Research Paper No. 1706151

Model Comparison for SRIA Macroeconomic Assessment

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June, 2017

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Research Papers on Energy, Resources, and Economic Sustainability

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For this project on comparison of SRIA assessment models, we express thanks to the California Energy Commission and the Department of Finance, who provided valuable guidance from their own experience with SRIAs. Special thanks are due to Pierre duVair, Sean Steffensen, and Irena Asmundsen.

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EXECUTIVE SUMMARY

The objective of this analysis is to conduct a model comparison exercise for Standardized Regulatory Impact Assessments (SRIA) for major regulations in California. The analysis focuses on four different models – RIMS II, IMPLAN, REMI PI+, and BEAR – which together account for all of the SRIAs performed by or for State agencies as of April, 2017. These models also represent an array of different methodological approaches to estimating macroeconomic impacts of proposed regulations. RIMS II and IMPLAN are examples of input-output models. REMI PI+ is an extended I-O model with dynamic forecasting capacity and greater specification of economic behavior. BEAR is a dynamic computable general equilibrium model.

The report is organized in 6 chapters. Chapter 1 provides a general summary of each of the four models. Chapter 2 discusses and analyses the data underpinning each of the models, as well as the theoretical assumptions used for modeling economic behavior in each model. Chapter 3 provides a brief description of the relevant outputs generated by each model, with a particular emphasis on reporting variables required for SRIAs. Chapter 4 presents results from two experiments. The first experiment compares baseline forecasts for the two dynamic models (REMI and BEAR). The second experiment analyzes a recent energy efficiency rulemaking using all four models. Results are compared to highlight differences across models for a similar policy experiment. Chapter 5 discusses several issues associated with implementing each model. Chapter 6 presents some general conclusions and suggestions for California agency staff involved in economic impact assessment.

Chapter 1: Economic Models Used to Explore Impacts of Proposed Regulations

The objective of this analysis is to conduct a model comparison exercise for four commonly used models for Standardized Regulatory Impact Assessments (SRIA) for major regulations in California. The analysis will focus on four different models – RIMS II, IMPLAN, REMI PI+, and BEAR – which together account for all of the SRIAs performed by or for State agencies as of April, 2017. This includes a total 26 SRIAs that had been completed and posted on the Department of Finance's (DOF) Major Regulations website.[1] The REMI model is currently the most widely used macroeconomic model for agency SRIAs, accounting for 14 assessments. The IMPLAN and RIMS II models, two examples of so-called multiplier models, accounted for 6 and 5 SRIAs, respectively. The BEAR model, a computable general equilibrium model, was used for one assessment.

The objective of this report is to evaluate four distinct types of economic impact models that have been recently used for SRIA assessments in California. The report is outline as follows:

- Chapter 1 provides a basic introduction to the four models compared in in this report.
- Chapter 2 reviews the data used to calibrate the models to the California economy.
- Chapter 3 details the types of outputs that the models generate.
- Chapter 4 reports results for a simple model comparison exercise showing how results differ across models a similar energy efficiency policy experiment.
- Chapters 5 discusses issues with model implementation and Chapter 6 outlines several general conclusions.

Brief Model Overviews

The four model frameworks fall into three basic categories: Input-Output (I-O) models, extended input-output models, and computable general equilibrium (CGE) models. RIMS II and IMPLAN are examples of input-output models, REMI is an example of an extended I-O model, and BEAR is an example of a CGE model.

1 http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/
A summary assessment of SRIAs conducted through 2016 is available in Roland-Holst et al: 2016a.

Table 1 shows a partial overview comparison of salient model assumptions and features.

RIMS II

The Regional Input-Output Modeling System (RIMS II) is a model maintained and distributed by the U.S. Bureau of Economic Analysis (BEA). The RIMS II model generates regional multipliers that can be used to assess the economy-wide impacts of an exogenous change in final demand for a good or service. Two types of multipliers are provided in RIMS II including, Type I multipliers, which reflect the direct spending effects of a change in final demand plus the indirect supply-chain effects necessary to support the increase in final demand, and Type II multipliers which reflect the direct, indirect, and induced effects of a change in final demand. Like other input-output models, RIMS II is a static model and therefore is not suitable for economic forecasting.

RIMS II is the simplest of the four economic impact models reviewed here. It consists of several spreadsheets with four types of Type I and Type II multipliers: output, value-added, earnings, and employment. Unlike some of the other models discussed, there is no model interface for RIMS II, requiring the user to have a fairly firm grasp of how multipliers should be used for impact analysis.

