California Energy Commission
CONSULTANT MEMORANDUM

Berkeley Energy and Resources (BEAR) Model: SRIA Baseline Forecast for the California Economy

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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).[1, 2, 3] 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.[4]

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 5 below.

Figure 2.1

[1] California Code of Regulations, title 1, section 2003(b)
[2] http://www.dof.ca.gov/research/demographic/reports/projections/
[3] http://www.dof.ca.gov/html/fs_data/LatestEconData/FS_Forecasts.htm
[4] 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.

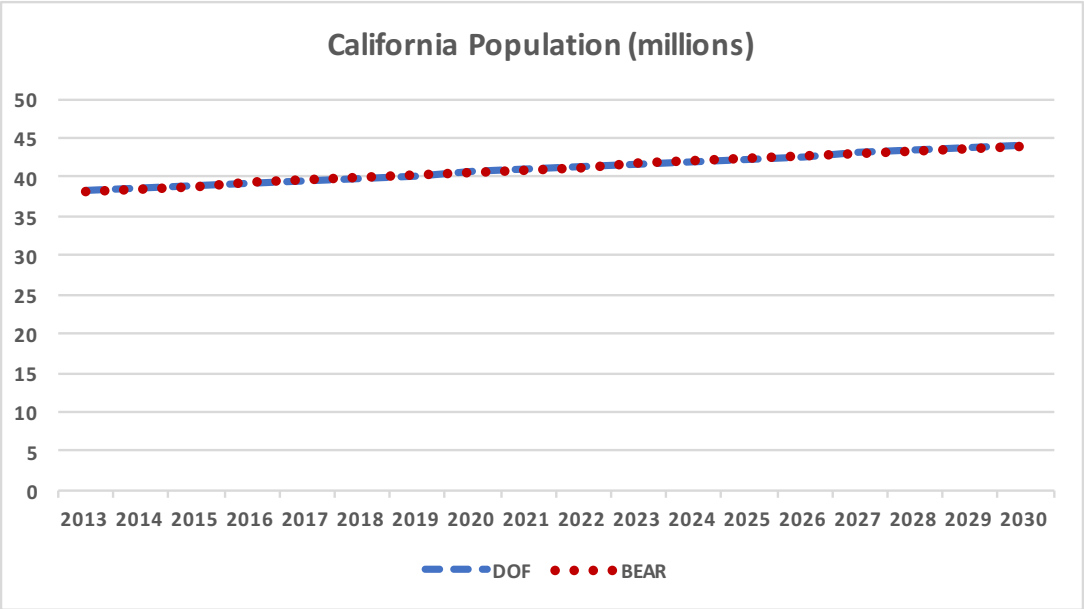
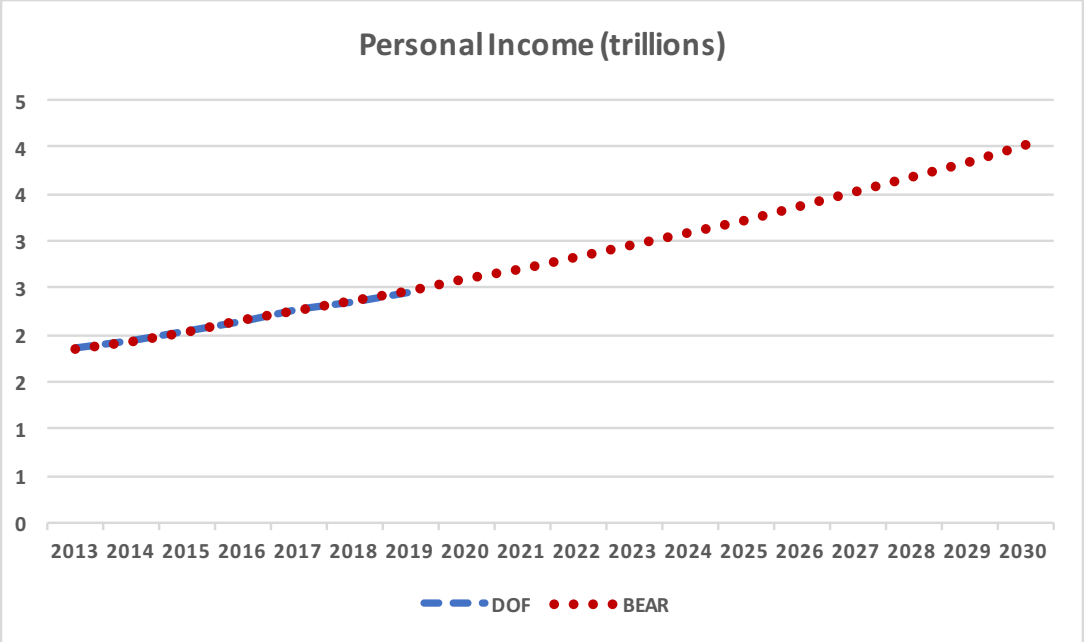


Figure 2.2



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 3

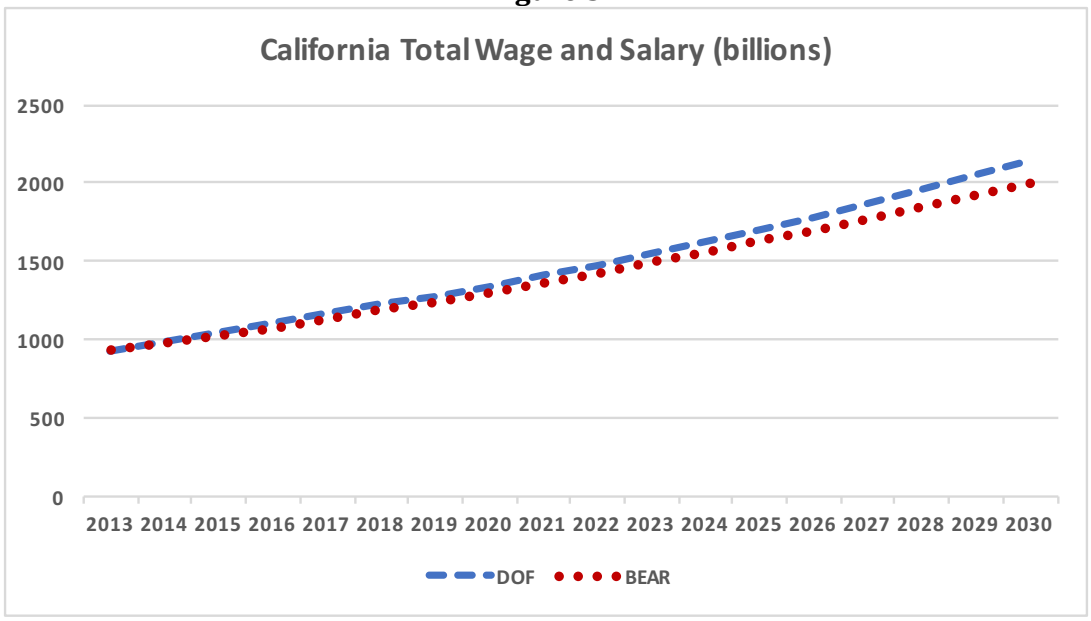
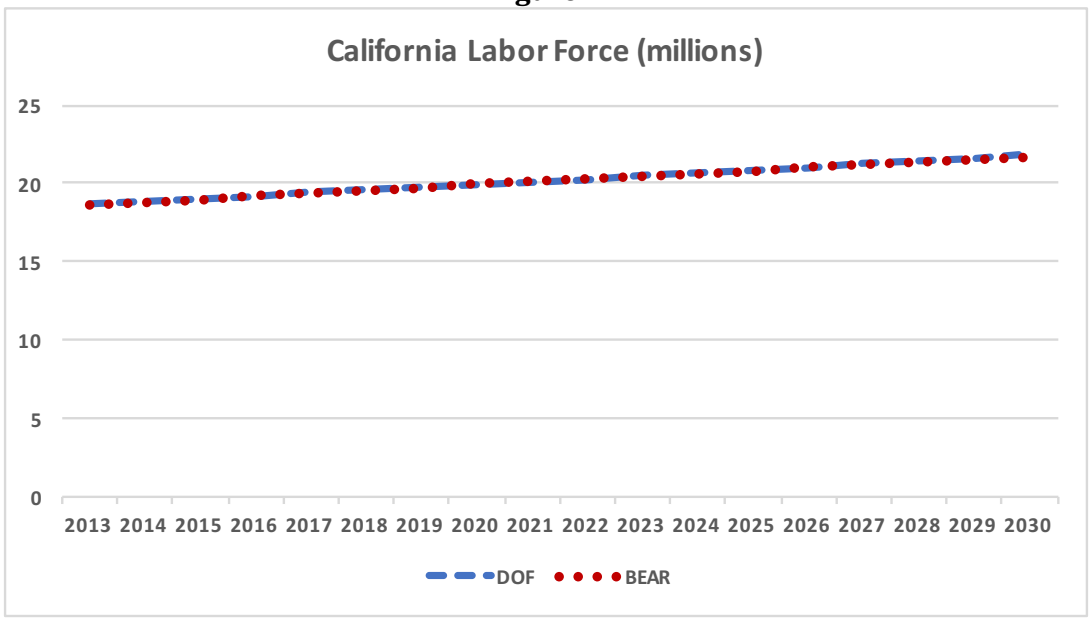


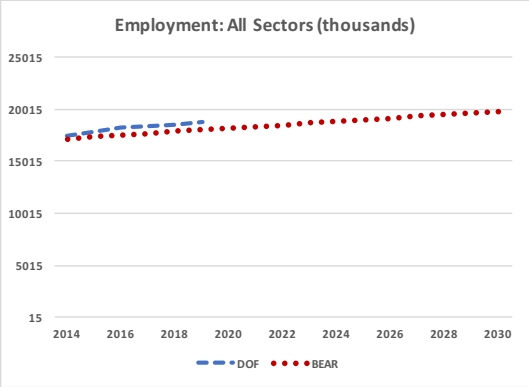
Figure 4



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 2013-2019 only, while BEAR extrapolates these annually to 2030.

