5.5
Farm	12	12	14	17	18	18	19	20	-3.1	-0.9	21.1
Non-Farm	221	228	239	239	248	248	260	272	1.4	3.3	4.7
Property Income	528	567	576	571	592	592	619	649	7.2	7.4	1.5
Interest	218	227	232	226	235	235	246	258	7.9	4.2	2.1
Monetary	85	88	91	89	92	92	96	101	16.5	3.9	3.0
Non-Monetary	133	139	141	138	143	143	149	157	3.0	4.3	1.6
Dividends	159	180	178	175	182	182	190	199	7.7	12.7	-1.1
Rent	151	161	166	169	175	175	183	192	5.9	6.6	3.5
Monetary	49	50	52	52	54	54	57	60	0.7	2.3	2.8
Non-Monetary	102	110	115	116	121	121	126	132	8.6	8.7	3.8
Transfer Receipts	335	351	373	539	560	560	585	613	-1.0	4.8	6.3
Less: Contributions for Social Ins.	171	182	192	196	204	204	213	223	5.0	6.1	5.5
Residence Adjustment	-2	-2	-2	-2	-2	-2	-3	-3	NA	NA	NA
Less: Personal Taxes	333	342	365	364	378	378	395	414	4.3	2.8	6.5
Disposable Income	2,050	2,172	2,268	2,450	2,544	2,544	2,660	2,787	4.9	5.9	4.4

Table 9.3: California Employment and Wages – DOF Projections

California Wages and Salaries ~ (Billion Current Dollars)	2017	2018	2019	2020	2021	2022	2023	2024	2017	2018	2019	2020	2021	2022	2023	2024
Total Wages and Salaries	1,189.7	1,258.6	1,333.1	1,354.3	1,405.4	1,493.4	1,575.9	1,653.0	6.5	5.8	5.9	1.6	3.8	6.3	5.5	4.9
Farm and Related	14.0	13.0	14.9	16.1	17.2	17.6	18.0	18.4	16.8	-7.7	15.2	8.2	6.4	2.5	2.2	2.2
Mining	2.4	2.5	2.5	2.1	2.2	2.3	2.4	2.5	-18.5	4.0	0.6	-15.7	1.9	4.8	4.7	4.9
Construction	56.9	62.5	67.3	68.8	73.2	78.0	83.1	87.9	9.7	9.8	7.6	2.3	6.4	6.6	6.5	5.7
Manufacturing	123.4	128.8	132.5	135.7	139.2	144.3	149.1	154.0	6.4	4.4	2.9	2.4	2.6	3.7	3.3	3.3
Trade, Transportation, Warehousing and Utilities	162.2	166.0	176.7	177.9	183.1	190.7	198.9	206.8	5.4	2.3	6.4	0.7	2.9	4.2	4.3	4.0
Retail, Wholesale Trade and Utilities	128.6	128.3	131.5	131.0	134.0	139.2	144.5	150.0	4.1	-0.3	2.5	-0.4	2.3	3.9	3.8	3.8
Retail Trade	62.3	64.2	65.6	65.4	65.3	67.3	69.5	71.9	3.5	3.0	2.3	-0.4	-0.1	3.1	3.3	3.4
Wholesale Trade and Utilities	66.3	64.1	65.9	65.7	68.8	71.9	75.0	78.2	4.6	-3.3	2.8	-0.3	4.7	4.6	4.3	4.1
Transport and Warehousing	33.6	37.8	45.2	46.9	49.0	51.5	54.3	56.8	10.9	12.3	19.6	3.7	4.7	4.9	5.6	4.6
Information	90.2	100.3	106.6	115.4	123.5	130.2	136.6	142.3	15.4	11.2	6.3	8.3	6.9	5.5	4.9	4.2
Financial Activities	93.1	96.2	102.1	106.4	110.8	115.2	119.3	123.5	7.5	3.3	6.2	4.2	4.1	4.0	3.5	3.5
Professional and Business Services	228.3	248.5	265.2	278.1	291.3	309.8	330.3	348.1	5.5	8.9	6.7	4.9	4.8	6.3	6.6	5.4
Professional, Scientific, Tech Services & Mgt	177.3	195.4	208.9	220.7	230.3	245.3	261.8	276.3	5.1	10.2	6.9	5.7	4.4	6.5	6.7	5.5
Administrative, Waste Mgt and Remediation	51.0	53.1	56.3	57.4	61.0	64.5	68.5	71.8	6.6	4.1	6.0	1.9	6.4	5.7	6.2	4.8
Educational and Health Services	138.2	145.9	154.9	160.4	166.8	178.2	189.6	200.7	5.7	5.6	6.2	3.6	4.0	6.9	6.4	5.8
Educational Services	19.8	20.7	21.4	20.9	21.3	23.5	24.7	25.7	5.4	4.6	3.5	-2.4	2.1	10.1	5.1	3.9
Health Services	118.4	125.2	133.5	139.5	145.4	154.7	164.9	175.0	5.7	5.7	6.6	4.5	4.2	6.4	6.6	6.1
Leisure and Hospitality	65.1	69.6	75.1	60.4	59.3	67.9	75.9	83.3	6.3	6.8	7.9	-19.6	-1.9	14.6	11.7	9.7
Other Services	32.7	34.1	35.6	33.1	33.2	36.4	39.4	42.0	6.6	4.2	4.5	-7.0	0.4	9.5	8.3	6.5
Government	183.1	191.2	199.7	199.7	205.7	222.7	233.2	243.6	3.8	4.4	4.4	0.0	3.0	8.3	4.7	4.4
Federal	31.0	32.4	33.1	34.4	35.2	36.6	38.2	39.8	1.3	4.5	2.1	4.0	2.3	4.0	4.4	4.3
Civilian	20.3	21.2	21.5	22.6	22.6	23.2	24.0	24.9	2.8	4.1	1.6	5.2	-0.2	2.7	3.6	3.5
Defense	10.7	11.3	11.6	11.8	12.6	13.4	14.2	15.0	-1.4	5.1	2.9	1.7	6.9	6.4	5.8	5.5
State & Local	152.1	158.8	166.6	165.3	170.5	186.1	195.0	203.7	4.3	4.4	4.9	-0.7	3.1	9.1	4.8	4.5
California Average Wages (Current Dollars)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
All Sectors	68,971	71,533	74,673	81,597	83,544	84,692	87,110	89,900	4.4	3.7	4.4	9.3	2.4	1.4	2.9	3.2
Farm and Related	33,259	30,726	35,340	39,561	40,928	41,501	42,242	43,079	17.8	-7.6	15.0	11.9	3.5	1.4	1.8	2.0
Mining	111,401	112,887	113,358	109,528	116,428	118,757	121,844	125,621	-16.9	1.3	0.4	-3.4	6.3	2.0	2.6	3.1
Construction	70,248	72,694	75,994	80,105	82,828	85,727	88,899	92,366	5.0	3.5	4.5	5.4	3.4	3.5	3.7	3.9
Manufacturing	93,981	97,272	99,834	106,975	109,309	111,836	114,967	118,531	6.2	3.5	2.6	7.2	2.2	2.3	2.8	3.1
Trade, Transportation, Warehousing and Utilities	53,792	54,493	57,874	61,126	61,131	62,773	64,758	66,960	3.7	1.3	6.2	5.6	0.0	2.7	3.2	3.4
Retail, Wholesale Trade and Utilities	52,659	52,591	54,667	58,658	58,298	59,905	61,854	64,034	3.6	-0.1	3.9	7.3	-0.6	2.8	3.3	3.5
Retail Trade	36,871	38,088	39,586	42,722	41,271	42,261	43,571	45,096	2.9	3.3	3.9	7.9	-3.4	2.4	3.1	3.5
Wholesale Trade and Utilities	88,059	84,963	88,078	93,268	95,823	98,315	101,166	104,302	4.4	-3.5	3.7	5.9	2.7	2.6	2.9	3.1
Transport and Warehousing	58,615	62,117	69,824	69,297	70,503	72,125	74,000	76,146	3.5	6.0	12.4	-0.8	1.7	2.3	2.6	2.9
Information	170,280	184,578	189,633	211,014	222,127	226,792	232,688	239,902	14.8	8.4	2.7	11.3	5.3	2.1	2.6	3.1
Financial Activities	111,809	114,751	121,416	130,508	135,598	138,038	141,351	145,592	6.3	2.6	5.8	7.5	3.9	1.8	2.4	3.0
Professional and Business Services	88,395	93,101	97,434	106,851	110,434	112,667	116,252	120,398	3.4	5.3	4.7	9.7	3.4	2.0	3.2	3.6
Professional, Scientific, Tech Services & Mgt	119,333	127,033	131,550	142,258	147,088	150,065	154,672	159,897	2.5	6.5	3.6	8.1	3.4	2.0	3.1	3.4
Administrative, Waste Mgt and Remediation	46,511	46,969	49,667	54,570	56,914	57,861	59,658	61,729	5.2	1.0	5.7	9.9	4.3	1.7	3.1	3.5
Educational and Health Services	52,146	53,595	55,183	58,871	60,279	61,907	63,935	66,170	1.8	2.8	3.0	6.7	2.4	2.7	3.3	3.5
Educational Services	54,421	55,374	55,899	59,436	60,244	61,787	63,715	65,947	2.8	1.7	0.9	6.3	1.4	2.6	3.1	3.5
Health Services	51,784	53,312	55,070	58,785	60,280	61,925	63,969	66,203	1.6	3.0	3.3	6.7	2.5	2.7	3.3	3.5
Leisure and Hospitality	33,336	34,906	36,874	40,769	39,664	38,177	39,660	41,326	3.6	4.7	5.6	10.6	-2.7	-3.8	3.9	4.2
Other Services	58,033	59,631	61,832	69,298	67,199	65,855	67,896	70,340	4.7	2.8	3.7	12.1	-3.0	-2.0	3.1	3.6
Government	71,698	74,075	76,862	80,361	83,540	86,219	89,354	92,822	2.3	3.3	3.8	4.6	4.0	3.2	3.6	3.9
Federal	125,114	131,735	133,385	132,142	138,490	143,940	149,387	155,048	1.1	5.3	1.3	-0.9	4.8	3.9	3.8	3.8
Civilian	108,475	114,326	115,946	115,700	120,356	124,315	128,341	132,498	2.6	5.4	1.4	-0.2	4.0	3.3	3.2	3.2
Defense	176,430	184,526	184,969	181,897	189,705	198,046	206,905	216,322	-1.9	4.6	0.2	-1.7	4.3	4.4	4.5	4.6
State & Local	65,949	67,996	70,892	74,313	77,216	79,915	82,831	86,067	2.6	3.1	4.3	4.8	3.9	3.5	3.6	3.9