The primary advantage of a simple multiplier model like RIMS II is its transparency. The economic theory used to develop the multipliers is well known and easy to understand. The RIMS II multipliers are based on BEA's data and have not been aggregated or transformed, except for a regionalization process used to downscale the national technology coefficient matrix to a specific state. The model is based on a 2007 national input-output table and 2015 regional data.

There are a number of limitations to the RIMS II model, depending on the type of analysis being conducted. First, as with all I-O models, the process of transforming inputs into outputs (an industry's "technology)" is assumed to be fixed. There is no substitution amongst different types of inputs. More broadly, I-O models such as RIMS II, do not include so-called price effects, which reflect basic market responses to scarcity and abundance, as well as economic theory that tells us that firm and consumer behavior changes as the prices of goods and services change. Therefore, policies or regulations that are expected to have impacts on market structure and prices need to account for these changes outside of the assessment model. Second, the RIMS II model is not based on a full Social Accounting Matrix (SAM) and therefore cannot capture important impacts such as estimates of fiscal impacts associated with changing spending patterns, nor can it fully account for linkage effects to households.[2] Third, I-0 models do not explicitly take account of supply and resource constraints, which implies that any increase in final demand is met by an equivalent increase in supply. This means there are essentially no trade-offs in the scenario assessment. For example, if an exogenous increase in demand for an industry requires more labor, this labor is not pulled away from other industries, but rather is met with an assumption that new workers will enter the region.

IMPLAN Pro

2 A Social Accounting Matrix is a tabular representation of all economic flows in an economy. These flows show both expenditures and incomes across various institutions.

The IMpact Analysis for PLANning (IMPLAN) model is a non-survey based input-output (I-O) model that is calibrated to a regional SAM. IMPLAN is perhaps the most widely used assessment tool for modeling the economic impacts of economic events. In addition to the direct economic impact of an event, IMPLAN also estimates the indirect economics on the supply chain necessary to support the event, and the induced impacts that result from changes in household income due to the event.

IMPLAN was originally developed in the late 1970's and early 1980's to support economic impact analysis for the United States Forest Service. The first version of the IMPLAN Pro, IMPLAN's modeling platform, was released in 1996. The current version of IMPLAN, version 3, was released in 2009. The data behind the regional accounts are updated annually, with the most current version of the model based on 2015 data.

As with RIMS II, the IMPLAN model generates regional multipliers, which are used to estimate direct, indirect, and induced effects of an exogenous change in household or industry demand for various activities. Because the IMPLAN model is based on a full Social Accounting Matrix, rather than just an I-O table, the results are more comprehensive than those available using the RIMS II model. While the IMPLAN model draws on a number of national and regional data sources, the I-O table is based largely on BEA's national I-O table. It is regionalized using regional purchase coefficients (RPCs) that attempt to estimate the percentage of industry purchases coming from within the region and the percentage that are imported. Purchases of imports, which can come from other states or countries, are considered a leakage from a regional economy.

IMPLAN has two important advantages over other models. First, its user interface and active user community make it very easy to conduct economic impact analysis for a wide range of potential applications. Second, the IMPLAN model is the most customizable of the four models considered in this analysis. If the analyst has additional information on an industry, trade patterns, or consumption patterns, these modifications to the model's default assumptions can be made very easily. The disadvantages to the IMPLAN model are the same as those described for RIMS II, which apply broadly to I-O models. These limitations make IMPLAN appropriate mainly for assessing the economic impacts of regulations that do not alter the structure of markets or patterns of consumer behavior (aside from general changes in spending).

REMI PI+

The Regional Economic Models, Inc. Policy Insights model (REMI PI+) is an integrated input-output and structural forecasting model. The model is widely used by government agencies and independent researchers for assessing a broad array of economic policies and events. The REMI PI+ model greatly extends the capacity of a traditional I-O model by including a number of dynamic forecasting equations that consider product and factor market price effects, labor supply adjustments that account for migration, more flexible household consumption behavior, and a variety of additional behavioral patterns. When these features are suppressed, the model reduces to an I-O model.

The input-output component of the model includes inter-industry linkages for 160 sectors (in the most recent version, PI+ 2.0). As with IMPLAN, the I-O component of the model is based on the BEA's national technical coefficient matrix, which is then regionalized using an estimation procedure outside of the model for determining the extent to which regional output is sourced through regional supply chains and how much is imported.

While, REMI PI+ in more grounded in economic theory than an I-O model, it differs in important ways from a CGE model. Perhaps the most important distinction between the two types of models is the assumption in CGE models that all product and factor markets clear (ie, supply equals demand).[3] The REMI model does not impose these equilibrium conditions as part of its model formulation.