Figure 3.0



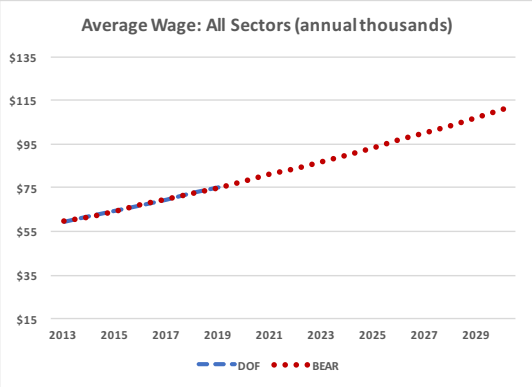
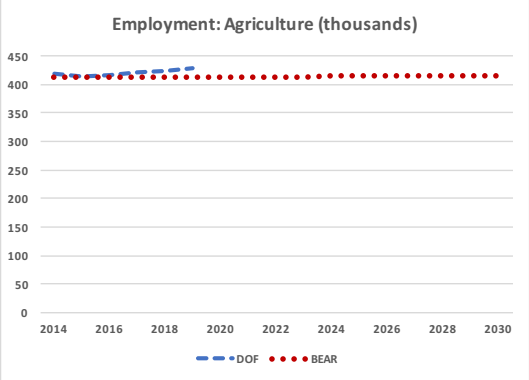


Figure 3.1



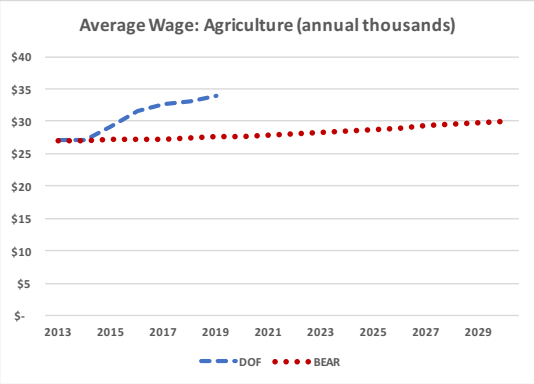
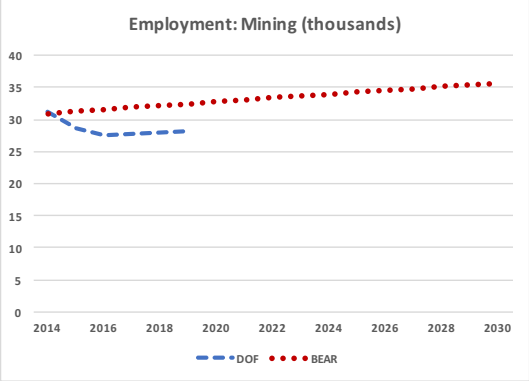
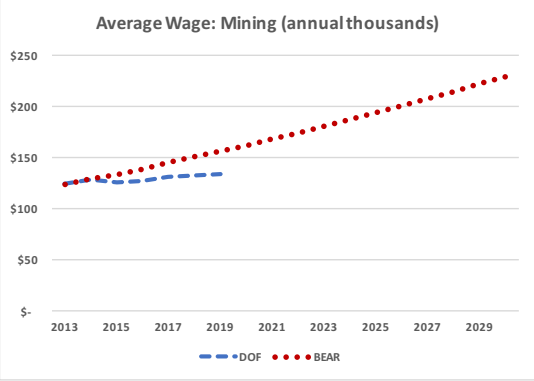


Figure 3.2





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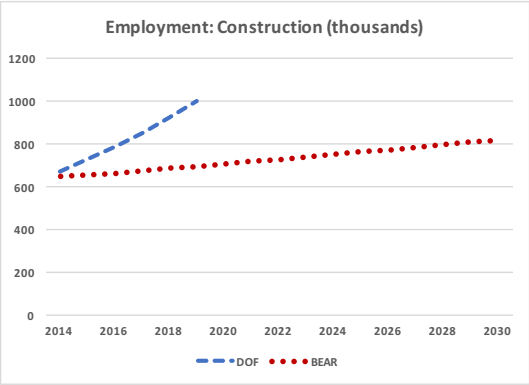

Employment: Construction (thousands)
1200
1000
800
600
400
200
0
2014
2016
2018
2020
2022
2024
2026
2028
2030
DOF
BEAR

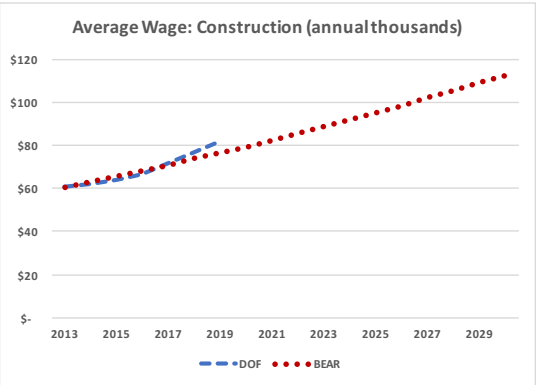
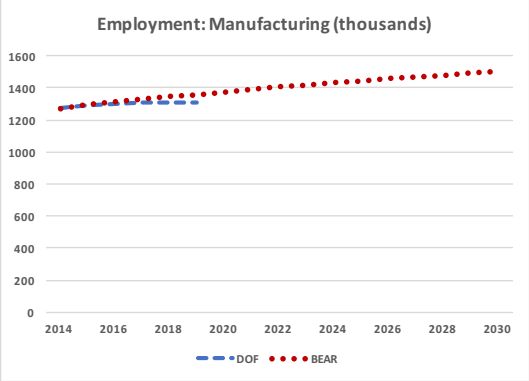
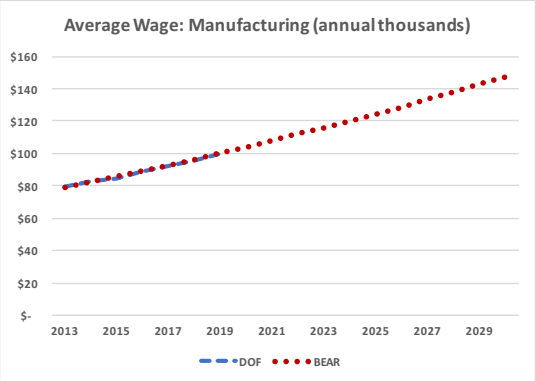

Average Wage: Construction (annual thousands)
$120
$100
$80
$60
$40
$20
$-
2013
2015
2017
2019
2021
2023
2025
2027
2029
DOF
BEAR

Figure 3.4





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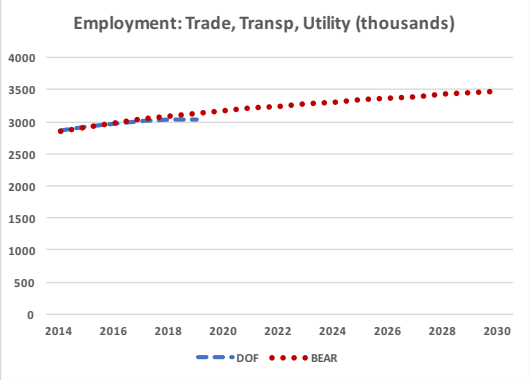