Data starting in 2021 are forecasts prepared in April 2021.
Average wages is wages and salaries divided by the number of wage and salary jobs (total wage and salary employment).
Data Sources: * CA Employment Development Department, Labor Market Information Division, seasonally-adjusted by the Department of Finance; ◦ U.S. Census Bureau; ~ U.S. Bureau of Economic Analys

Table 9.4: California Labor Force Forecasts – BEAR Projections

California Labor Force & Employment (Thousands) *	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2017**	**2018**	**2019**
Civilian Labor Force	19,172	19,264	19,354	18,819	18,972	19,182	19,559	20,115	0.8	0.5	0.5
Civilian Employment	18,245	18,441	18,552	16,907	17,044	17,232	17,571	18,071	1.6	1.1	0.6
Civilian Unemployment	927	823	802	1,913	1,452	1,134	947	859	-11.6	-11.3	-2.6
Civilian Unemployment Rate	5	4	4	10	8	6	5	4	NA	NA	NA
Farm Employment	422	422	422	408	405	403	397	388	-0.8	-0.1	0.1
Non-Farm Payroll Employment	16,826	17,172	17,430	16,216	16,348	16,528	16,854	17,333	2.1	2.1	1.5
Year-to-Year Change	346	346	258	-1,214	188	803	457	296	NA	NA	NA
Goods Producing	2,145	2,207	2,234	2,148	2,165	2,189	2,233	2,296	1.7	2.9	1.3
Mining and Logging	22	22	22	20	20	20	20	21	-1.8	2.7	0.2
Construction	810	860	885	859	866	875	893	918	4.4	6.2	2.9
Manufacturing	1,313	1,324	1,327	1,270	1,280	1,294	1,319	1,357	0.2	0.9	0.2
Machinery, Computers and Transportation	772	787	792	768	774	783	798	821	0.6	1.9	0.5
Food, Textiles and Other Manufacturing	540	537	535	502	506	511	521	536	-0.4	-0.7	-0.2
Service Providing	14,681	14,966	15,196	14,068	14,182	14,339	14,621	15,037	2.2	1.9	1.5
Trade, Transportation, Warehousing and Utilities	3,016	3,047	3,053	2,913	2,937	2,969	3,028	3,114	1.7	1.0	0.2
Retail, Wholesale Trade and Utilities	2,442	2,439	2,406	2,237	2,255	2,280	2,325	2,391	0.5	-0.1	-1.3
Retail Trade	1,689	1,684	1,658	1,532	1,545	1,562	1,593	1,638	0.6	-0.3	-1.6
Wholesale Trade and Utilities	753	755	748	705	710	718	732	753	0.2	0.2	-0.8
Transport and Warehousing	574	608	647	676	682	689	703	723	7.2	6.0	6.5
Information	529	543	562	548	552	558	569	586	0.5	2.6	3.5
Financial Activities	833	838	841	816	822	831	848	872	1.1	0.6	0.4
Professional and Business Services	2,582	2,669	2,722	2,605	2,626	2,655	2,707	2,784	2.0	3.4	2.0
Professional, Scientific, Tech Services & Mgt.	1,485	1,538	1,588	1,552	1,565	1,582	1,613	1,659	2.5	3.6	3.2
Administrative, Waste Mgt and Remediation	1,097	1,131	1,134	1,053	1,061	1,073	1,094	1,125	1.3	3.1	0.2
Educational and Health Services	2,650	2,722	2,807	2,726	2,748	2,779	2,833	2,914	3.8	2.7	3.1
Educational Services	364	374	383	352	355	359	366	376	2.5	2.8	2.5
Health Services	2,287	2,349	2,424	2,374	2,393	2,420	2,467	2,538	4.0	2.7	3.2
Ambulatory Services	814	839	872	849	856	866	883	908	3.5	3.1	4.0
Social Assistance	779	807	840	824	831	840	857	881	6.5	3.6	4.2
Other Health Care Services	694	703	711	700	706	714	728	749	2.0	1.2	1.2
Leisure and Hospitality	1,953	1,993	2,036	1,492	1,504	1,521	1,550	1,595	2.7	2.0	2.2
Other Services	564	572	576	482	486	491	501	515	1.8	1.4	0.8
Government	2,554	2,582	2,598	2,487	2,507	2,534	2,584	2,658	1.5	1.1	0.6
Federal	248	246	248	261	263	266	271	279	0.3	-0.8	0.8
Civilian	187	185	185	196	197	200	204	209	0.2	-1.2	0.2
Defense	61	61	63	65	65	66	67	69	0.5	0.5	2.7
State & Local	2,306	2,335	2,350	2,226	2,244	2,269	2,313	2,379	1.7	1.3	0.6
State	528	534	533	521	526	531	542	557	1.6	1.2	-0.1
Local	1,778	1,801	1,816	1,705	1,718	1,737	1,772	1,822	1.7	1.3	0.8

Table 9.5: California Personal Income – BEAR Projections

California Personal Income ~ (Billion Current Dollars)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2017**	**2018**	**2019**
Total Personal Income	2,383	2,515	2,632	2,814	2,922	2,922	3,055	3,201	4.8	5.5	4.7
Taxable Personal Income	1,704	1,805	1,892	1,910	1,983	1,983	2,074	2,173	6.2	5.9	4.8
Total Wages and Salaries	1,190	1,259	1,333	1,354	1,406	1,406	1,470	1,541	6.5	5.8	5.9
Supplements to Wages and Salaries	270	281	291	292	304	304	317	333	4.0	4.0	3.4
Proprietors' Income	233	240	253	257	266	266	279	292	1.1	3.0	5.5
Farm	12	12	14	17	18	18	19	20	-3.1	-0.9	21.1
Non-Farm	221	228	239	239	248	248	260	272	1.4	3.3	4.7
Property Income	528	567	576	571	592	592	619	649	7.2	7.4	1.5
Interest	218	227	232	226	235	235	246	258	7.9	4.2	2.1
Monetary	85	88	91	89	92	92	96	101	16.5	3.9	3.0
Non-Monetary	133	139	141	138	143	143	149	157	3.0	4.3	1.6
Dividends	159	180	178	175	182	182	190	199	7.7	12.7	-1.1
Rent	151	161	166	169	175	175	183	192	5.9	6.6	3.5
Monetary	49	50	52	52	54	54	57	60	0.7	2.3	2.8
Non-Monetary	102	110	115	116	121	121	126	132	8.6	8.7	3.8
Transfer Receipts	335	351	373	539	560	560	585	613	-1.0	4.8	6.3
Less: Contributions for Social Ins.	171	182	192	196	204	204	213	223	5.0	6.1	5.5
Residence Adjustment	-2	-2	-2	-2	-2	-2	-3	-3	NA	NA	NA
Less: Personal Taxes	333	342	365	364	378	378	395	414	4.3	2.8	6.5
Disposable Income	2,050	2,172	2,268	2,450	2,544	2,544	2,660	2,787	4.9	5.9	4.4