The REMI model has been calibrated for the California economy and provides a state-specific forecast of the California economy out to 2060. REMI also includes economic and demographic projections from California's Department of Finance in its baseline calibration. The development of a dynamic baseline forecast is an important improvement over I-O models and allows for a much richer assessment of policy and economic impact analysis. The data used to regionalize the REMI model is generally similar to IMPLAN, although REMI uses a different method for calculating regional purchase coefficients. The result is that the production structure of the California economy will look somewhat different from RIMS II and IMPLAN.

REMI has several features that make it attractive for economic impact assessment. First, it has a user interface that makes it easy to conduct policy simulations and view results. The user has a large list of policy variables that can be used for simulations. The ease of use with REMI is unique for a model of its complexity. Second, as noted above, the model incorporates a much more realistic representation of economic behavior than the I-O models.

There are several disadvantages to the REMI model. First, unlike IMPLAN, the model cannot be customized if the user has information that differs from REMI's default assumptions. The user is also unable, in the current version, to change behavioral assumptions, such as elasticity parameters. Second, although the model is more realistic in terms of its behavioral assumptions than an I-O model, is does not adhere to the unified economic theory of a general equilibrium model. For example, model closure conditions and market clearing conditions, which are central to general equilibrium theory and application, are not present in the REMI model. Like input output models, this limits the capacity to account for market and behaviorally responses to trade-offs.

Berkeley Energy and Resource Model (BEAR)

The BEAR model is a dynamic economic forecasting model for evaluating long-term growth pathways for California. The model is an advanced policy simulation tool that models demand, supply, and resource allocation across the state economy, estimating economic outcomes

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3 See Treyz et al. (1991) for a discussion of this distinction.

annually over the periods (depending on implementation) 2017–2030 and 2017-2050. This kind of Computable General Equilibrium (CGE) model is an economic forecasting tool, using a system of equations and detailed economic data 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 included, with varying degrees of detail, to close the model and account for economy-wide resource allocation, production, and income determination.

BEAR is calibrated to a variety of publically and privately available data sources, including the 2015 IMPLAN dataset of the California economy, detailing information on the states employment characteristics, energy system, emissions inventory, and vehicle fleet. The model includes disaggregated representation of enterprise, household, employment, government, and trade behavior. The BEAR model baseline forecast is calibrated to California Department of Finance economic and demographic projections (Roland-Holst, 2016b).[4] The model baseline is recalibrated to incorporate new data whenever more up-to-date projections are released.

The BEAR model has several advantages. Like the REMI model, BEAR incorporates a much richer behavioral framework than I-O models. This allows for analysis of a wider range of economic policies and events, including those that may have pervasive structural implications for the state economy. Historically, the development of CGE modeling technology was driven by the need to evaluate these sorts of major economic shifts. A second advantage of the BEAR model is its flexible sectoral aggregation scheme. Unlike RIMS II and REMI, the BEAR model can be aggregated from IMPLAN's original 536 sectors into a subset of activities appropriate to more focused analysis.

The BEAR model does not have a user interface and thus should be implemented by analysts that are trained in the model's programming language (GAMS). Also, like REMI and RIMS II, the underlying economic data cannot be easily altered to reflect additional information that the user might have. However, different behavioral assumptions, such as elasticities can be easily modified if additional information is available.

4 DOF's latest economic forecast is available at http://dof.ca.gov/Forecasting/Economics/Eco_Forecasts_Us_Ca/index.html

Model Comparison Literature Review

Several prior studies have compared REMI PI+ and IMPLAN Pro, although the scope of these comparisons has been limited to specific contexts. For example, Bonn and Harrington (2008) compare the two models and their different estimates on the economic impacts of Florida's tourism industry. A series of IMPLAN-REMI comparison studies were also published in the 1990's, focusing on the implied multipliers generated by the two models (Rickman and Schwer, 1993, 1995, Rickman et al. 1995). None of these studies incorporated a CGE model into their comparison exercise.