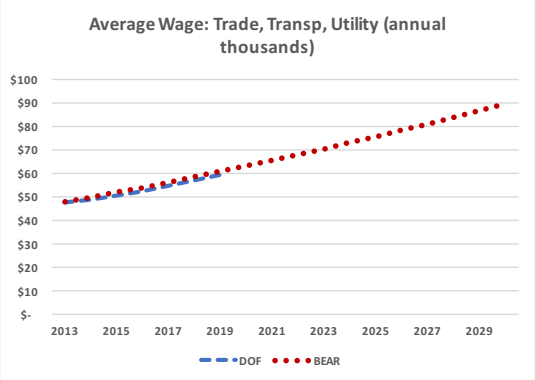

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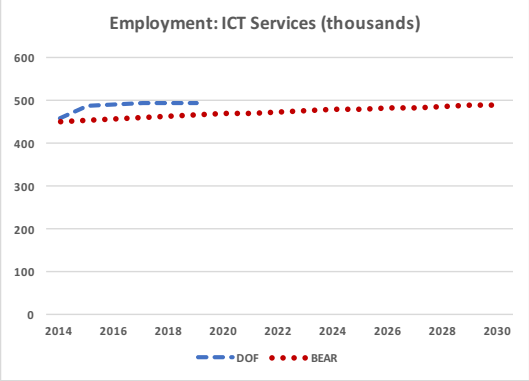

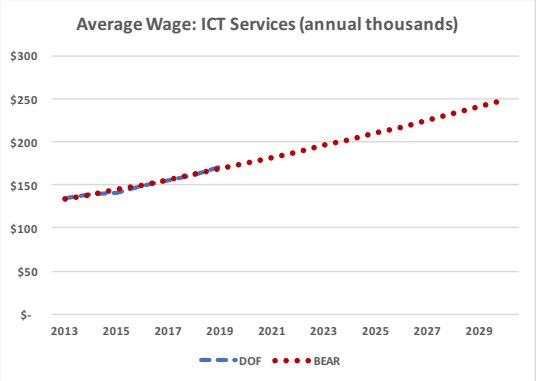

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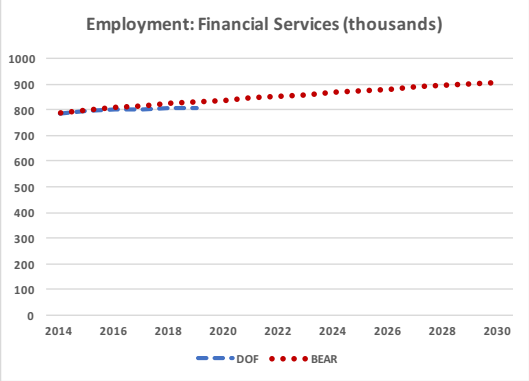

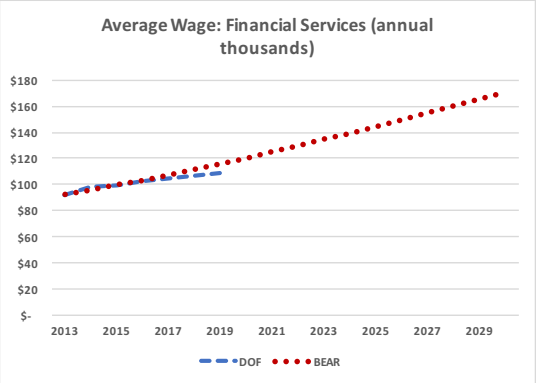

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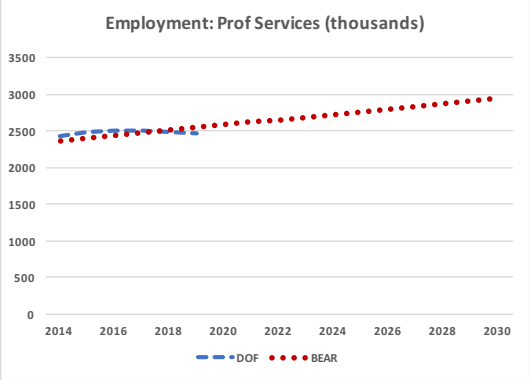

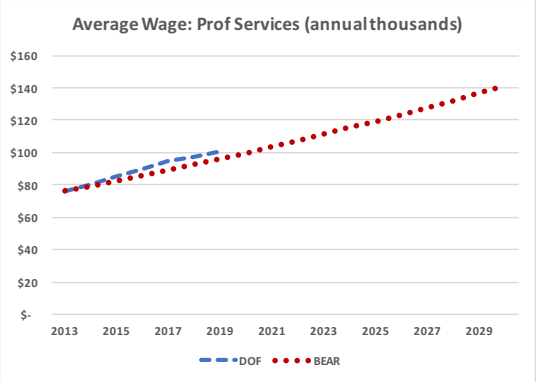

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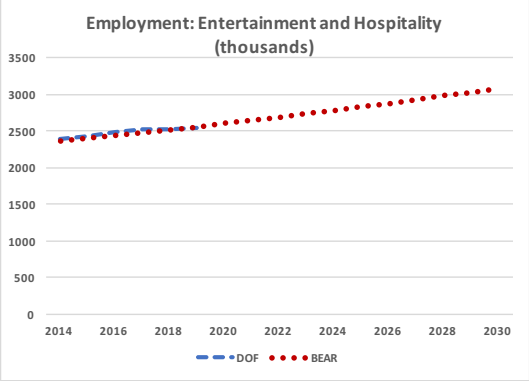

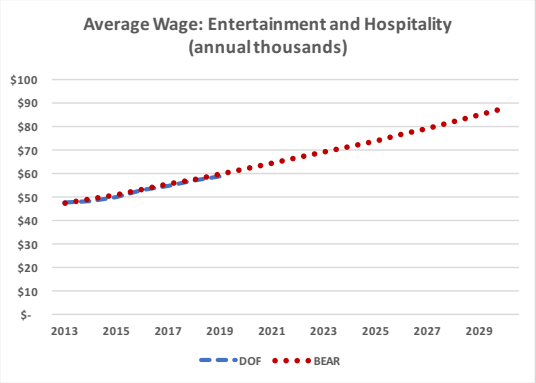

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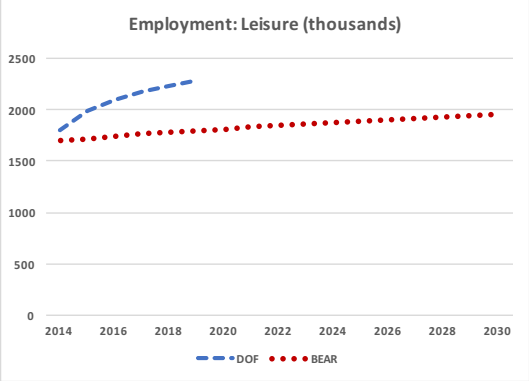

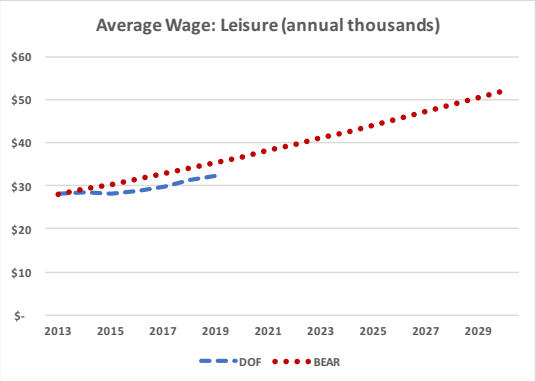

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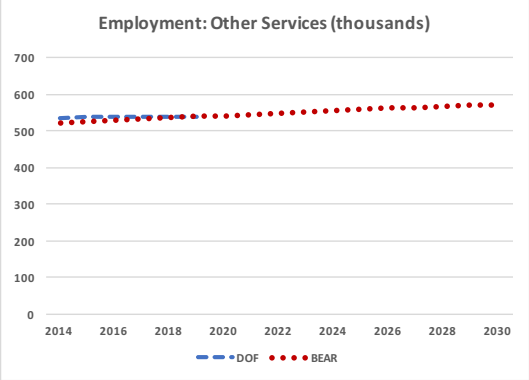

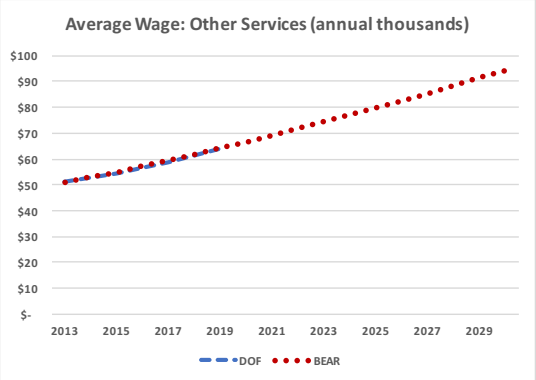

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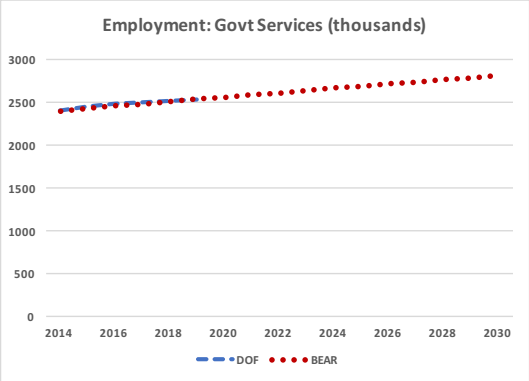
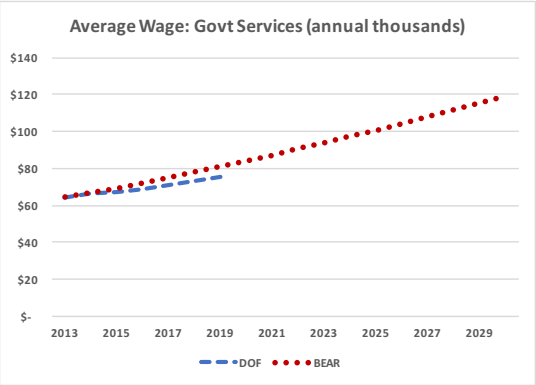




4 DETAILED MACROECONOMIC PROJECTIONS

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 2012-2019.