Table 9.6: California Employment and Wages – BEAR Projections

California Wages and Salaries ~ (Billion Current Dollars)	2017	2018	2019	2020	2021	2022	2023	2024	2017	2018	2019	2020	2021	2022	2023	2024
Total Wages and Salaries	1,190	1,259	1,333	1,354	1,411	1,441	1,507	1,580	6.5	5.8	5.9	1.6	4.2	2.1	4.6	4.8
Farm and Related	14	13	15	16	17	17	18	19	16.8	-7.7	15.2	8.2	4.2	2.1	4.6	4.8
Mining	2	3	3	2	2	2	2	3	-18.5	4.0	0.6	-15.7	4.2	2.1	4.6	4.8
Construction	57	63	67	69	72	73	77	80	9.7	9.8	7.6	2.3	4.2	2.1	4.6	4.8
Manufacturing	123	129	132	136	141	144	151	158	6.4	4.4	2.9	2.4	4.2	2.1	4.6	4.8
Trade, Transportation, Warehousing and Utilities	162	166	177	178	185	189	198	208	5.4	2.3	6.4	0.7	4.2	2.1	4.6	4.8
Retail, Wholesale Trade and Utilities	129	128	132	131	137	139	146	153	4.1	-0.3	2.5	-0.4	4.2	2.1	4.6	4.8
Retail Trade	62	64	66	65	68	70	73	76	3.5	3.0	2.3	-0.4	4.2	2.1	4.6	4.8
Wholesale Trade and Utilities	66	64	66	66	68	70	73	77	4.6	-3.3	2.8	-0.3	4.2	2.1	4.6	4.8
Transport and Warehousing	34	38	45	47	49	50	52	55	10.9	12.3	19.6	3.7	4.2	2.1	4.6	4.8
Information	90	100	107	115	120	123	128	135	15.4	11.2	6.3	8.3	4.2	2.1	4.6	4.8
Financial Activities	93	96	102	106	111	113	118	124	7.5	3.3	6.2	4.2	4.2	2.1	4.6	4.8
Professional and Business Services	228	249	265	278	290	296	309	324	5.5	8.9	6.7	4.9	4.2	2.1	4.6	4.8
Professional, Scientific, Tech Services & Mgt	177	195	209	221	230	235	246	257	5.1	10.2	6.9	5.7	4.2	2.1	4.6	4.8
Administrative, Waste Mgt and Remediation	51	53	56	57	60	61	64	67	6.6	4.1	6.0	1.9	4.2	2.1	4.6	4.8
Educational and Health Services	138	146	155	160	167	171	179	187	5.7	5.6	6.2	3.6	4.2	2.1	4.6	4.8
Educational Services	20	21	21	21	22	22	23	24	5.4	4.6	3.5	-2.4	4.2	2.1	4.6	4.8
Health Services	118	125	133	140	145	148	155	163	5.7	5.7	6.6	4.5	4.2	2.1	4.6	4.8
Leisure and Hospitality	65	70	75	60	63	64	67	70	6.3	6.8	7.9	-19.6	4.2	2.1	4.6	4.8
Other Services	33	34	36	33	35	35	37	39	6.6	4.2	4.5	-7.0	4.2	2.1	4.6	4.8
Government	183	191	200	200	208	212	222	233	3.8	4.4	4.4	0.0	4.2	2.1	4.6	4.8
Federal	31	32	33	34	36	37	38	40	1.3	4.5	2.1	4.0	4.2	2.1	4.6	4.8
Civilian	20	21	22	23	24	24	25	26	2.8	4.1	1.6	5.2	4.2	2.1	4.6	4.8
Defense	11	11	12	12	12	13	13	14	-1.4	5.1	2.9	1.7	4.2	2.1	4.6	4.8
State & Local	152	159	167	165	172	176	184	193	4.3	4.4	4.9	-0.7	4.2	2.1	4.6	4.8
California Average Wages (Current Dollars)	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
All Sectors	68,971	71,533	74,673	81,597	84,336	85,792	88,879	92,219	4.4	3.7	4.4	9.3	3.4	1.7	3.6	3.8
Farm and Related	33,259	30,726	35,340	39,561	40,889	41,595	43,091	44,711	17.8	-7.6	15.0	11.9	3.4	1.7	3.6	3.8
Mining	111,401	112,887	113,358	109,528	113,204	115,158	119,302	123,785	-16.9	1.3	0.4	-3.4	3.4	1.7	3.6	3.8
Construction	70,248	72,694	75,994	80,105	82,793	84,222	87,253	90,532	5.0	3.5	4.5	5.4	3.4	1.7	3.6	3.8
Manufacturing	93,981	97,272	99,834	106,975	110,565	112,474	116,521	120,900	6.2	3.5	2.6	7.2	3.4	1.7	3.6	3.8
Trade, Transportation, Warehousing and Utilities	53,792	54,493	57,874	61,126	63,178	64,268	66,581	69,083	3.7	1.3	6.2	5.6	3.4	1.7	3.6	3.8
Retail, Wholesale Trade and Utilities	52,659	52,591	54,667	58,658	60,627	61,673	63,892	66,293	3.6	-0.1	3.9	7.3	3.4	1.7	3.6	3.8
Retail Trade	36,871	38,088	39,586	42,722	44,156	44,918	46,534	48,283	2.9	3.3	3.9	7.9	3.4	1.7	3.6	3.8
Wholesale Trade and Utilities	88,059	84,963	88,078	93,268	96,399	98,063	101,591	105,409	4.4	-3.5	3.7	5.9	3.4	1.7	3.6	3.8
Transport and Warehousing	58,615	62,117	69,824	69,297	71,623	72,859	75,481	78,318	3.5	6.0	12.4	-0.8	3.4	1.7	3.6	3.8
Information	170,280	184,578	189,633	211,014	218,097	221,861	229,843	238,481	14.8	8.4	2.7	11.3	3.4	1.7	3.6	3.8
Financial Activities	111,809	114,751	121,416	130,508	134,889	137,217	142,154	147,497	6.3	2.6	5.8	7.5	3.4	1.7	3.6	3.8
Professional and Business Services	88,395	93,101	97,434	106,851	110,437	112,343	116,385	120,759	3.4	5.3	4.7	9.7	3.4	1.7	3.6	3.8
Professional, Scientific, Tech Services & Mgt	119,333	127,033	131,550	142,258	147,033	149,571	154,953	160,776	2.5	6.5	3.6	8.1	3.4	1.7	3.6	3.8
Administrative, Waste Mgt and Remediation	46,511	46,969	49,667	54,570	56,401	57,375	59,439	61,673	5.2	1.0	5.7	9.9	3.4	1.7	3.6	3.8
Educational and Health Services	52,146	53,595	55,183	58,871	60,847	61,898	64,125	66,535	1.8	2.8	3.0	6.7	3.4	1.7	3.6	3.8
Educational Services	54,421	55,374	55,899	59,436	61,431	62,492	64,740	67,173	2.8	1.7	0.9	6.3	3.4	1.7	3.6	3.8
Health Services	51,784	53,312	55,070	58,785	60,759	61,807	64,031	66,438	1.6	3.0	3.3	6.7	3.4	1.7	3.6	3.8
Leisure and Hospitality	33,336	34,906	36,874	40,769	42,137	42,864	44,407	46,075	3.6	4.7	5.6	10.6	3.4	1.7	3.6	3.8
Other Services	58,033	59,631	61,832	69,298	71,624	72,861	75,482	78,319	4.7	2.8	3.7	12.1	3.4	1.7	3.6	3.8
Government	71,698	74,075	76,862	80,361	83,059	84,493	87,533	90,822	2.3	3.3	3.8	4.6	3.4	1.7	3.6	3.8
Federal	125,114	131,735	133,385	132,142	136,578	138,935	143,934	149,343	1.1	5.3	1.3	-0.9	3.4	1.7	3.6	3.8
Civilian	108,475	114,326	115,946	115,700	119,583	121,648	126,024	130,761	2.6	5.4	1.4	-0.2	3.4	1.7	3.6	3.8
Defense	176,430	184,526	184,969	181,897	188,003	191,248	198,129	205,575	-1.9	4.6	0.2	-1.7	3.4	1.7	3.6	3.8
State & Local	65,949	67,996	70,892	74,313	76,808	78,133	80,945	83,987	2.6	3.1	4.3	4.8	3.4	1.7	3.6	3.8

Data starting in 2021 are forecasts prepared in April 2021.
Average wages is wages and salaries divided by the number of wage and salary jobs (total wage and salary employment).
Data Sources: * CA Employment Development Department, Labor Market Information Division, seasonally-adjusted by the Department of Finance; ◦ U.S. Census Bureau; ~ U.S. Bureau of Economic Analys