Table 1: Model Comparison Summary Table

	RIMS II	IMPLAN	REMI	BEAR
Model Type	I-O	I-O	I-O + Structural Equations	CGE
Number of Sectors	369	536	160	up to 536
Dynamic/Static	Static	Static	Dynamic	Dynamic
Price Effects?	No	No	Yes	Yes
Producer Behavior	Leontief	Leontief	Cobb-Douglass	User specified
Regional Characteristics				
I-O Table	BEA	BEA	BEA	BEA
Method for I-O regionalization	Location Quotient	Multiple Options	Regional Purchase Coefficients	Same as IMPLAN
Baseline Calibration	None	None	Yes, REMI forecast	Yes, based on DOF Forecast
Model Outputs Required for SRIAs				
Gross State Product	Yes	Yes	Yes	Yes
Employment	Yes	Yes	Yes	Yes
Household Income	Yes	Yes	Yes	Yes
Gross Output	Yes	Yes	Yes	Yes
Investment	No	No	Yes	Yes
Fiscal Impacts	No	Yes	No	Yes
Energy System	No	Yes	No	Yes
Vehicle Fleet	No	No	No	Yes
Emissions	No	No	No	Yes
Disadvantaged Communities	No	No	No	Yes
Usability				
User interface	No	Yes	Yes	No

Chapter 2: Model Input and Assumption Comparison

The objective of this chapter is to describe in more detail the basic data sources and modeling assumptions used for each of the four models.

Data Sources

All four models rely on national data that has been regionalized to reflect the conditions of the California economy. The general method of transforming national economic accounts into regional accounts is referred to as "non-survey based" method. The alternative, survey-based methodology, requires collecting regional data and building the regional accounts from the bottom-up. This method is very costly and would require a massive data collection operation to develop regional accounts for all counties in the U.S.

The simplest of the four models, RIMS II, calculates its multipliers from two data sources produced by the U.S. BEA. The BEA's national I-O table from 2007, showing the input-output relationship for 369 industries, is regionalized using the most current year of BEA's regional economic accounts.

The IMPLAN and REMI models use a variety of data sources for model development. A full discussion of all the data sources used in the development of the REMI and IMPLAN database is beyond the scope of this report. Instead, we focus on several especially important data topics. The BEAR model uses the California social accounting matrix for calibration. For the purposes of the data discussion in this chapter, all comments about IMPLAN's data apply to BEAR as well.

As with RIMS II, both the IMPLAN and REMI models use the BEA's national input-output matrix as the starting point for understanding the inter-industry flows of goods and services in the economy. The primary source of employment and wage data is the U.S. Bureau of Labor Statistics, which conducts detailed surveys at the county and industry level. These data sources are also used to scale the national data to a specific region.

Table 2 shows summary output and employment information, by aggregate sector, for the IMPLAN and REMI models. Since the RIMS model only provides multipliers, the underlying production and employment data cannot be reported. The main purpose for understanding this data is to reveal each model's general assumptions about the productivity of workers in each industry (output per worker) and the inverse of this, which is the direct employment supported by a change in final demand for that industry. For some sectors, such as utilities, these metrics are quite different. For example, the IMPLAN model assumes that workers are over 40% more productive than in the REMI model. This implies a lower labor intensity in IMPLAN for the utilities sector. Construction is another important sector where IMPLAN's worker productivity estimates are much higher than REMI. In general, these discrepancies are important because they suggest that REMI will produce larger (whether positive or negative) employment estimates in the utility and construction sectors when these industries are affected by regulations or policy.

Table 2: Output and Employment by Sector

	Output (billion 2009$)		Employment (1,000 workers)		Output per Worker (2009$)		
Industry Aggregation	**REMI**	**IMPLAN**	**REMI**	**IMPLAN**	**REMI**	**IMPLAN**	**diff.**
Farming, Forestry, etc.	76	59	483	511	157,659	115,636	-27%
Mining	19	16	75	71	258,812	228,408	-12%
Utilities	39	56	60	60	643,897	919,082	43%
Construction	115	176	1,050	1,091	109,152	161,160	48%
Manufacturing	634	653	1,394	1,377	455,150	474,105	4%
Wholesale Trade	170	192	821	803	207,432	238,929	15%
Retail Trade	170	166	2,108	1,961	80,690	84,757	5%
Transport/Warehousing	92	107	686	700	133,655	152,373	14%
Information	303	302	563	581	537,604	519,459	-3%
Finance and Insurance	187	223	1,032	1,025	180,934	217,412	20%
Real Estate	483	434	1,266	1,243	381,573	348,980	-9%
Professional Services	293	338	1,949	2,068	150,124	163,549	9%
Management of Companies	54	56	249	244	216,524	229,833	6%
Admin/Waste Mgmt. Svs.	101	101	1,492	1,488	68,008	67,686	0%
Educational services	31	27	507	412	62,058	65,004	5%
Health Care	217	216	2,512	2,500	86,321	86,234	0%
Arts, Entertainment, Rec.	49	46	614	581	79,798	79,845	0%
Accommodation /Food Svs.	98	107	1,669	1,732	58,687	61,882	5%
Other Services	70	119	1,413	1,545	49,263	77,202	57%
Total	**3201**	**3393**	**19942**	**19993**	**160,499**	**169,702**	**6%**