Table 4.1: California Labor Force Forecasts – DOF Projections

California Labor Force and Employment 1/	Annual Averages									Annual Percent Change						
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
Civilian Labor Force	18,361.3	18,483.6	18,638.5	18,800.0	19,012.2	19,210.7	19,388.5	19,553.6	19,729.3	0.8	0.9	1.1	1.0	0.9	0.9	0.9
Civilian Employment	16,236.1	16,592.3	17,001.2	17,383.5	17,827.8	18,117.3	18,305.2	18,478.4	18,652.4	2.5	2.2	2.6	1.6	1.0	0.9	0.9
Civilian Unemployment	2,125.1	1,891.4	1,637.3	1,416.6	1,184.4	1,093.4	1,083.3	1,075.2	1,076.9	(13.4)	(13.5)	(16.4)	(7.7)	(0.9)	(0.7)	0.2
Civilian Unemployment Rate	11.6%	10.2%	8.8%	7.5%	6.2%	5.7%	5.6%	5.5%	5.5%							
Farm Employment	389.8	399.4	411.7	417.8	414.6	417.0	421.5	424.4	427.8	3.1	1.5	(0.8)	0.6	1.1	0.7	0.8
Non-Farm Employment	14,363.8	14,711.8	15,183.4	15,653.4	16,131.5	16,488.1	16,730.3	16,882.1	17,037.8	3.2	3.1	3.1	2.2	1.5	0.9	0.9
Year-to-Year Change	149.0	348.0	471.6	470.0	478.0	356.6	242.2	151.8	155.8							
Goods Producing	1,840.4	1,875.2	1,924.3	1,975.1	2,047.2	2,119.5	2,190.4	2,260.3	2,336.3	2.6	2.6	3.7	3.5	3.3	3.2	3.4
Mining and Logging	28.8	30.5	30.6	31.1	28.6	27.6	27.8	28.0	28.1	0.4	1.5	(8.1)	(3.5)	0.9	0.7	0.3
Construction	561.4	590.0	637.4	673.3	728.8	788.5	853.7	924.3	1,000.9	8.0	5.6	8.2	8.2	8.3	8.3	8.3
Manufacturing	1,250.1	1,254.7	1,256.3	1,270.7	1,289.8	1,303.4	1,308.9	1,308.0	1,307.3	0.1	1.1	1.5	1.1	0.4	(0.1)	(0.1)
High Technology	346.7	341.1	334.9	334.0	340.5	348.9	354.8	357.1	358.5	(1.8)	(0.3)	1.9	2.5	1.7	0.6	0.4
Aerospace Prod. & Parts Mfg.	71.5	71.1	72.0	71.4	76.9	81.2	84.4	86.0	87.5	1.3	(0.9)	7.7	5.7	3.9	1.9	1.7
Computer & Elect. Prod. Mfg.	275.1	270.0	262.9	262.7	263.7	267.7	270.4	271.1	271.1	(2.6)	(0.1)	0.4	1.5	1.0	0.3	(0.0)
Food & Bev. Manufacturing	192.4	195.0	198.1	202.9	209.6	210.5	210.8	211.3	212.1	1.6	2.5	3.3	0.4	0.1	0.3	0.4
Textiles and Apparel	74.2	73.8	74.4	72.0	69.4	69.0	68.8	68.7	68.4	0.8	(3.2)	(3.6)	(0.5)	(0.4)	(0.1)	(0.4)
Other Manufacturing	636.9	644.8	648.9	661.7	670.3	674.9	674.5	670.9	668.3	0.6	2.0	1.3	0.7	(0.1)	(0.5)	(0.4)
Durables	434.4	442.9	448.6	459.6	466.9	472.0	477.4	482.6	484.5	1.3	2.4	1.6	1.1	1.1	1.1	0.4
Nondurables	202.5	201.9	200.4	202.2	203.5	202.9	197.1	188.3	183.8	(0.8)	0.9	0.6	(0.3)	(2.9)	(4.4)	(2.4)
Service Providing	12,523.5	12,836.6	13,259.1	13,678.3	14,084.2	14,368.6	14,539.9	14,621.8	14,701.5	3.3	3.2	3.0	2.0	1.2	0.6	0.5
Trade, Transportation & Utilities	2,678.6	2,733.9	2,793.4	2,870.7	2,927.3	2,974.2	3,001.9	3,023.0	3,041.9	2.2	2.8	2.0	1.6	0.9	0.7	0.6
Wholesale & Retail Trade	2,204.4	2,246.7	2,290.6	2,345.2	2,375.7	2,399.1	2,420.2	2,433.6	2,445.0	2.0	2.4	1.3	1.0	0.9	0.6	0.5
Wholesale Trade	657.9	675.5	693.8	712.4	715.4	717.5	723.1	729.6	736.9	2.7	2.7	0.4	0.3	0.8	0.9	1.0
Retail Trade	1,546.5	1,571.1	1,596.8	1,632.9	1,660.3	1,681.7	1,697.1	1,704.0	1,708.0	1.6	2.3	1.7	1.3	0.9	0.4	0.2
Utilities	58.4	59.4	58.9	58.0	57.6	57.5	57.4	57.5	57.3	(0.8)	(1.6)	(0.6)	(0.2)	(0.1)	0.1	(0.2)
Transportation and Warehousing	415.8	427.9	443.9	467.5	494.0	517.6	524.3	531.8	539.5	3.7	5.3	5.7	4.8	1.3	1.4	1.4
Information	430.6	435.1	448.6	458.1	485.7	490.8	492.7	494.8	494.4	3.1	2.1	6.0	1.0	0.4	0.4	(0.1)
Motion Picture and Sound Recording	143.9	141.0	144.1	143.0	154.1	154.6	154.2	155.6	158.4	2.2	(0.8)	7.7	0.4	(0.3)	0.9	1.8
Publishing Industries (except Internet)	84.8	87.1	88.0	88.4	93.7	92.4	88.9	86.2	82.7	1.0	0.4	6.0	(1.3)	(3.8)	(3.1)	(4.0)
Telecommunications	94.8	89.9	89.8	88.2	82.1	78.9	75.9	74.6	74.6	(0.1)	(1.8)	(6.8)	(3.9)	(3.8)	(1.7)	0.0
Other Information	107.1	117.1	126.7	138.6	155.8	164.8	173.6	178.4	178.6	8.2	9.4	12.4	5.8	5.4	2.7	0.1
Financial Activities	761.8	773.4	782.8	783.6	796.2	800.6	804.1	805.6	805.6	1.2	0.1	1.6	0.6	0.4	0.2	(0.0)
Professional and Business Services	2,134.5	2,242.3	2,341.0	2,430.9	2,479.6	2,506.2	2,507.6	2,481.8	2,464.1	4.4	3.8	2.0	1.1	0.1	(1.0)	(0.7)
High Technology	333.3	353.8	371.1	389.9	418.3	429.7	432.6	434.8	436.0	4.9	5.1	7.3	2.7	0.7	0.5	0.3
Computer Systems Design	212.6	228.2	243.6	261.8	282.9	291.3	292.9	295.1	295.9	6.8	7.5	8.1	3.0	0.6	0.7	0.3
Scientific Research & Development	120.7	125.6	127.5	128.1	135.4	138.4	139.6	139.8	140.0	1.5	0.5	5.7	2.3	0.8	0.1	0.2
Legal, Accounting, Arch., Bus. Svcs	403.8	413.2	421.0	429.1	428.8	427.7	428.4	426.5	423.7	1.9	1.9	(0.1)	(0.3)	0.2	(0.5)	(0.7)
Employment Services	346.8	378.7	409.0	441.6	450.2	455.6	453.0	451.2	445.6	8.0	8.0	1.9	1.2	(0.6)	(0.4)	(1.2)
Other Business Services	1,050.5	1,096.6	1,139.9	1,170.4	1,182.4	1,193.2	1,193.5	1,169.3	1,158.8	4.0	2.7	1.0	0.9	0.0	(2.0)	(0.9)
Educational and Health Services	2,083.8	2,172.7	2,325.9	2,390.0	2,427.1	2,486.3	2,516.4	2,531.7	2,547.4	7.0	2.8	1.6	2.4	1.2	0.6	0.6
Leisure and Hospitality	1,535.8	1,598.5	1,676.6	1,798.2	1,983.5	2,094.4	2,182.1	2,235.6	2,285.4	4.9	7.2	10.3	5.6	4.2	2.4	2.2
Other Services	493.7	504.7	516.6	535.9	538.3	539.2	539.7	538.2	537.3	2.4	3.7	0.4	0.2	0.1	(0.3)	(0.2)
Government	2,404.6	2,376.0	2,374.1	2,410.9	2,446.6	2,476.9	2,495.3	2,511.2	2,525.4	(0.1)	1.5	1.5	1.2	0.7	0.6	0.6
Federal	255.2	250.5	245.5	242.2	243.3	242.6	241.4	241.5	242.6	(2.0)	(1.3)	0.5	(0.3)	(0.5)	0.1	0.5
DoD	62.2	61.3	60.1	58.4	57.8	56.2	54.0	56.2	60.0	(2.0)	(2.9)	(1.0)	(2.8)	(3.9)	4.2	6.8
Civilian	193.0	189.1	185.3	183.8	185.5	186.5	187.4	185.3	182.6	(2.0)	(0.8)	0.9	0.5	0.5	(1.1)	(1.5)
State	485.4	482.2	484.3	496.7	507.6	516.6	522.1	525.9	530.1	0.4	2.6	2.2	1.8	1.1	0.7	0.8
Local	1,664.0	1,643.4	1,644.4	1,672.0	1,695.6	1,717.6	1,731.9	1,743.8	1,752.7	0.1	1.7	1.4	1.3	0.8	0.7	0.5
Units: Thousands																