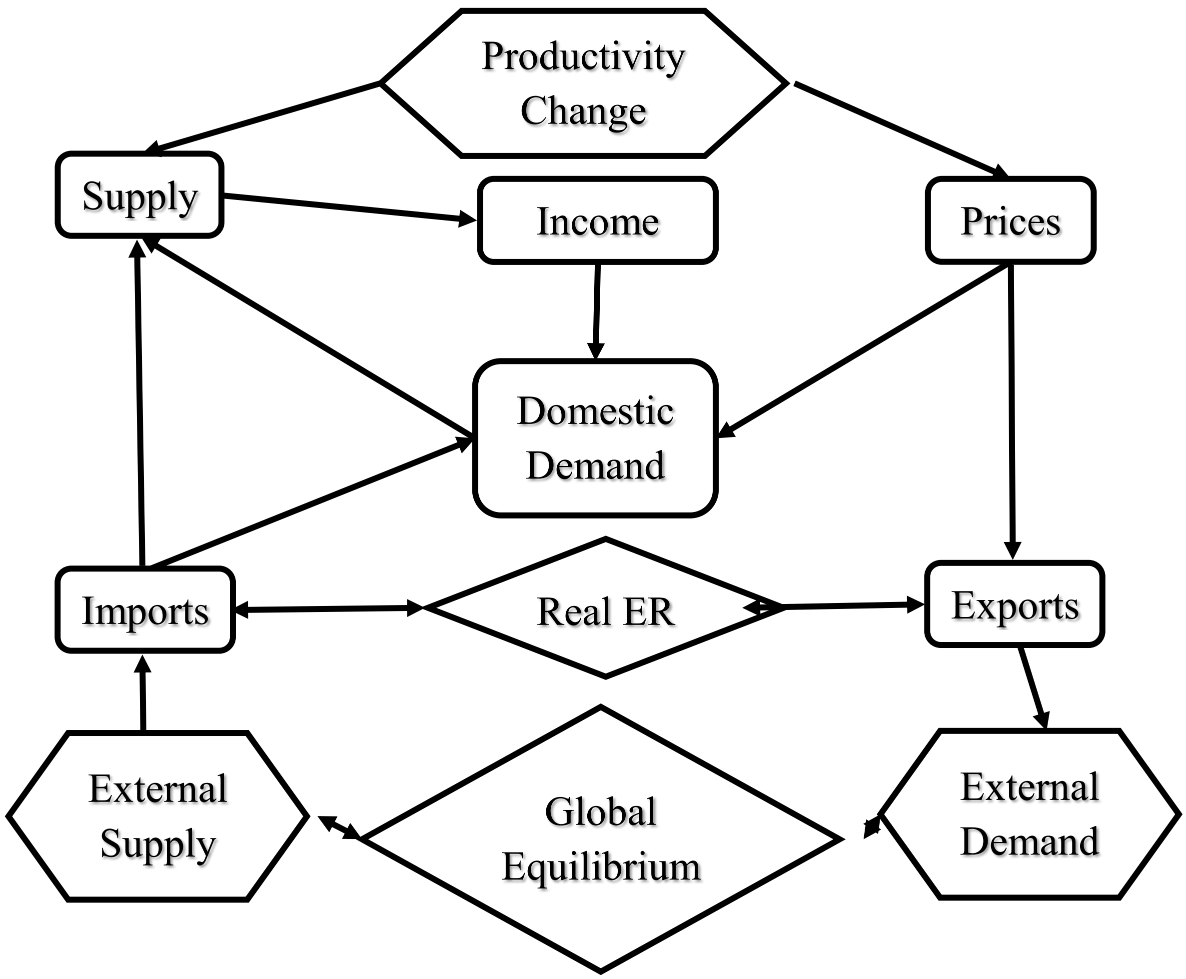
9.5. Baseline Calibration of the Bear Model

The BEAR model is calibrated to state real Personal Income growth rates, obtained from The California Department of Finance. Using exogenous rates of implied growth in total factor productivity (TFP), the model computes supply, demand, and trade patterns compatible with domestic and state market equilibrium conditions. Equilibrium is achieved by adjustments in the relative prices of domestic resources and commodities, while international equilibrium is achieved by adjusting trade patterns and real exchange rates to satisfy fixed real balance of payments constraints. The general process is schematically represented in the figure below.

The calibration procedure highlights the two salient adjustment mechanisms in the model (as well as the real economies), prices in California, US domestic and international markets. General equilibrium price adjustments are generally well understood by professional economists but the degree of segmentation between state, national, and global markets depends on many factors.

Because CGE models like this do not capture the aggregate price level or other nominal quantities, there are no pure inflationary or monetary effects in the sense of traditional macroeconomics or finance. Since there is no money metric in the model, all prices are relative prices. If there were financial assets in the model, one could define a nominal inflation and interest rates as the relative prices of financial assets (money, bonds, etc.). Without them, prices only reflect real purchasing power, i.e. the relative price of goods and services in terms of each other.

Figure 9.19: General Equilibrium Calibration Mechanism



10. Appendix 2 - Estimates Based on Federal Regulatory Impact Analysis

This appendix explains how the Federal Regulatory Impact Analysis (RIA) for of the Federal Motor Carrier Safety Administration (FMCSA) informed the estimation of California costs and benefits of requiring commercial motor vehicles (CMV) drivers to use electronic logging devices (ELDs) for recording driving and other duty status periods.

FMCSA determined there were significant violations to the hours-of-service (HOS) rules and that violations were leading to increased driver fatigue posing an unacceptable risk to public safety, necessitating a rulemaking process. The ELD requirements evaluated in the RIA are intended to improve compliance with hours of service rules and decrease the risk of fatigue related crashes.

The RIA considers two regulatory options.

Option 1: ELDs are required for all CMV operations subject to 49 CFR part 395, which establishes the HOS requirements for drivers. Under this option approximately 4.27 million drivers would be subject to the regulation, requiring the purchase of 3.5 million ELDs or upgrades to an existing fleet management system (FMS).

Option 2: ELDs are required for all CMV operations subject to 49 CFR part 395.8, which establishes the requirements for drivers to complete paper Records of Duty Status. Thus option 2 is a subset of option 1 and under this requirement approximately 3.5 million drivers would be subject to the rule, requiring the purchase of approximately 2.8 million ELDs or upgrades to an existing FMS.

For the final rule, the FMCSA adopted Option 2 with additional clarification specifying that providing a data backup requires either a display or printout regardless of the data transfer technologies required.

The next section provides an overview of the costs and benefits of these regulatory options estimated in the federal RIA. Section 2 then details the methods and data used to derive direct cost and benefits estimates and Section 3 discusses how the federal RIA relates to the proposed California regulation.

10.1. Overview of Total Estimated Costs and Benefits

Option 1 cumulative costs over 10 years are estimated to be $17.1-$23.1 billion and cumulative benefits are estimated at $23.5-$31.7 billion. For Option 2 the analogous estimates are $13.8-$18.6 billion for costs and $22.6-$30.5 billion for benefits (Table 1). These estimates constitute a net benefit of $6.3-$8.6 billion for Option 1 and $8.8 billion for Option 2. The benefit-cost ratios are 1.37 for Option 1 and 1.64 for Option 2.

The reason that net benefits are estimated to be higher under Option 2 is that benefits estimates were similar for both Option 1 and Option 2, however, costs were higher for Option 1 due to the inclusion of categories of drivers that do not currently collect paper records of duty status (RODS). It is more expensive for these drivers to come into compliance with the regulation because they are not currently recording duty status. Moreover, the benefits of adoption of ELDs are lower because this category of drivers has less accidents on average.

Table 10.1: Cumulative Costs, Benefits, and Net Benefits Estimated over 10 Years (2013 Million$)

	Option 1			Option 2		
Discount Rate	**0%**	**3%**	**7%**	**0%**	**3%**	**7%**
Benefits	$31,708	$27,680	$23,479	$30,544	$26,665	$22,619
Costs	$23,117	$20,191	$17,138	$18,622	$16,259	$13,794
Net Benefits	$8,591	$7,489	$6,341	$11,922	$10,406	$8,825

The next section details the procedures that were used to derive these estimates.

10.2. Estimation of Direct Costs and Benefits

Identifying Affected Entities and Drivers

The aggregate costs and benefits described in Section 2 rely on estimates of the number of affected entities. FMCSA analyzed data from the Motor Carrier Management Information System (MCMIS) to determine how many drivers, carriers, and commercial motor vehicles would be affected by the proposed regulations. FMCSA estimates that there are 539,000 FMCSA-regulated carriers, 4,604,000 CMV's, and 4,409,000 drivers in the U.S. Of these 4.4 million drivers, FMCSA estimates that 3,365,000 (76%) are subject to the ELD rules. FMCSA makes the assumption that a carrier will acquire an ELD for each driver subject to the rule but not for each CMV operated by the carrier.

Costs

Direct costs of the regulation are broken down into several categories (Table 2). The largest expense category is the hardware requirement of CMV operators to purchase ELDs. Cost information was obtained through marketing materials or communication with various FMS vendors. The RIA bases its calculation on a device produced by the largest manufacturer (by market share) of FMS in North America. The specific device is known as the Mobile Computing Platform 50, which is produced by Omnitracs and has an annualized cost of $419 per CMV. This estimate includes all installation, service, repairs, and hardware costs, and falls in the middle of the range of other ELDs, which span from $166 - $667 per CMV on an annualized basis. Depending on the regulatory option and discount rate the total cost for new ELDs range from $1 - $1.3 billon per year.

Other hardware costs come from the replacement of existing Automatic On-Board Recording Devices (AOBRDs). Many carriers will have previously purchased AOBRDs for the CMVs and will need to replace or update them to ELDs to be compliant with the regulation. Thus, an additional cost will come from carriers needing to uninstall AORBDs to be replaced with new ELDs and is estimated at approximately $2 million in annualized costs. Roadside inspectors will also need new equipment, and this represents the final hardware cost. The RIA assumes that inspectors will use a Bluetooth adapter (opposed to a QR code scanners) and this will result in an annualized cost of $1.3 million

Other costs are related to training, specifically enforcement training and CMV driver training. In regard to enforcement, the RIA estimates there are approximately 11,000 State and Federal employees who need to travel to training sites (cost of $200 per person) and receive 8 hours of training in the first year (cost of $40 per hour). Additionally, new inspectors will be required to be trained in following years. In total, inspector training costs are estimated at $5.8 million in year 1 and $930 thousand per year in subsequent years. This brings the annualized cost of training over the ten-year period to $1.6 million. Although the regulation does not mandate training for drivers, it is assumed drivers must be familiar with the use of ELDs and therefore the RIA assumes 30 minutes of training for each driver in the first year, with additional training required as new drivers are hired. In total, annualized cost estimates range from $7 - $10 million depending on the regulatory option and discount rate.