Source: Authors' estimates

Electric Power Sector

The electric power sector data is of particular interest to state agencies because electric power generation still represents over one third of the state's GHG emissions. The data and structural specification of this sector is quite different between the models. REMI and RIMS II have a single sector for electric power generation, transmission, and distribution. The IMPLAN data, which is also used by BEAR, has eight electric power generation sectors and a ninth electric power distribution and transmission sector. These sectors are classified by energy fuel source: fossil fuels, nuclear, wind, solar PV, biomass, hydroelectric, geothermal, and "other".

Table 3 shows compares the gross output (measured in 2015$) reported for IMPLAN's California model to state and national generation and capacity data. The IMPLAN estimates reflect the gross sales of each electricity type in California. If there was perfect price parity across California electricity markets, the percentages would be comparable to the Energy Commission's in-state generation estimates. However, if prices differ by fuel source, these percentages may differ. This may be the cause for the large discrepancy in IMPLAN's nuclear category, which is more than twice as high as the actual in-state generation.

Table 3: Electric Power Sector Comparison in IMPLAN

	IMPLAN (gross output in 2015$)	CEC In-State Generation[1]	CEC In-State Capacity[1]	National Average Generation[2]
Hydroelectric	2%	7%	18%	6%
Fossil Fuel	55%	60%	58%	67%
Nuclear	24%	9%	3%	20%
Solar	3%	8%	9%	1%
Wind	8%	6%	8%	5%
Geothermal	3%	6%	3%	0%
Biomass	5%	3%	2%	2%
Other	1%	0%	0%	0%

[1] Source: California Energy Commission
[2] Source: U.S. Energy Information Administration

Multiplier Comparison: RIMS II vs. IMPLAN

Results from the IMPLAN and RIMS II models are based on California-specific multipliers. Each model generates several multipliers that can be used to assess the economy-wide impacts of a change in final demand for a good or service. There are four types of multipliers in RIMS II: output, earnings, value-added, and employment. The first three show the dollar change resulting from a dollar change in final demand. For example, an output multiplier of 1.8 means that for every $1 increase in final demand, output will increase by $1.8. The employment multiplier shows the number of jobs gained for a $1 million increase in final demand.

IMPLAN provides all of the same multipliers as RIMS, along with several sub-categories of value-added multipliers, including employee compensation, proprietor income, other property type income, and tax on production and imports.

Because the method for regionalizing the national economic accounts differs between the two models, IMPLAN and RIMS produce different multipliers. Table 4 compares output and employment multipliers for California's top 10 industries, along with several additional industries pertinent to CEC's interest. Output multipliers are generally comparable between the two models, although in some cases the multipliers can differ by over 20%. In nearly all cases, the RIMS multipliers are larger than IMPLAN multipliers, which implies that studies using RIMS will generate larger positive or negative output effects. The employment multipliers differ widely between IMPLAN and RIMS. For example, the petroleum refineries sector in RIMS shows an employment multiplier of 3.7, which is nearly twice as high as the employment multiplier in IMPLAN. This would result in employment estimates that are much different depending on which model is used. The variation in employment multipliers is likely attributable to two factors. First, each model has a difference method for estimating imports, which act as a leakage from the economy. Second, differences in employment multipliers could also be due to differences in the underlying output and employment data underlying the two models. If the models have different assumed employment intensities in a given sector, employment multipliers will also differ.

The value-added multipliers show the ultimate contribution of a $1 increase in final demand to California Gross State Product (GSP). The value-added multipliers for IMPLAN are generally significantly higher than the value-added multipliers in RIMS. This suggests that studies using the IMPLAN model will predict larger effects of regulations on California's Gross State Product.