Table 4.2: California Personal Income – DOF Projections

California	Annual Averages								Annual Percent Change						
Personal Income 1/	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Total Personal Income	1,812.3	1,849.5	1,939.5	2,043.0	2,155.3	2,267.9	2,369.5	2,476.4	2.1	4.9	5.3	5.5	5.2	4.5	4.5
Taxable Personal Income	1,268.3	1,291.2	1,363.7	1,445.9	1,535.3	1,621.4	1,694.1	1,770.1	1.8	5.6	6.0	6.2	5.6	4.5	4.5
Total Wages and Salaries	903.7	933.9	991.2	1,049.6	1,113.8	1,173.1	1,225.6	1,280.2	3.3	6.1	5.9	6.1	5.3	4.5	4.5
Supplements to Wages and Salaries	220.4	230.7	235.0	247.0	262.6	277.7	293.4	310.0	4.6	1.9	5.1	6.3	5.8	5.6	5.7
Proprietors' Income	166.4	172.1	180.4	188.7	198.5	207.9	216.5	225.2	3.4	4.9	4.6	5.2	4.7	4.1	4.0
Farm	10.0	12.1	12.0	10.6	10.4	10.9	11.7	11.8	21.1	(0.9)	(11.4)	(1.5)	4.0	8.0	0.8
Non-Farm	156.5	160.0	168.4	178.1	188.1	197.1	204.8	213.3	2.2	5.3	5.7	5.6	4.8	3.9	4.2
Property Income	371.0	372.7	389.2	411.3	436.8	462.9	482.2	501.8	0.4	4.4	5.7	6.2	6.0	4.2	4.1
Interest	165.0	163.1	166.5	168.6	184.6	196.1	202.3	208.8	(1.1)	2.1	1.3	9.5	6.2	3.2	3.2
Monetary	61.4	55.7	57.9	59.3	68.4	77.4	81.6	85.7	(9.3)	3.9	2.5	15.2	13.2	5.5	5.0
Non-Monetary	103.6	107.5	108.7	109.3	116.3	118.7	120.7	123.1	3.7	1.1	0.6	6.4	2.1	1.7	2.0
Dividends	105.7	100.7	103.2	111.8	116.2	121.6	127.3	133.4	(4.7)	2.6	8.3	3.9	4.7	4.7	4.8
Rent	100.4	108.8	119.4	130.9	136.0	145.2	152.6	159.5	8.5	9.7	9.6	3.9	6.7	5.1	4.6
Monetary	41.1	41.0	43.0	47.1	48.9	52.2	54.8	57.3	(0.3)	4.8	9.6	3.8	6.7	5.1	4.6
Transfer Receipts	271.6	282.0	293.7	307.2	317.7	328.0	342.1	357.8	3.8	4.1	4.6	3.4	3.3	4.3	4.6
Less: Contributions for Social Ins.	118.7	139.6	147.6	158.4	171.6	179.3	187.8	196.2	17.6	5.7	7.3	8.4	4.5	4.7	4.5
Residence Adjustment	(2.1)	(2.2)	(2.3)	(2.4)	(2.4)	(2.4)	(2.4)	(2.3)							
Less: Personal Taxes	224.9	253.2	271.3	287.6	305.4	322.6	337.0	352.1	12.6	7.1	6.0	6.2	5.6	4.5	4.5
Disposable Income	1,587.4	1,596.3	1,668.2	1,755.3	1,849.9	1,945.4	2,032.4	2,124.3	0.6	4.5	5.2	5.4	5.2	4.5	4.5

Table 4.3: California Employment and Wages – DOF Projections

California	Annual Averages								Annual Percent Change						
Wages and Salaries 1/	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Total Wages and Salaries	903.7	933.9	991.2	1,049.6	1,113.8	1,173.1	1,225.6	1,280.2	3.3	6.1	5.9	6.1	5.3	4.5	4.5
Farm and Related	10.0	11.1	11.3	12.1	13.1	13.8	14.1	14.5	11.0	1.9	6.9	8.3	4.9	2.1	3.0
Mining	3.8	3.8	4.0	3.6	3.5	3.6	3.7	3.8	(0.3)	5.0	(9.7)	(2.6)	4.0	1.9	1.5
Construction	35.8	38.7	41.8	46.5	52.7	61.4	71.1	81.9	8.3	7.8	11.3	13.3	16.5	15.8	15.1
Manufacturing	98.9	99.5	105.5	108.6	116.2	120.7	125.4	130.1	0.6	6.0	3.0	7.0	3.9	3.9	3.7
Trade, Transportation & Utilities	129.3	133.4	140.3	148.1	155.2	164.0	172.4	180.8	3.2	5.1	5.6	4.8	5.7	5.1	4.8
Information	49.8	60.1	63.6	68.5	73.1	76.6	80.3	84.5	20.6	5.8	7.8	6.7	4.8	4.9	5.1
Financial Activities	71.3	72.2	76.6	79.5	82.3	84.4	86.2	87.9	1.3	6.1	3.7	3.6	2.5	2.1	2.0
Professional and Business Services	176.0	178.5	194.5	211.3	224.7	236.6	241.4	248.4	1.4	9.0	8.6	6.3	5.3	2.0	2.9
Educational and Health Services	106.6	110.0	114.7	121.2	130.8	137.5	143.6	149.3	3.2	4.3	5.6	8.0	5.1	4.4	4.0
Leisure and Hospitality	45.3	47.2	51.1	55.9	60.6	65.0	69.9	73.7	4.3	8.2	9.5	8.4	7.2	7.6	5.4
Other Services	25.5	26.3	28.3	29.4	30.5	31.8	33.0	34.3	3.1	7.5	3.9	3.5	4.4	3.7	4.1
Government	151.4	153.0	159.6	164.9	171.0	177.6	184.4	191.3	1.1	4.3	3.3	3.7	3.9	3.9	3.7
Units: Billion Current Dollars															
California	**Annual Averages**								**Annual Percent Change**						
Average Wages 1/ 2/	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
All Sectors	59,794	59,878	61,669	63,432	65,879	68,394	70,814	73,299	0.1	3.0	2.9	3.9	3.8	3.5	3.5
Farm and Related	25,105	27,025	27,149	29,240	31,489	32,676	33,127	33,860	7.6	0.5	7.7	7.7	3.8	1.4	2.2
Mining *	124,323	123,518	127,764	125,628	126,867	130,819	132,418	133,958	(0.6)	3.4	(1.7)	1.0	3.1	1.2	1.2
Construction	60,652	60,792	62,050	63,795	66,800	71,889	76,878	81,747	0.2	2.1	2.8	4.7	7.6	6.9	6.3
Manufacturing	78,850	79,209	82,989	84,198	89,171	92,250	95,865	99,489	0.5	4.8	1.5	5.9	3.5	3.9	3.8
Trade, Transportation & Utilities	47,296	47,769	48,863	50,603	52,194	54,640	57,040	59,424	1.0	2.3	3.6	3.1	4.7	4.4	4.2
Information	114,552	133,848	138,784	141,089	148,906	155,497	162,377	170,814	16.8	3.7	1.7	5.5	4.4	4.4	5.2
Financial Activities	92,118	92,215	97,760	99,820	102,840	104,980	106,991	109,092	0.1	6.0	2.1	3.0	2.1	1.9	2.0
Professional and Business Services	78,425	76,229	79,991	85,203	89,636	94,362	97,268	100,800	(2.8)	4.9	6.5	5.2	5.3	3.1	3.6
Educational and Health Services	49,069	47,298	47,993	49,914	52,609	54,642	56,714	58,602	(3.6)	1.5	4.0	5.4	3.9	3.8	3.3
Leisure and Hospitality	28,319	28,160	28,420	28,188	28,959	29,782	31,285	32,242	(0.6)	0.9	(0.8)	2.7	2.8	5.0	3.1
Other Services	50,616	50,978	52,833	54,666	56,499	58,941	61,299	63,899	0.7	3.6	3.5	3.4	4.3	4.0	4.2
Government	63,701	64,433	66,183	67,383	69,026	71,161	73,448	75,747	1.1	2.7	1.8	2.4	3.1	3.2	3.1
Units: Current Dollars per Job															
1/ Data starting in 2015 are forecasts prepared in November 2015															
2/ Average wages is wages and salaries divided by the number of wage and salary jobs (total wage and salary employment).															