The final cost category considers the additional drivers and CMVs needed to ensure that no driver exceeds the hours of service (HOS) limits. ELDs are expected to significantly reduce HOS non-compliance by ensuring hours are accurately recorded and tracked. The RIA assumes that ELDs will result in full HOS compliance, which in turn means additional drivers and CMVs are needed to meet the hours that HOS violations permit. In total, this category is the second largest cost category with an estimated annual cost of $790 - $939 million depending on regulatory option and discount rate.

Table 10.2: Estimated Annualized Costs for Preferred Option 2 (7% Discount Rate)

Cost	Annualized Total Value (2013 Millions)	Notes
New ELD Costs	$1,032.2	For all long-haul (LH) and short-haul (SH) drivers that use RODS, to pay for new devices and FMS upgrades.
Automatic On-Board Recording Device (AOBRD) Replacement Costs	$2.0	Carriers that purchased AOBRDs for their CMVs and can be predicted to still have them in 2019 and would need to replace or update them with ELDs.
Enforcement Equipment Costs	$1.3	The final rule does not require inspectors to purchase QR code scanners. Instead, inspectors would have Bluetooth capability and USB 2.0.

Enforcement Training Costs	$1.6	Costs include travel to training sites, as well as training time, for all inspectors in the first year and for new inspectors each year thereafter.
CMV Driver Training Costs	$8.0	Costs of training new drivers in 2017, and new drivers each year thereafter.
HOS Compliance Costs	$790.4	Extra drivers and CMVs needed to ensure that no driver exceeds HOS limits.
Total Costs	**$1,836**	

Benefits

Benefits are separated into two categories, paperwork savings and savings through avoided crashes. Paperwork savings come from ELDs reducing the paperwork and recordkeeping burden associated with HOS regulations. Paperwork benefits are further divided into three categories: driver time savings, clerical time savings, and paper cost savings. Starting with driver time savings, ELDs do not completely eliminate driver time logging HOS. Drivers are still required to interact with ELDs at the beginning of the shift, log out at the end of the shift, and change duty status. Therefore, ELDs result in an estimated time savings of 4.5 minutes per record of duty status (RODS), which occur an average of 240 times per year. ELDs are also expected to eliminate the time required filling or forwarding (RODS) to carriers, which is estimated to take 5 minutes and occurs 25 times per year. Using average wages of drivers, the total cost savings per driver is estimated to be $623.

Clerical time savings represents the next paperwork savings category. ELDs automate RODS by automatically submitting and storing hours on a secure website. Therefore, traditional carrier clerical staff will no longer be required to handle RODS documents. The RIA estimates that clerical staff spend one minute to file each RODS and these are submitted on average 240 times per year. This cost will be eliminated entirely and thus the labor cost saving is the number hours spent times the average clerical labor rate. In total this results in an estimated savings of $144 per driver.

The final paperwork savings category comes from the reduction in actual paper costs. Bound paper packets with a month's worth of paper RODs retails for approximately $3.50. ELDs will eliminate the need for paper books resulting in a cost savings of $38.5 per driver. In total, the overall paperwork reduction savings is estimated at $805 per driver. Note that, ELDs only reduce the paperwork burden of RODS, which are included in both regulatory options. Therefore, the paperwork savings are identical for both options.

The next benefit category is the safety benefits from a reduction in the number of crashes associated with fatigued drivers (Table 3). The RIA derives crash reduction estimates from the Federal Motor Carrier Safety Administration (FMCSA) Roadside Intervention Model. The model is an analytical tool that measures the effectiveness of roadside inspections, traffic enforcements, and other interventions in terms of crashes and injuries avoided, and lives saved. The number of avoided crashes is estimated in several steps. First, data on 8,545 roadside inspections among companies using ELDs is used to estimate the reduction in HOS violations associated with adoption of ELDs. The reduction in violations is then used with the model, which assigns different crash risks to different types of violations and adjusts for unobserved violations, to estimate the expected crash reduction per observed violation. The difference in the number of violations caused by adoption of ELDs is then multiplied by the estimated crash reduction per observed violation to estimate the number of avoided crashes associated with ELD use. Injuries and lives saved estimates also follow from the model. Several downward adjustments are then made to these estimates to reflect more conservative assumptions regarding the effectiveness of ELDs in reducing violations.

Table 10.3: Estimated Reductions in Crashes, Injury, and Mortality

	Option 1: All HOS Drivers	Option 2: RODS Drivers Only
Crashes Avoided	2,217	1,844
Injuries Avoided	675	562
Lives Saved	31	26

Once the number of avoided crashes, injuries, and deaths are estimated they need to be valued. Lives saved are valued using the standard Value of a Statistical Life (VSL) approach where a dollar value is assigned to each avoided death. VSL estimates are derived from scaled up estimates of people's willingness to pay for mortality risk reductions and have a long history of use in cost-benefit analyses. The VSL value recommended by the Department of Transportation is $9.2 million in 2013 USD. In addition, the RIA estimates benefits using a low VSL value of $5.2 million and a high value of $13 million to calculate alternative estimates. The value of an avoided injury is estimated according to Department of Transportation guidelines, which suggest use of the abbreviated injury scale (AIS) shown in Table 4 to assign different fractions of a VSL to different injuries depending on severity. The value of an avoided crash is drawn from a 2006 report that examined the cost of CMV crashes and updated to reflect current year dollars.

Table 10.4: Fractions of VSL for AIS

AIS Level	Severity	Fraction of VSL	Value of VSL Fraction (2013 $ millions)
AIS 1	Minor	0.003	$0.03
AIS 2	Moderate	0.047	$0.43
AIS 3	Serious	0.105	$0.97
AIS 4	Severe	0.266	$2.45
AIS 5	Critical	0.593	$5.46
AIS 6	Unsurvivable	1.000	$9.20

In total, the RIA estimates the benefits from crash reductions to be between $570 and $700 million depending on regulatory option and discount rate.

Combined, overall annualized net benefits range between $840 and $1.1 billion depending on option and discount rate. Of the two options, Option 2 produces the higher overall benefit (Table 5) as the bulk of benefits are derived from the reduction in paper cost, which is constant across options. Therefore, although safety benefits are higher when all CMV operations are included (Option 1), the marginal costs from including this larger population are more than 3.5 times higher than the marginal benefits. This makes option 2, requiring ELDs for RODS drivers only, the more appealing option.

Table 10.5: Estimated Annualized Benefits for Preferred Option 2 (7% Discount Rate)

Benefit	Annualized Total Value (2013 Millions)	Notes
Paperwork Savings	$2,438	Sum 1-3
1) Driver Time	$1,877	Reflects time saved as drivers no longer have to fill out and submit paper RODS.
2) Clerical Time	$434	Reflects time saved as office staff no longer have to process paper RODS.
3) Paper Costs	$127	Purchases of paper logbooks are no longer necessary
Safety (Crash Reductions)	$572	Although the predicted number of crash reductions is lower for SH than LH drivers, both should exhibit less fatigued driving if HOS compliance increases. Complete HOS compliance is not assumed.
Total Benefits	**$3,010**	

10.3. Federal Analysis and the CHP SRIA

The FMCSA Interstate ELD rule offers a number of useful methodological and data insights that can be used for CHP's intrastate ELD SRIA. This section outlines which methods and data could be transferred and utilized for the SRIA.

Costs

Much of the data and methods used to calculate compliance costs in the federal RIA can be used in the CHP SRIA.

- BEAR suggests using the annualized cost of purchasing, installing, and maintaining an ELD (after appropriate inflation adjustments are made). The technologies being considered for California are comparable and this estimate is based on extensive consultation with ELD manufacturers and likely presents the highest quality estimate available.
- BEAR suggests following the methodology for calculating the cost of hiring new drivers as HOS compliance improves. If (as intended) installing ELDs reduces HOS violations, in order to meet demand carriers will need to hire new drivers. This is a complicated cost to estimate, but the FMCSA RIA has a valid and detailed methodology for doing so. Applying this methodology to California data is appropriate for the CHP's ELD SRIA.

These two categories of cost (new ELDs and additional hiring resulting from improved HOS compliance) account for 99% of the total compliance costs in the FMCSA RIA.

FMCSA's estimates for the number of affected drivers, disaggregated by Long Haul (76%) and Short Haul (24%) are useful for the CHP SRIA since this data is not available for the state fleet.

Benefits

Data and methods used to calculate benefits in the federal RIA can also be used in the CHP SRIA with appropriate adjustments.