Table 4: Multiplier Comparison for California's Top 10 Industries, by Gross Output

	Output		**Employment[1]**		**Value-Added**	
Sector	**RIMS**	**IMPLAN**	**RIMS**	**IMPLAN**	**RIMS**	**IMPLAN**
Real Estate	1.69	1.47	10.8	7.6	1.11	1.37
Wholesale Trade	1.95	1.90	11.1	9.3	1.13	1.83
Scientific Research & Development Services	2.36	2.08	12.4	9.5	1.32	2.09
Motion picture and video industries	2.07	1.57	10.2	5.8	1.14	1.45
Electronic computer manufacturing	1.97	1.73	7.8	3.8	1.13	1.86
Hospitals	2.24	2.07	15.0	12.2	1.38	2.01
Pharmaceutical preparation manufacturing	1.91	1.79	6.9	4.4	1.48	1.93
Management of companies & enterprises	2.31	2.11	17.7	10.5	1.41	2.03
Other financial investment activities	2.59	2.49	14.8	14.2	1.40	3.26
Internet publishing & broadcasting	1.97	2.31	8.2	9.0	1.39	2.59
Other Sectors of Interest						

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Petroleum refineries	1.51	1.35	3.7	1.9	1.00	1.66
Oil and Gas Extraction	1.51	1.64	5.0	8.2	0.97	1.66
Electric power generation, transmission, and distribution	1.71	1.65	5.6	4.5	0.87	2.10
Natural gas distribution	1.74	1.66	5.4	4.9	1.13	1.75
Water, sewage and other systems	1.80	1.87	7.8	8.0	1.08	2.39
Residential Construction	2.11	1.99	12.3	11.0	1.22	1.98
Non-Residential Construction	2.11	1.90	15.3	11.3	1.11	1.86
Computer storage device manufacturing	2.07	1.73	16.8	3.8	1.04	1.89
Computer terminals and other computer peripheral equipment manufacturing	1.99	1.69	18.6	3.6	1.00	1.66

Source: Authors' estimates
[1] Employment multipliers measure the change in jobs per $1 million change in final demand.

Economic Behavior

Producer Behavior

Each of the four models estimates changes in intermediate input use and total sector output by industry. Producer behavior is an essential determinant for predicting employment outcomes. The basic feature of producer behavior is the "technology" that producers use for turning inputs into outputs. For example, if producers must increase output by $1,000, will all of their inputs increase in fixed proportions or will producers adjust their relative input use based on other factors, such as the price of these inputs? Will the hypothetical demand stimulus lead to resource/labor constraints and price/wage increases? The latter can have significant impacts on the former as enterprises and consumers substitute away from rising prices of inputs, goods, and services. This question gets to the core difference between multiplier models, such as IMPLAN and RIMS, and models that include more complex producer behavior, such as REMI and BEAR.

Multiplier models assume what are called Leontief input coefficients, based on a linear model of economic activity invented in Russia in 1937. This means that when final demand for an industry's product changes, the inputs used to produce that output will change in fixed proportions. These proportions are calibrated from the input-output table used by the model and do not change. This fixed input assumption also applies to factor value-added (and employment) in production, such as labor and capital. This assumption is one of the main conceptual disadvantages and empirical shortcomings of using I-O models for economic impact assessment.

The REMI and BEAR models do not rely on the fixed coefficient assumption for producers. In REMI, intermediate inputs still follow the I-O approach, but value-added factors of production follow a Cobb-Douglas production technology. In REMI, value-added factors of production include labor, capital, and fuels. The Cobb-Douglas allows for some substitutability between value-added factors based on the relative price of these factors. For example, if the price of labor increases, firms will use more fuels and capital. The BEAR model uses a more flexible production technology, called a constant elasticity of substitution production function. There is also substitution between inputs but the degree of substitution can vary by industry and grouping of inputs. BEAR uses a nested production structure that allows for complex adjustment patterns that are unique to individual industries. The more general nested CES functional form can be restricted to either the Leontief technology used by IMPLAN and RIMS, or the Cobb-Douglas technology used by REMI. The econometric literature suggests, however, that the general for is much more robust than linearity (Leontief) or Cobb-Douglas, and abandoned these specifications for empirical work half a century ago.

Industry output is also treated very differently in the various models. The I-O models assume that industry output is driven by exogenous changes in final demand for industry products. In the BEAR model industry output is determined by the market interactions of supply and demand equilibrium across all goods, services. Thus production is endogenous to the model and depends on the complex interaction between resources, technology, institutions, and behavior.

Household Consumption

Household spending is modeled quite differently across the models. RIMS II and IMPLAN don't model household expenditure behavior explicitly, since household income changes are generally treated as an exogenous source of final demand.

Taking account of modern economic theory, BEAR and REMI have much more complex, explicitly behavioral treatments of household expenditure. In BEAR, household consumption is modeled using an Extended Linear Expenditure System (ELES). The ELES functional form estimates household consumption and savings, for each decile of the California income distribution, based on the relative consumer prices of goods and services, while allowing for subsistence minimum levels of consumption for certain goods. The main advantages of the ELES specification are its rigorous conceptual link to traditional demand theory based on utility maximization and a long history of robust econometric evidence.[5] The REMI model uses a consumption function that was developed by Treyz and Petraglia (2001). The REMI consumption structure allows for substitution amongst goods and services based on relative prices and income effects. Price and income elasticities are specified separately for luxuries and necessities. Both the REMI and BEAR consumption equations adjust total consumption by population growth to allow for exogenous increases in spending as California's population expands. This is an important link between the macroeconomic models and DOF's demographic projections.