Table 4.4: California Labor Force Forecasts – BEAR Projections

California Labor Force and Employment 1/	Annual Averages								Annual Percent Change						
	2012	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
Civilian Labor Force	18,483.6	18,638.5	18,810.2	18,997.4	19,193.4	19,387.2	19,565.6	19,745.9	0.9	1.0	1.0	1.0	0.9	0.9	0.9
Civilian Employment	16,592.3	17,001.2	17,483.8	18,027.5	18,613.1	19,204.9	19,755.5	20,328.9	2.8	3.1	3.2	3.2	2.9	2.9	2.9
Civilian Unemployment	1,891.4	1,637.3	1,417.3	1,226.3	1,025.3	946.5	937.7	930.8	(13.4)	(13.5)	(16.4)	(7.7)	(0.9)	(0.7)	0.2
Civilian Unemployment Rate	10.2%	8.8%	0.1	0.1	0.1	0.1	0.1	0.1							
Farm Employment	399.4	411.7	415.5	419.7	424.0	428.3	432.2	436.2	0.9	1.0	1.0	1.0	0.9	0.9	0.9
Non-Farm Employment	14,711.8	15,183.4	15,614.5	16,100.1	16,623.0	17,151.6	17,643.3	18,155.4	2.8	3.1	3.2	3.2	2.9	2.9	2.9
Year-to-Year Change	348.0	471.6	471.6	471.6	471.6	471.6	471.6	471.6							
Goods Producing	1,875.2	1,924.3	1,974.8	2,026.5	2,079.6	2,134.1	2,190.0	2,247.4	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Mining and Logging	30.5	30.6	30.9	31.2	31.6	31.9	32.2	32.5	0.9	1.0	1.0	1.0	0.9	0.9	0.9
Construction	590.0	637.4	645.6	654.5	664.0	674.0	684.3	694.8	1.3	1.4	1.5	1.5	1.5	1.5	1.5
Manufacturing	1,254.7	1,256.3	1,272.9	1,290.9	1,309.5	1,327.3	1,343.1	1,358.7	1.3	1.4	1.4	1.4	1.2	1.2	1.1
High Technology	341.1	334.9	339.3	344.1	349.1	353.8	358.0	362.2	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Aerospace Prod. & Parts Mfg.	71.1	72.0	73.0	74.0	75.1	76.1	77.0	77.9	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Computer & Elect. Prod. Mfg.	270.0	262.9	266.3	270.1	274.0	277.7	281.0	284.3	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Food & Bev. Manufacturing	195.0	198.1	200.7	203.5	206.4	209.2	211.7	214.2	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Textiles and Apparel	73.8	74.4	75.4	76.5	77.6	78.6	79.5	80.5	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Other Manufacturing	644.8	648.9	657.5	666.8	676.4	685.6	693.8	701.8	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Durables	442.9	448.6	454.5	460.9	467.6	473.9	479.6	485.1	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Nondurables	201.9	200.4	203.0	205.9	208.8	211.7	214.2	216.7	1.3	1.4	1.4	1.4	1.2	1.2	1.1
Service Providing	12,836.6	13,259.1	13,695.5	14,146.3	14,611.9	15,092.8	15,589.6	16,102.7	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Trade, Transportation & Utilities	2,733.9	2,793.4	2,856.4	2,923.6	2,989.6	3,047.3	3,090.1	3,131.3	2.3	2.4	2.3	1.9	1.4	1.3	1.2
Wholesale & Retail Trade	2,246.7	2,290.6	2,342.3	2,397.4	2,451.5	2,498.9	2,534.0	2,567.7	2.3	2.4	2.3	1.9	1.4	1.3	1.2
Wholesale Trade	675.5	693.8	709.5	726.1	742.5	756.9	767.5	777.7	2.3	2.4	2.3	1.9	1.4	1.3	1.2
Retail Trade	1,571.1	1,596.8	1,632.9	1,671.3	1,709.0	1,742.0	1,766.5	1,790.0	2.3	2.4	2.3	1.9	1.4	1.3	1.2
Utilities	59.4	58.9	60.2	61.6	63.0	64.2	65.1	66.0	2.3	2.4	2.3	1.9	1.4	1.3	1.2
Transportation and Warehousing	427.9	443.9	453.9	464.6	475.0	484.2	491.0	497.6	2.3	2.4	2.3	1.9	1.4	1.3	1.2
Information	435.1	448.6	451.2	454.0	456.9	459.9	462.6	465.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Motion Picture and Sound Recording	141.0	144.1	145.0	145.9	146.8	147.8	148.6	149.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Publishing Industries (except Internet)	87.1	88.0	88.5	89.0	89.6	90.2	90.7	91.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Telecommunications	89.9	89.8	90.3	90.9	91.5	92.1	92.6	93.2	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Other Information	117.1	126.7	127.4	128.2	129.0	129.9	130.6	131.4	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Financial Activities	773.4	782.8	790.4	798.6	807.2	815.6	823.2	830.8	1.0	1.0	1.1	1.0	0.9	0.9	0.9
Professional and Business Services	2,242.3	2,341.0	2,370.9	2,403.4	2,438.0	2,473.6	2,508.6	2,544.3	1.3	1.4	1.4	1.5	1.4	1.4	1.4
High Technology	353.8	371.1	375.8	381.0	386.5	392.1	397.7	403.3	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Computer Systems Design	228.2	243.6	246.7	250.1	253.7	257.4	261.0	264.7	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Scientific Research & Development	125.6	127.5	129.1	130.9	132.8	134.7	136.6	138.6	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Legal, Accounting, Arch., Bus. Svcs	413.2	421.0	426.4	432.2	438.4	444.8	451.1	457.6	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Employment Services	378.7	409.0	414.2	419.9	425.9	432.1	438.3	444.5	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Other Business Services	1,096.6	1,139.9	1,154.5	1,170.3	1,187.2	1,204.5	1,221.5	1,238.9	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Educational and Health Services	2,172.7	2,325.9	2,358.4	2,393.6	2,431.6	2,471.7	2,513.1	2,555.8	1.4	1.5	1.6	1.7	1.7	1.7	1.7
Leisure and Hospitality	1,598.5	1,676.6	1,697.8	1,720.5	1,743.4	1,764.5	1,781.5	1,798.2	1.3	1.3	1.3	1.2	1.0	0.9	0.9
Other Services	504.7	516.6	520.1	523.8	527.8	531.6	535.1	538.5	0.7	0.7	0.8	0.7	0.6	0.6	0.6
Government	2,376.0	2,374.1	2,398.9	2,426.0	2,454.4	2,482.5	2,508.3	2,534.2	1.0	1.1	1.2	1.1	1.0	1.0	1.0
Federal	250.5	245.5	248.0	250.8	253.8	256.7	259.3	262.0	1.0	1.1	1.2	1.1	1.0	1.0	1.0
DoD	61.3	60.1	60.8	61.4	62.2	62.9	63.5	64.2	1.0	1.1	1.2	1.1	1.0	1.0	1.0
Civilian	189.1	185.3	187.3	189.4	191.6	193.8	195.8	197.8	1.0	1.1	1.2	1.1	1.0	1.0	1.0
State	482.2	484.3	489.3	494.9	500.7	506.4	511.6	516.9	1.0	1.1	1.2	1.1	1.0	1.0	1.0
Local	1,643.4	1,644.4	1,661.6	1,680.4	1,700.0	1,719.5	1,737.3	1,755.3	1.0	1.1	1.2	1.1	1.0	1.0	1.0
Units: Thousands															