- BEAR suggests using the same benefit categories used in the federal RIA
- BEAR suggests using the same methods to estimate paperwork savings
- BEAR suggests utilizing FMCSA's estimates of the rate of reduction in HOS violations associated with adoption of ELDs after any adjustments deemed

necessary for California specific differences. This estimate is based on detailed data from thousands of CMVs that were required to adopt ELDs and likely represents the best estimate available.

- BEAR also suggests utilizing the FMCSA's estimates for the rates of avoided crashes and injuries associated with a reduction in HOS violations. These estimates can be adjusted to reflect California conditions (e.g., separate estimates for short-haul and long-haul drivers, accident rates in California relative to the rest of the United States, etc.), however, they are based on the US Department of Transportation's best available model and data for predicting crashes and injuries associated with ELD adoption and likely represent the best relevant information available.

- BEAR suggests utilizing the same methods used in the federal RIA to estimate the values of avoided injuries, crashes, and lives saved.

Generally, wherever California-specific data is available, its use is prioritized for the SRIA, but in the absence of original or timely California data BEAR estimates from the federal RIA are adopted or adjusted to reflect California conditions to the best extent possible.

11. Appendix 3 - Data related to HOS Violations

Table 11.1: Estimated HOS violations & inspections per year

Violation Code	Violation Description	# Inspections	# Violations
395.13D	Driving after being declared out-of-service for HOS violation(s)	2	2
395.3A2	Driving beyond 14 hour duty period (Property carrying vehicle)	386	418
395.8	Record of Duty Status violation (general/form and manner)	2777	2945
395.8A	No drivers record of duty status when one is required	1517	1529
395.8A1	Not using the appropriate method to record hours of service	2	2
395.8A2	Driver failed to submit their record of duty status within 13 days.	1	1
395.8D9	The driver failed to include name of co-driver for each 24 hour period.	1	1
395.8E	False report of drivers record of duty status	1161	1220
395.8F1	Drivers record of duty status not current	518	520
395.8F10	Failure To Record Days Off Duty In Driver Activities Report	1	1
395.8F11	Failing To Require Driver To Prepare Record Of Duty Status In Form And Manner Prescribed	22	22
395.8F12	Failure To Include Shipping Document Numbers And Commodity List In Duty Status Records	29	29
395.8F2	Driver's record of duty status entries not legible.	5	5
395.8F3	Driver failed to record date for each 24 hour period.	2	2
395.8F4	Driver failed to record total miles driven for each 24 hour period.	21	21
395.8F5	Driver failed to record truck or tractor and trailer unit number for each 24 hour period.	7	7
395.8F6	Driver failed to record name of carrier for each 24 hour period.	3	3
395.8F7	Driver failed to record driver signature/certification for each 24 hour period.	8	8
395.8F9	Driver failed to record main office address for each 24 hour period.	12	12
395.8H1	Driver failed to have a continuous line between appropriate time marker(s).	1	1
395.8H5	Driver failed to appropriately indicate location and remarks for changes in duty status.	10	10
395.8K2	Driver failing to retain previous 7 days records of duty status	1013	1020

Source: Source data from FMCSA Motor Carrier Management Information System (MCMIS). Author calculations described in section.

Table 11.2: HOS violations before and after ELD adoption

Violation Type		# Violations	
Code	**Description**	**Pre**	**Post**
395.8	Form and Manner	0	0
395.15B	Duty Status Record Display.	0	0
395.15C	Driver and Carrier Information	0	0
395.15G	AOBRD Data Retrieval	0	0
395.3A1	11-Hour	18	1
395.3A2	14-Hour	23	10
395.3B	Property: 60/70 Hour	5	0
395.5B	Passenger: 60/70 Hour	2	0
395.8A	RODS show status for every 24 hour period	3	0
395.8E	Incomplete or false	17	17
395.8F1	RODS current to last change of duty	0	0
395.8K2	RODS retained for last 7 days	19	1
395.8	Form and Manner	0	0
395.15B	Duty Status Record Display.	0	0
395.15C	Driver and Carrier Information.	0	0
395.15G	AOBRD Data Retrieval	0	0
395.3A1	11-Hour	16	1
395.3A2	14-Hour	22	1
395.3B	Property: 60/70 Hour	3	0
395.5B	Passenger: 60/70 Hour	0	0
395.8A	Form and Manner	2	2
395.8E	Form and Manner	12	2
395.8F1	Form and Manner	0	0
395.8K2	Form and Manner.	3	1

Table 11.3: Estimated crash reductions for §395 HOS violations

Violation number	Violation description	Crash reduction coefficient
395.13D, 395.13D1, 395.13D2	Driving after being declared out-of-service	1.37784
395.15B, 395.15B5, 395.15C, 395.15D1, 395.15F, 395.15G, 395.15H3, 395.15I5	On-board recording device information requirements not met	0.02952
395.3A1	Requiring or permitting driver to drive more than 11 hours	0.02496
395.3A2	Requiring or permitting driver to drive after 14 hours on duty	0.02496
395.8A	No driver's record of duty status	0.02952
395.8A1	Other Log/Form and Manner	0.00521
395.8A2	Incomplete/Wrong Log	0.02952
395.8C	Other Log/Form and Manner	0.00521
395.8D1	Other Log/Form and Manner	0.00521
395.8D2, 395.8D4, 395.8D5, 395.8D6, 395.8D7, 395.8D8, 395.8D9, 395.8D10, 395.8D11	Other Log/Form and Manner	0.02952
395.8E	False report of driver's record of duty status	0.05088
395.8F1, 395.8F2, 395.8F3, 395.8F4, 395.8F5, 395.8F6, 395.8F7, 395.8F9, 395.8F9, 395.8F10, 395.8F11, 395.8F12	Driver's record of duty status not current	0.02952
395.8G	Other Log/Form and Manner	0.02952
395.8H1, 395.8H2, 395.8H4, 395.8H5	Other Log/Form and Manner	0.02952
395.8I	Incomplete/Wrong Log	0.02952
395.8J2	Other Log/Form and Manner	0.02952
395.8K1, 395.8K2	Incomplete/Wrong Log	0.02952

Source: *FMCSA Safety Program Effectiveness Measurement: Intervention Model Fiscal Year 2009*.

Following 2015 Federal RIA crash reduction figures are adjusted from 30 to 240 driver working day

12. Appendix 4 - Technical Summary of the BEAR Model

The Berkeley Energy and Resources (BEAR) model is in reality a constellation of research tools designed to elucidate linkages across the California economy. The schematics in Figures A1.1 and A1.2 describe the four generic components of the modeling facility and their interactions. This section provides a brief summary of the formal structure of the BEAR model.[34] For the purposes of this report, the 2013 California Social Accounting Matrix (SAM), was aggregated along certain dimensions. The current version of the model includes 195 activity sectors, 22 occupations, and ten households aggregated from the original California SAM. The equations of the model are completely documented elsewhere (Roland-Holst: 2015), and for the present we only review its salient structural components.

12.1. Structure of the CGE Model

Technically, a CGE model is a system of simultaneous equations that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economywide resource allocation, production, and income determination.

The role of markets is to mediate exchange, usually with a flexible system of prices, the most important endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system is solved for prices that correspond to equilibrium in markets and satisfy the accounting identities governing economic behavior. If such a system is precisely specified, equilibrium always exists and such a consistent model can be calibrated to a base period data set. The resulting calibrated general equilibrium model is then used to simulate the economywide (and regional) effects of alternative policies or external events.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed-form specification of all activities in the economic system under study. This can be contrasted with more traditional partial equilibrium analysis, where linkages to other domestic markets and agents are deliberately excluded from consideration. A large and growing body of evidence suggests that indirect effects (e.g., upstream and downstream production linkages) arising from policy changes

[34] See Roland-Holst (2015) for a complete model description.

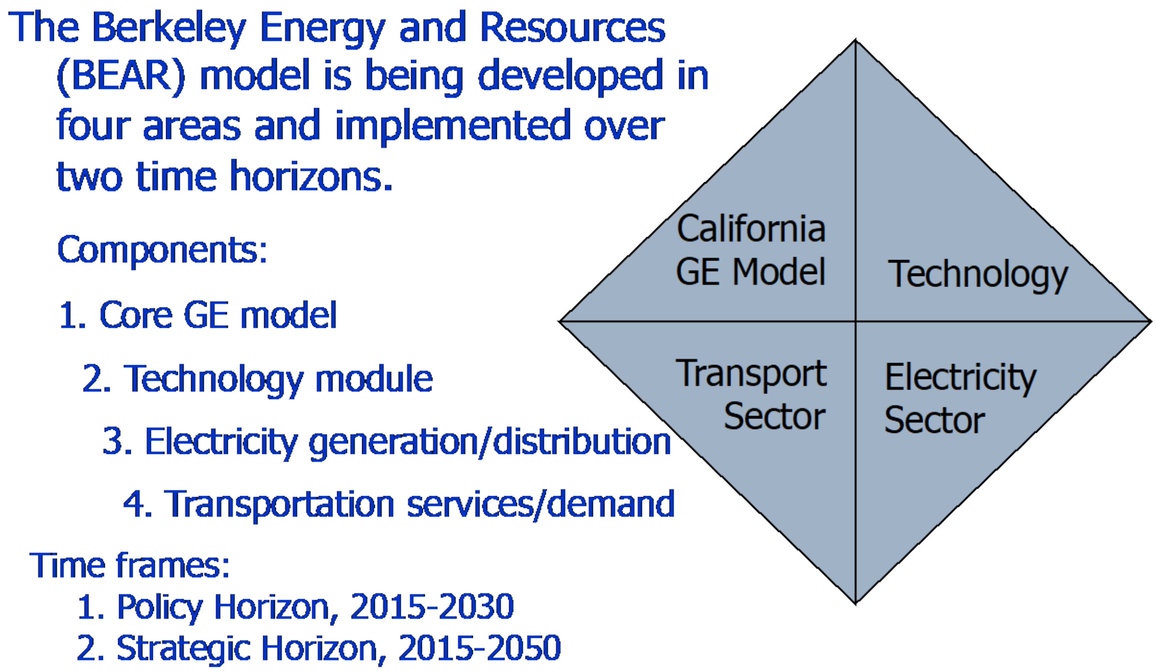
are not only substantial but may in some cases even outweigh direct effects. Only a model that consistently specifies economywide interactions can fully assess the implications of economic policies or business strategies. In a multi-country model like the one used in this study, indirect effects include the trade linkages between countries and regions which themselves can have policy implications.