Capital Investment

Another core difference between the types of models reviewed here is the treatment of new capital formation, or investment. In the I-O models, investment is an exogenous determinant of final demand and thus is not directly modeled. While industries use capital in the production of goods and services, there is no real competition between firms or industries for capital goods or other resources. This implies that there is no capital supply or other resource constraint in I-O

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5 Largely for his contributions in this area, Angus Deaton was awarded the 2015 Nobel Prize in economics. See, e.g. Deaton and Muellbauer: 1980.

models. If more capital is needed to satisfy an increase in final demand, it appears at no cost. In this way, I-O models have very limited capacity to address dynamics and economic growth issues.

Both the REMI and BEAR models take a more explicit approach to modeling new capital formation. Each model specifies a dynamic process of capital formation where capital supply in the current period is equal to depreciated capital from prior periods and new capital formation (investment). The key difference between the models is how the new capital is determined/estimated. In the REMI model, which includes four types of investment activities (residential, non-residential, equipment, and intellectual property products), capital formation is driven by capital demand. This approach differs, however, from the I-O approach in that there is competition for capital between industries. This demand in turn affects the price of capital, which causes industries to adjust their demand for capital relative to the other value-added inputs (labor and fuel).

In CGE models, such as BEAR, new capital investment is driven by the stock of available savings, and approach more consistent with economic theory than the other modeling approaches. The supply of new capital depends both on the demand from industry as well as household and government savings resources, recycled through financial markets to stimulate new investment. The savings-investment link in CGE models creates important economic growth dynamics that are not necessarily present in the other economic impact models. For example, a policy or regulation that effectively increases household income (e.g., an energy efficiency policy) will also increase household savings and spur new investment activity, yielding a larger macroeconomic growth effect than models that do not include the savings-investment link.

Government

The government sector is also treated very differently across the four model frameworks. In RIMS, government is entirely exogenous to the model. Government spending can be a source of final demand changes, but the multipliers do not capture any fiscal impacts. In IMPLAN, government spending is also an exogenous source of final demand. However, the IMPLAN model has the capacity to trace tax payments from industry to government, so fiscal impacts of final demand changes can be evaluated. Household fiscal interactions, however, are absent from both these approaches, as are their distributional consequences.

In REMI, government income is not modeled explicitly. Tax rates can be changed in the model, which allows for an analysis of the impacts of tax policy on consumers and producers, but the effects on government revenue are not captured. This limits the scope to evaluate agency and other public sector spillover effects. Government spending on goods and services is modeled in REMI.

In the BEAR model, government income is modeled using a number of business and household taxes. A distinction is made between federal and state/local governments, with up to 27 separate agency accounts in the BEAR database. Tax rates can be adjusted exogenously to evaluate various tax policies. Details federal, state, and local government expenditures on goods and services are also explicitly modeled.

Chapter 3: Model Output Comparison

California Senate Bill 617 outlines the general requirements for agencies completing SRIAs for proposed major regulations (1 CCR § 2001-2003, Roland-Holst et al., 2016a). These include several categories of guidance such as (i) identifying which economic impacts should be quantified and addressed, (ii) requiring that costs and benefits be separately identified for different subgroups, and (iii) instructing how baseline scenarios and regulatory alternatives should be developed and evaluated.

When putting together SRIAs, agencies are required to address a very specific set of economic impacts of the proposed regulation. This includes quantifying several specific variables, including personal income, employment by sector, exports and imports, and gross state product. SRIAs are also expected to address a broader set of economic impacts associated with the proposed regulation, including:

- The creation and elimination of jobs within the state
- The creation and/or elimination of businesses within the state
- Any competitive advantage or disadvantage (due to the regulation) to businesses currently operating within the state
- Expected changes in investment in the state
- Changes in incentives for innovation in products, materials, and processes
- Benefits of the regulation, such as improvements in health, safety, and welfare for California residents.
- Spillover effects on other state agencies.

The macroeconomic models reviewed in this report do not quantify all of these impacts, nor are they designed to do so. Rather they focus on a select number of macroeconomic indicators such as real GDP, household income and spending, sector output, gross investment, and other economy-wide metrics. Each of these metrics is compared below. A summary of each model's key reporting variables is shown in Table 5.