Table 4.5: California Personal Income – BEAR Projections

California	Annual Averages								Annual Percent Change						
Personal Income 1/	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Total Personal Income	######	1,849.5	######	1,978.9	######	2,196.9	2,309.6	######	2.1	4.8	5.3	5.4	5.1	4.4	4.4
Taxable Personal Income	######	1,291.2	######	1,374.0	######	1,511.4	1,580.6	######	1.8	4.5	4.9	4.9	4.6	3.9	3.8
Total Wages and Salaries	903.7	933.9	965.1	1,028.2	######	1,182.1	1,267.8	######	3.3	6.5	7.1	7.4	7.3	6.7	6.7
Supplements to Wages and Salaries	220.4	230.7	241.4	245.9	250.6	255.3	260.1	264.9	4.6	1.9	1.9	1.9	1.9	1.9	1.9
Proprietors' Income	166.4	172.1	177.9	184.1	191.1	198.6	206.0	212.6	3.4	3.5	3.8	3.9	3.7	3.2	3.2
Farm	10.0	12.1	14.6	15.2	15.7	16.3	17.0	17.5	21.1	3.5	3.8	3.9	3.7	3.2	3.2
Non-Farm	156.5	160.0	163.6	169.3	175.8	182.6	189.4	195.5	2.2	3.5	3.8	3.9	3.7	3.2	3.2
Property Income	371.0	372.7	374.3	387.4	402.2	417.9	433.4	447.3	0.4	3.5	3.8	3.9	3.7	3.2	3.2
Interest	165.0	163.1	161.3	167.0	173.3	180.1	186.8	192.8	(1.1)	3.5	3.8	3.9	3.7	3.2	3.2
Monetary	61.4	55.7	50.5	52.3	54.3	56.4	58.5	60.4	(9.3)	3.5	3.8	3.9	3.7	3.2	3.2
Non-Monetary	103.6	107.5	111.5	115.4	119.8	124.4	129.1	133.2	3.7	3.5	3.8	3.9	3.7	3.2	3.2
Dividends	105.7	100.7	95.9	99.3	103.1	107.1	111.1	114.6	(4.7)	3.5	3.8	3.9	3.7	3.2	3.2
Rent	100.4	108.8	118.1	122.2	126.8	131.8	136.7	141.1	8.5	3.5	3.8	3.9	3.7	3.2	3.2
Monetary	41.1	41.0	40.9	42.3	43.9	45.6	47.3	48.8	(0.3)	3.5	3.8	3.9	3.7	3.2	3.2
Transfer Receipts	271.6	282.0	292.8	304.9	317.5	330.7	344.3	358.6	3.8	4.1	4.1	4.1	4.1	4.1	4.1
Less: Contributions for Social Ins.	118.7	139.6	164.2	171.9	180.6	190.0	199.8	209.4	17.6	4.7	5.0	5.2	5.2	4.8	4.8
Residence Adjustment	(2.1)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)							
Less: Personal Taxes	224.9	253.2	285.1	296.0	307.6	319.0	329.2	339.7	12.6	3.8	3.9	3.7	3.2	3.2	3.2
Disposable Income	######	1,596.3	######	1,662.8	######	1,796.8	1,865.6	######	0.6	3.6	3.9	4.0	3.8	3.3	3.3
Units: Billion Current Dollars															

Table 4.6: California Employment and Wages – BEAR Projections

California	Annual Averages								Annual Percent Change						
Wages and Salaries 1/	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Total Wages and Salaries	903.7	933.9	991.2	1,049.6	1,113.8	1,173.1	1,225.6	1,280.2	3.3	6.1	5.9	6.1	5.3	4.5	4.5
Farm and Related	10.0	11.1	11.3	12.1	13.1	13.8	14.1	14.5	11.0	1.9	6.9	8.3	4.9	2.1	3.0
Mining	3.8	3.8	4.0	3.6	3.5	3.6	3.7	3.8	(0.3)	5.0	(9.7)	(2.6)	4.0	1.9	1.5
Construction	35.8	38.7	41.8	46.5	52.7	61.4	71.1	81.9	8.3	7.8	11.3	13.3	16.5	15.8	15.1
Manufacturing	98.9	99.5	105.5	108.6	116.2	120.7	125.4	130.1	0.6	6.0	3.0	7.0	3.9	3.9	3.7
Trade, Transportation & Utilities	129.3	133.4	140.3	148.1	155.2	164.0	172.4	180.8	3.2	5.1	5.6	4.8	5.7	5.1	4.8
Information	49.8	60.1	63.6	68.5	73.1	76.6	80.3	84.5	20.6	5.8	7.8	6.7	4.8	4.9	5.1
Financial Activities	71.3	72.2	76.6	79.5	82.3	84.4	86.2	87.9	1.3	6.1	3.7	3.6	2.5	2.1	2.0
Professional and Business Services	176.0	178.5	194.5	211.3	224.7	236.6	241.4	248.4	1.4	9.0	8.6	6.3	5.3	2.0	2.9
Educational and Health Services	106.6	110.0	114.7	121.2	130.8	137.5	143.6	149.3	3.2	4.3	5.6	8.0	5.1	4.4	4.0
Leisure and Hospitality	45.3	47.2	51.1	55.9	60.6	65.0	69.9	73.7	4.3	8.2	9.5	8.4	7.2	7.6	5.4
Other Services	25.5	26.3	28.3	29.4	30.5	31.8	33.0	34.3	3.1	7.5	3.9	3.5	4.4	3.7	4.1
Government	151.4	153.0	159.6	164.9	171.0	177.6	184.4	191.3	1.1	4.3	3.3	3.7	3.9	3.9	3.7
Units: Billion Current Dollars															

California	Annual Averages								Annual Percent Change						
Average Wages 1/ 2/	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
All Sectors	59,794	59,878	61,669	63,432	65,879	68,394	70,814	73,299	0.1	3.0	2.9	3.9	3.8	3.5	3.5
Farm and Related	25,105	27,025	27,149	29,240	31,489	32,676	33,127	33,860	7.6	0.5	7.7	7.7	3.8	1.4	2.2
Mining *	124,323	123,518	127,764	125,628	126,867	130,819	132,418	133,958	(0.6)	3.4	(1.7)	1.0	3.1	1.2	1.2
Construction	60,652	60,792	62,050	63,795	66,800	71,889	76,878	81,747	0.2	2.1	2.8	4.7	7.6	6.9	6.3
Manufacturing	78,850	79,209	82,989	84,198	89,171	92,250	95,865	99,489	0.5	4.8	1.5	5.9	3.5	3.9	3.8
Trade, Transportation & Utilities	47,296	47,769	48,863	50,603	52,194	54,640	57,040	59,424	1.0	2.3	3.6	3.1	4.7	4.4	4.2
Information	114,552	133,848	138,784	141,089	148,906	155,497	162,377	170,814	16.8	3.7	1.7	5.5	4.4	4.4	5.2
Financial Activities	92,118	92,215	97,760	99,820	102,840	104,980	106,991	109,092	0.1	6.0	2.1	3.0	2.1	1.9	2.0
Professional and Business Services	78,425	76,229	79,991	85,203	89,636	94,362	97,268	100,800	(2.8)	4.9	6.5	5.2	5.3	3.1	3.6
Educational and Health Services	49,069	47,298	47,993	49,914	52,609	54,642	56,714	58,602	(3.6)	1.5	4.0	5.4	3.9	3.8	3.3
Leisure and Hospitality	28,319	28,160	28,420	28,188	28,959	29,782	31,285	32,242	(0.6)	0.9	(0.8)	2.7	2.8	5.0	3.1
Other Services	50,616	50,978	52,833	54,666	56,499	58,941	61,299	63,899	0.7	3.6	3.5	3.4	4.3	4.0	4.2
Government	63,701	64,433	66,183	67,383	69,026	71,161	73,448	75,747	1.1	2.7	1.8	2.4	3.1	3.2	3.1
Units: Current Dollars per Job															

1/ Data starting in 2015 are forecasts prepared in November 2015

2/ Average wages is wages and salaries divided by the number of wage and salary jobs (total wage and salary employment).