The model we use for this work has been constructed according to generally accepted specification standards, implemented in the GAMS programming language, and calibrated to the new California SAM estimated for the year 2020. The result is a single economy model calibrated over the ten -year time path from 2022 to 2031. Using the very detailed accounts of the California SAM, we include the following in the present model:

12.2. Production

All sectors are assumed to operate under constant returns to scale and cost optimization. Production technology is modeled by a nesting of constant-elasticity-of-substitution (CES) function.

Figure 12.1: Component Structure of the Modeling Facility



In each period, the supply of primary factors — capital, land, and labor — is usually predetermined.[35] The model includes adjustment rigidities. An important feature is the distinction between old and new capital goods. In addition, capital is assumed to be partially mobile, reflecting differences in the marketability of capital goods across sectors.[36] Once the optimal combination of inputs is determined, sectoral output prices are calculated assuming competitive supply conditions in all markets.

12.3. Consumption and Closure Rule

All income generated by economic activity is assumed to be distributed to consumers. Each representative consumer allocates optimally his/her disposable income among the different commodities and saving. The consumption/saving decision is completely static: saving is treated as a "good" and its amount is determined simultaneously with the demand for the other commodities, the price of saving being set arbitrarily equal to the average price of consumer goods.

[35] Capital supply is to some extent influenced by the current period's level of investment.

[36] For simplicity, it is assumed that old capital goods supplied in second-hand markets and new capital goods are homogeneous. This formulation makes it possible to introduce downward rigidities in the adjustment of capital without increasing excessively the number of equilibrium prices to be determined by the model.

The government collects income taxes, indirect taxes on intermediate inputs, outputs and consumer expenditures. The default closure of the model assumes that the government deficit/saving is exogenously specified.[37] The indirect tax schedule will shift to accommodate any changes in the balance between government revenues and government expenditures.

The current account surplus (deficit) is fixed in nominal terms. The counterpart of this imbalance is a net outflow (inflow) of capital, which is subtracted (added to) the domestic flow of saving. In each period, the model equates gross investment to net saving (equal to the sum of saving by households, the net budget position of the government and foreign capital inflows). This particular closure rule implies that investment is driven by saving.

12.4. Trade

Goods are assumed to be differentiated by region of origin. In other words, goods classified in the same sector are different according to whether they are produced domestically or imported. This assumption is frequently known as the *Armington* assumption. The degree of substitutability, as well as the import penetration shares are allowed to vary across commodities. The model assumes a single Armington agent. This strong assumption implies that the propensity to import and the degree of substitutability between domestic and imported goods is uniform across economic agents. This assumption reduces tremendously the dimensionality of the model. In many cases this assumption is imposed by the data. A symmetric assumption is made on the export side where domestic producers are assumed to differentiate the domestic market and the export market. This is modeled using a *Constant-Elasticity-of-Transformation* (CET) function.

12.5. Dynamic Features and Calibration

The current version of the model has a simple recursive dynamic structure as agents are assumed to be myopic and to base their decisions on static expectations about prices and quantities. Dynamics in the model originate in three sources: i) accumulation of productive capital and labor growth; ii) shifts in production technology; and iii) the putty/semi-putty specification of technology.

[37] In the reference simulation, the real government fiscal balance converges (linearly) towards 0 by the final period of the simulation.

12.6. Capital accumulation

In the aggregate, the basic capital accumulation function equates the current capital stock to the depreciated stock inherited from the previous period plus gross investment. However, at the sectoral level, the specific accumulation functions may differ because the demand for (old and new) capital can be less than the depreciated stock of old capital. In this case, the sector contracts over time by releasing old capital goods. Consequently, in each period, the new capital vintage available to expanding industries is equal to the sum of disinvested capital in contracting industries plus total saving generated by the economy, consistent with the closure rule of the model.

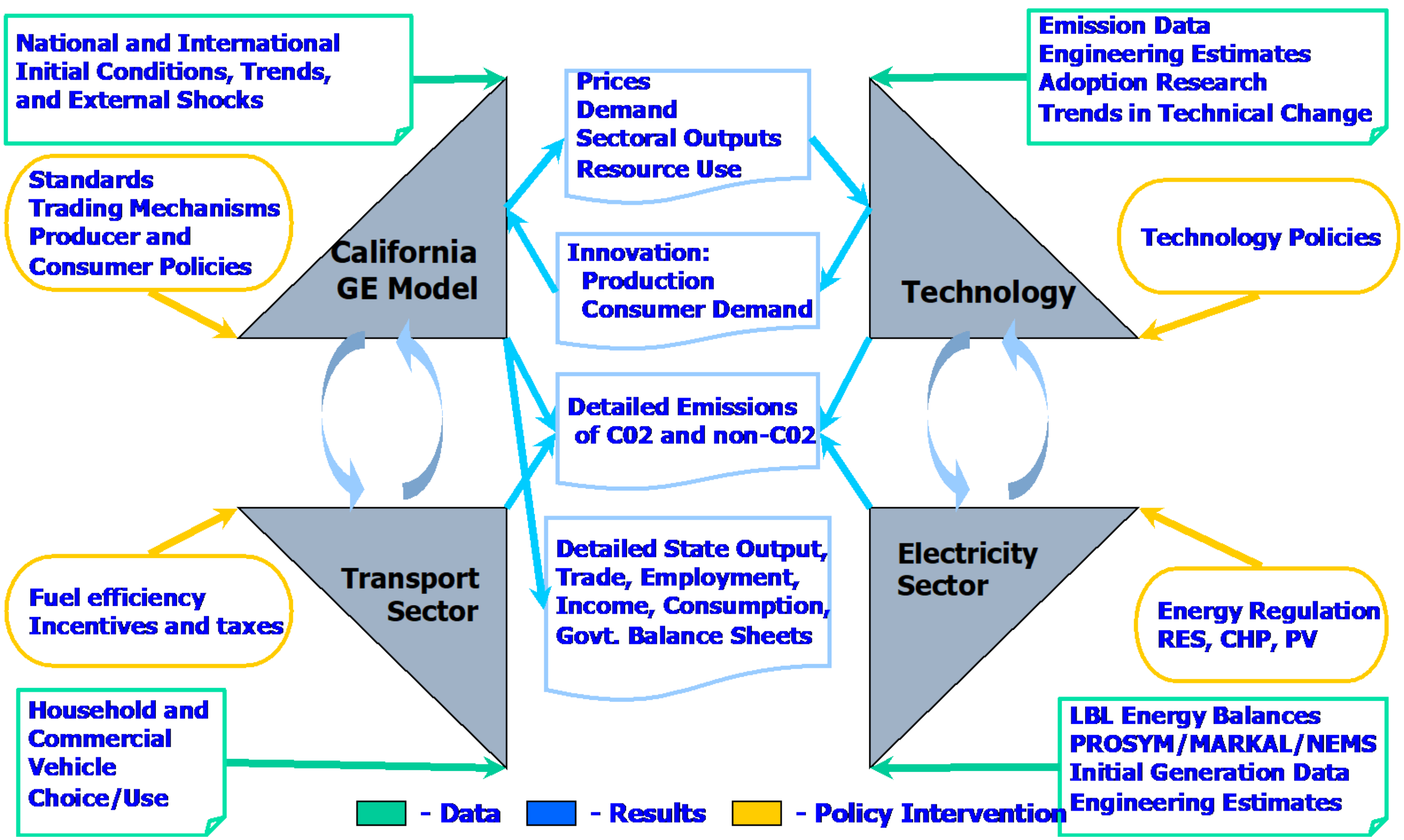
12.7. The putty/semi-putty specification

The substitution possibilities among production factors are assumed to be higher with the new than the old capital vintages — technology has a putty/semi-putty specification. Hence, when a shock to relative prices occurs (e.g. the imposition of an emissions fee), the demands for production factors adjust gradually to the long-run optimum because the substitution effects are delayed over time. The adjustment path depends on the values of the short-run elasticities of substitution and the replacement rate of capital. As the latter determines the pace at which new vintages are installed, the larger is the volume of new investment, the greater the possibility to achieve the long-run total amount of substitution among production factors.