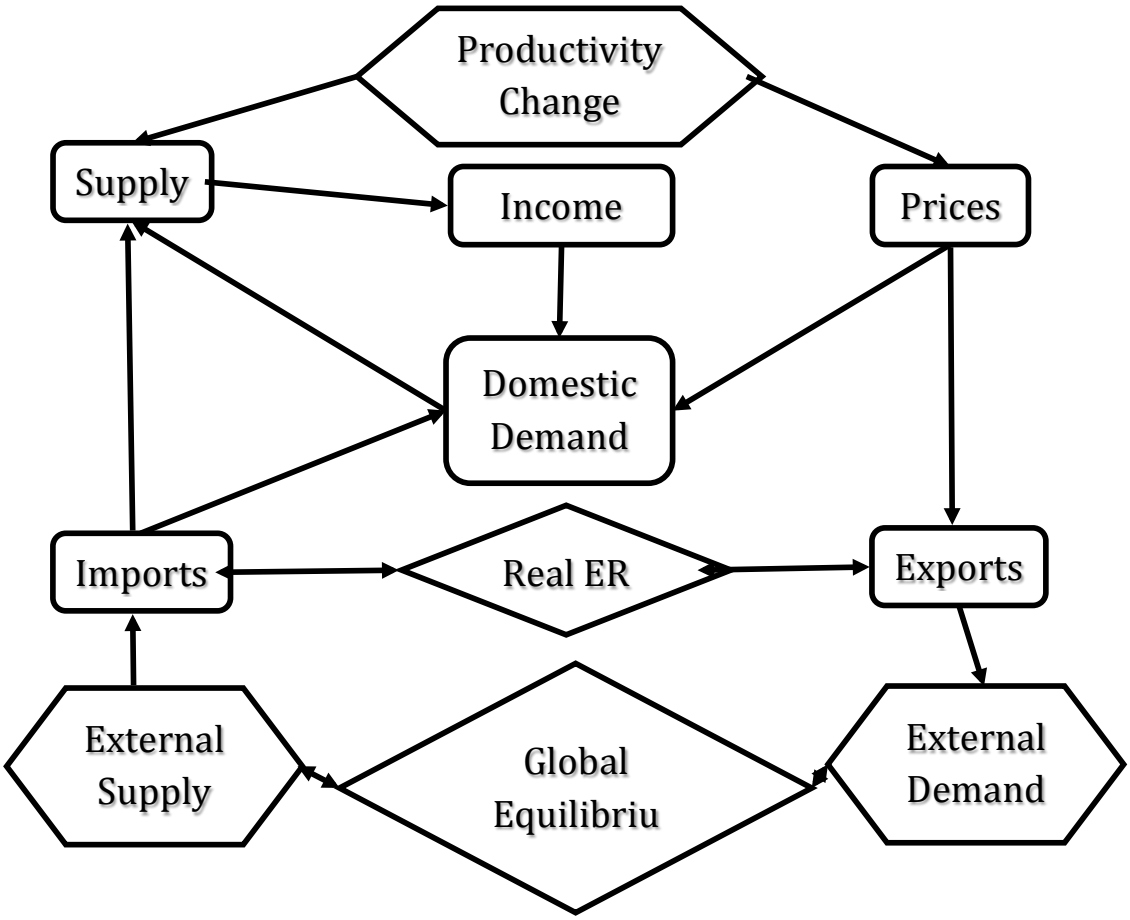
5 BASELINE CALIBRATION OF THE BEAR MODEL

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 like this to 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 5.1: General Equilibrium Calibration Mechanism



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7 Annex: Technical Summary of the BEAR Model

1. 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.[5] 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.

7.1 Structure of the CGE Model

2. 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.

3. 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.

4. 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

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

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 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.

5. 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 2012. The result is a single economy model calibrated over the thirty-five year time path from 2015 to 2050. Using the very detailed accounts of the California SAM, we include the following in the present model:

7.2 Production

6. 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 5.1: Component Structure of the Modeling Facility

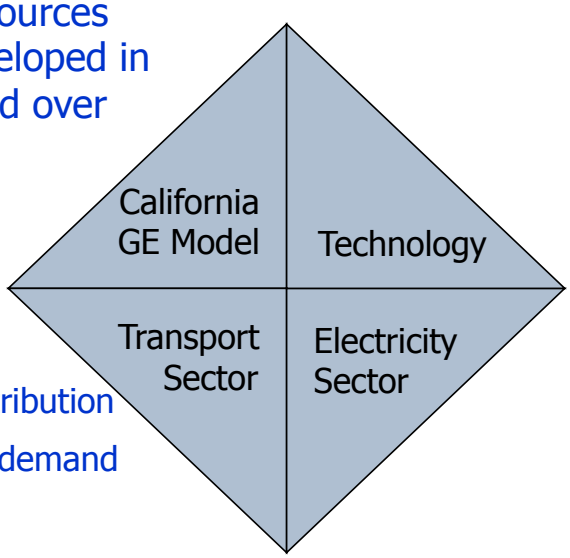
The Berkeley Energy and Resources (BEAR) model is being developed in four areas and implemented over two time horizons.

Components:

1. Core GE model
2. Technology module
3. Electricity generation/distribution
4. Transportation services/demand

Time frames:

1. Policy Horizon, 2015-2030
2. Strategic Horizon, 2015-2050



7. In each period, the supply of primary factors — capital, land, and labor — is usually predetermined.[6] 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.[7] Once the optimal combination of inputs is determined, sectoral output prices are calculated assuming competitive supply conditions in all markets.

7.3 Consumption and Closure Rule

8. 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.

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

[7] 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.

9. 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. [8] The indirect tax schedule will shift to accommodate any changes in the balance between government revenues and government expenditures.

10. 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.

7.4 Trade

11. 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.

7.5 Dynamic Features and Calibration

12. 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

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

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.

7.6 Capital accumulation

13. 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.

7.7 The putty/semi-putty specification

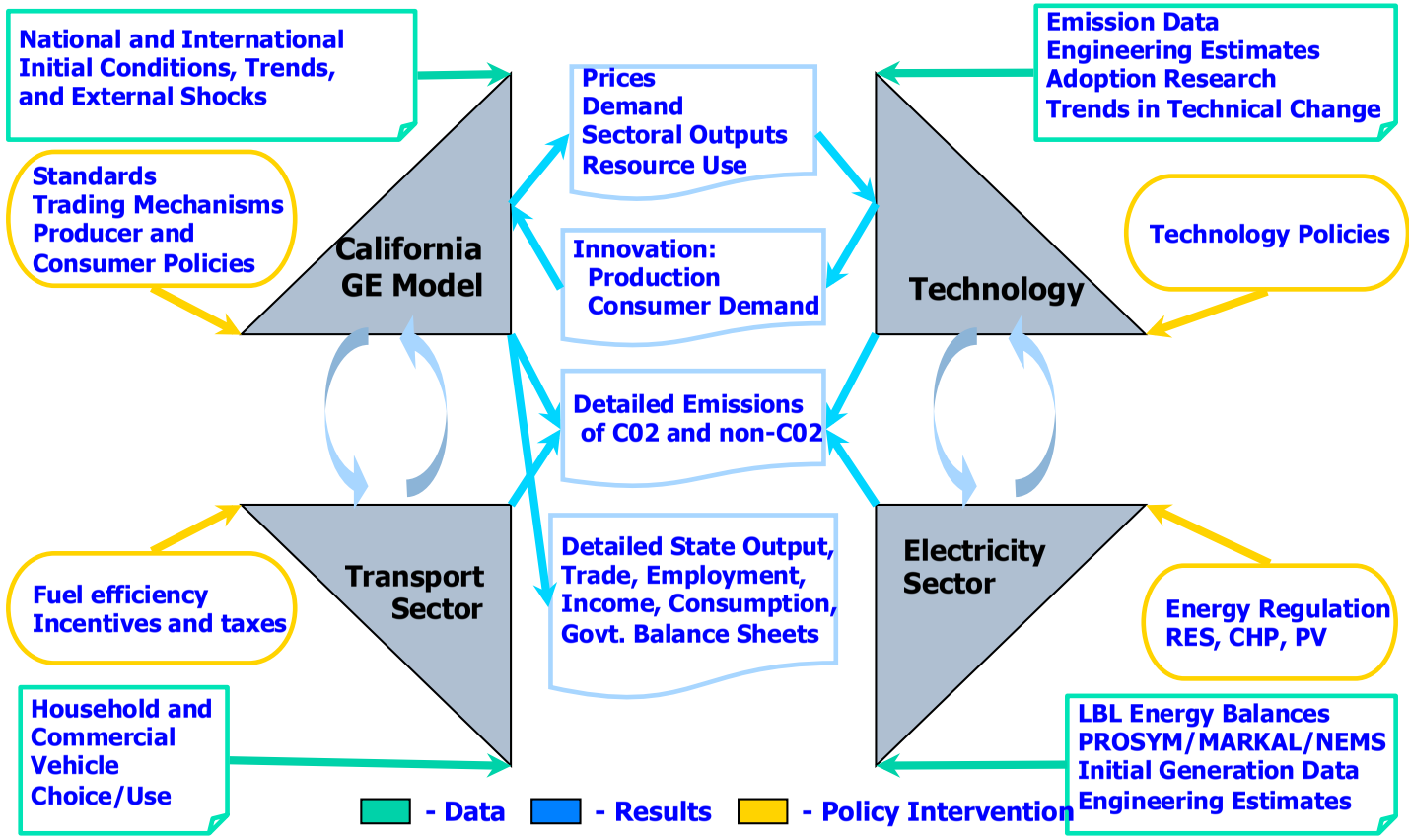
14. The substitution possibilities among production factors are assumed to be higher with the new than the old capital vintages — technology has a putty/semi-putty specification. Hence, when a shock to relative prices occurs (e.g. the imposition of an emissions fee), the demands for production factors 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.

7.8 Profits, Adjustment Costs, and Expectations

15. 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 5.2: Schematic Linkage between Model Components



7.9 Dynamic calibration

16. 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.[9] 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.

7.10 Modelling Emissions

17. 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.[10] 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).

[9] 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.

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

18. The BEAR model has the capacity to track 13 categories of individual pollutants and consolidated emission indexes, each of which is listed in Table A1.1 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.

19. 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 A1.1: 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 A1.2 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 A1.3: 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

20. 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.

21. 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.

7.11 Emissions Data

22. 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.

23. 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.