12.8. Profits, Adjustment Costs, and Expectations

Firms output and investment decisions are modeled in accordance with the innovative approach of Goulder and co-authors (see e.g. Goulder et al: 2009 for technical details). In particular, we allow for the possibility that firms reap windfall profits from events such as free permit distribution. Absent more detailed information on ownership patterns, we assume that these profits accrue to US and foreign residents in proportion to equity shares of publically traded US corporations (16% in 2009, Swartz and Tillman:2010). Between California and other US residents, the shares are assumed to be proportional to GSP in GDP (11% in 2009).

Figure 12.2: Schematic Linkage between Model Components



12.9. Dynamic calibration

The model is calibrated on exogenous growth rates of population, labor force, and GDP. In the so-called Baseline scenario, the dynamics are calibrated in each region by imposing the assumption of a balanced growth path. This implies that the ratio between labor and capital (in efficiency units) is held constant over time.[38] When alternative scenarios around the baseline are simulated, the technical efficiency parameter is held constant, and the growth of capital is endogenously determined by the saving/investment relation.

12.10. Modelling Emissions

The BEAR model captures emissions from production activities in agriculture, industry, and services, as well as in final demand and use of final goods (e.g. appliances and autos). This is done by calibrating emission functions to each of these activities that vary depending upon the emission intensity of the inputs used for the activity in question. We model both CO2 and the other primary greenhouse gases, which are converted to CO2 equivalent. Following standards set in the research literature, emissions in production are modeled as factors inputs. The base version of the model does not have a full representation of emission reduction or abatement. Emissions abatement occurs by substituting additional labor or capital for emissions when an emissions tax is applied. This is an accepted modeling practice, although in specific instances it may either understate or overstate actual emissions reduction potential.[39] In this framework, mission levels have an underlying monotone relationship with production levels, but can be reduced by increasing use of other, productive factors such as capital and labor. The latter represent investments in lower intensity technologies, process cleaning activities, etc. An overall calibration procedure fits observed intensity levels to baseline activity and other factor/resource use levels. In some of the policy simulations we evaluate sectoral emission reduction scenarios, using specific cost and emission reduction factors, based on our earlier analysis (Hanemann and Farrell: 2006).

The BEAR model has the capacity to track 13 categories of individual pollutants and consolidated emission indexes, each of which is listed in Table 12.1 below. Our focus in the current study is the emission of CO2 and other greenhouse gases, but the other effluents are of relevance to a variety of environmental policy issues. For more detail, please consult the full model documentation.

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[38]This involves computing in each period a measure of Harrod-neutral technical progress in the capital-labor bundle as a residual. This is a standard calibration procedure in dynamic CGE modeling.

[39] See e.g. Babiker et al (2001) for details on a standard implementation of this approach.

An essential characteristic of the BEAR approach to emissions modeling is endogeniety. Contrary to assertions made elsewhere (Stavins et al:2007), the BEAR model permits emission rates by sector and input to be exogenous or endogenous, and in either case the level of emissions from the sector in question is endogenous unless a cap is imposed. This feature is essential to capture structural adjustments arising from market based climate policies, as well as the effects of technological change.

Table 12.1: Emission Categories

Air Pollutants		
1.	Suspended particulates	PART
2.	Sulfur dioxide (SO_2)	SO2
3.	Nitrogen dioxide (NO_2)	NO2
4.	Volatile organic compounds	VOC
5.	Carbon monoxide (CO)	CO
6.	Toxic air index	TOXAIR
7.	Biological air index	BIOAIR
Water Pollutants		
8.	Biochemical oxygen demand	BOD
9.	Total suspended solids	TSS
10.	Toxic water index	TOXWAT
11.	Biological water index	BIOWAT
Land Pollutants		
12.	Toxic land index	TOXSOL
13.	Biological land index	BIOSOL

Table 12.2 California SAM for 2013 – Structural Characteristics

1.	195 commodities (includes trade and transport margins)
2.	24 factors of production
3.	22 labor categories
4.	Capital
5.	Land
6.	10 Household types, defined by income tax bracket
7.	Enterprises
8.	Federal Government (7 fiscal accounts)
9.	State Government (27 fiscal accounts)
10.	Local Government (11 fiscal accounts)
11.	Consolidated capital account
12.	External Trade Account

Table 12.3: Aggregate Accounts for the SRIA Assessment

The 50 Production Sectors and Commodity Groups represent the aggregation of the 195 original sectors that will be used for the current assessment.

Sectoring Scheme for the BEAR Model

The following sectors are aggregated from a new, 199 sector California SAM

	Label	Description
1	A01Agric	Agriculture
2	A02Cattle	Cattle and Feedlots
3	A03Dairy	Dairy Cattle and Milk Production
4	A04Forest	Forestry, Fishery, Mining, Quarrying
5	A05OilGas	Oil and Gas Extraction
6	A06OthPrim	Other Primary Products
7	A07DistElec	Generation and Distribution of Electricity
8	A08DistGas	Natural Gas Distribution
9	A09DistOth	Water, Sewage, Steam
10	A10ConRes	Residential Construction
11	A11ConNRes	Non-Residential Construction
12	A12Constr	Construction
13	A13FoodPrc	Food Processing
14	A14TxtAprl	Textiles and Apparel
15	A15WoodPlp	Wood, Pulp, and Paper
16	A16PapPrnt	Printing and Publishing
17	A17OilRef	Oil Refining
18	A18Chemicl	Chemicals
19	A19Pharma	Pharmaceutical Manufacturing
20	A20Cement	Cement
21	A21Metal	Metal Manufacture and Fabrication
22	A22Aluminm	Aliminium
23	A23Machnry	General Machinery
24	A24AirCon	Air Conditioning and Refridgeration
25	A25SemiCon	Semi-conductor and Other Computer Manufacturing
26	A26ElecApp	Electrical Appliances
27	A27Autos	Automobiles and Light Trucks
28	A28OthVeh	Vehicle Manufacturing
29	A29AeroMfg	Aeroplane and Aerospace Manufacturing
30	A30OthInd	Other Industry
31	A31WhlTrad	Wholesale Trade
32	A32RetVeh	Retail Vehicle Sales and Service
33	A33AirTrns	Air Transport Services
34	A34GndTrns	Ground Transport Services
35	A35WatTrns	Water Transport Services
36	A36TrkTrns	Truck Transport Services
37	A37PubTrns	Public Transport Services
38	A38RetAppl	Retail Electronics
39	A39RetGen	Retail General Merchandise
40	A40InfCom	Information and Communication Services
41	A41FinServ	Financial Services
42	A42OthProf	Other Professional Services
43	A43BusServ	Business Services
44	A44WstServ	Waste Services
45	A45LandFill	Landfill Services
46	A46Educatn	Educational Services
47	A47Medicin	Medical Services
48	A48Recratn	Recreation Services
49	A49HotRest	Hotel and Restaurant Services
50	A50OthPrSv	Other Private Services

These data enable us to trace the effects of responses to climate change and other policies at unprecedented levels of detail, tracing linkages across the economy and clearly indicating the indirect benefits and tradeoffs that might result from comprehensive policies pollution taxes or trading systems. As we shall see in the results section, the effects of climate policy can be quite complex. In particular, cumulative indirect effects often outweigh direct consequences, and affected groups are often far from the policy target group. For these reasons, it is essential for policy makers to anticipate linkage effects like those revealed in a general equilibrium model and dataset like the ones used here.

It should be noted that the SAM used with BEAR departs in a few substantive respects from the original 2012 California SAM. The two main differences have to do with the structure of production, as reflected in the input-output accounts, and with consumption good aggregation. To specify production technology in the BEAR model, we rely on both activity and commodity accounting, while the original SAM has consolidated activity accounts. We chose to maintain separate activity and commodity accounts to maintain transparency in the technology of emissions and patterns of tax incidence. The difference is non-trivial and considerable additional effort was needed to reconcile use and make tables separately. This also facilitated the second SAM extension, however, where we maintained final demand at the full 119 commodity level of aggregation, rather than adopting six aggregate commodities like the original SAM.

12.11. Emissions Data

Emissions data were obtained form California's own detailed emissions inventory. In most of the primary pollution databases like this, measured emissions are directly associated with the volume of output. This has several consequences. First, from a behavioral perspective, the only way to reduce emissions, with a given technology, is to reduce output. This obviously biases results by exaggerating the abatement-growth tradeoff and sends a misleading and unwelcome message to policy makers.

More intrinsically, output based pollution modeling imperfectly to capture the observed pattern of abatement behavior. Generally, firms respond to abatement incentives and penalties in much more complex and sophisticated ways by varying internal conditions of production. These responses include varying the sources, quality, and composition of inputs, choice of technology, etc. The third shortcoming of the output approach is that it give us no guidance about other important pollution sources outside the production process, especially pollution in use of final goods. The most important example of this category is household consumption. BEAR estimates emissions from both intermediate and (in-state) final demand.