Employment

The capacity to estimate impacts on regional employment is a key feature of all the models reviewed in this report. All four frameworks have the capacity to estimate changes in labor force by sector. In RIMS and IMPLAN, there is a single employment category, labor, which is used by individual sectors in the production of goods and services. The REMI and BEAR models disaggregate employment based on occupational classes, 18 or 95 in the former case and 22 in the latter.

Employment is measured in all models as full- and part-time jobs. This is different from another commonly used employment metrics, full-time equivalents (FTEs). It is important to note that employment results in the static I-O models should be interpreted as differences from the base year, while the employment results in the REMI and BEAR models are interpreted as difference from the dynamic baseline or reference scenario in a given year. For example, negative employment impacts in an I-O model imply a net loss of jobs compared to the employment level in 2015, whereas a negative employment result in the dynamic models doesn't necessarily imply that jobs were lost relative to the initial year (2015), just that employment grew more slowly to the year being considered, compared to the baseline.

Household Impacts

SRIAs are required to report the effects of a proposed regulation on household income. All four models can provide this estimate for an aggregate or "representative" California household, although there are differences across the models in how household results are reported. REMI and RIMS II that income accrues single household group. IMPLAN disaggregates households according to nine tax brackets. The BEAR model disaggregates households in two stages. The first of these are statewide income deciles, using information from the American Community Survey (ACS) published by the U.S. Census Bureau.[6]

Secondly, BEAR has a spatial dataset, calibrated to individual US Census tracts and county-level IMPLAN data, which enables it to report income (employment and other) impacts for each of the California's Disadvantaged Communities. This classification was created in recognition of the need to assess impacts on economically and environmentally vulnerable communities, of which there are over 1200 in the state. BEAR is the only statewide economic model with this capacity, dynamic otherwise.

Industry Impacts

All four models estimate gross sector output, which along with employment is often used in SRIAs as the primary variable for reporting business impacts, especially for sectors that are not directly affected by a proposed regulation. In I-O and CGE models, gross sector output is defined as the summation of all industry costs, including the costs of intermediate inputs (including imported inputs) and payments to value-added inputs (such as labor and capital).

One of the requirements for SRIAs is to comment on whether the proposed regulation will lead to the creation or elimination of businesses in the state (Roland-Holst et al., 2016a). Gross output is an imperfect metric for this purpose. While each of the models can estimate the impact on total sector output, there is no current method available to distinguish whether this change in output is due to more firms entering the market or existing firms producing more output. For this reason, alternative methods, outside of the model, must be used to address the business creation/elimination reporting requirement.

Capital Investment

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6 https://www.census.gov/programs-surveys/acs/

The REMI model reports four types of capital investments: residential, non-residential, equipment, and intellectual property products. The BEAR model reports a single investment category. RIMS and IMPLAN do not report new capital investment.

Gross State Product

Each of the models is capable of reporting real gross state product (GSP). In the RIMS and IMPLAN models, GSP can be measured from the income side as the contribution of value-added to sector production. In I-O models this is measured as gross output minus purchases of intermediate inputs. REMI and BEAR both calculate real GSP as well. They provide estimate real GSP using both the income (factor cost) approach of an I-O model and the expenditure approach, which is the market value of all goods and services sold in the state.

Fiscal Impacts

Fiscal impacts refer to changes in revenue and expenditure by the government as this would be affected by a proposed regulation. The fiscal impacts referred to in the SRIA context result from economy-wide changes due to a proposed state regulation. For example, if a regulation boosted economic activity in certain sectors and incomes for certain households, government tax collections might be expected to increase (although the rate structure remains unchanged). Not all of the models capture these fiscal impacts. RIMS II does not model government spending or revenue at all. REMI PI+ can model government spending but does not calculate government revenues.[7] IMPLAN treats government spending as exogenous (and is therefore not affected in model simulations) but does calculate changes in state and national government tax revenue. The BEAR model reports both changes in government spending and changes in government revenue, detailing across up to 27 federal, state, and local fiscal accounts.

Small Business Impacts

SRIAs are required to pay specific attention to the impact of proposed regulation on small businesses. However, these impacts must be addressed separately from the macroeconomic impact assessment since none of the four models make a distinction between types of businesses within a sector. All models currently assume a single representative firm for each industry.

Energy and Emissions

The BEAR model includes a full energy and GHG accounting module for tracking energy and emissions flows throughout the California economy. This feature is unique amongst the four models. In BEAR, energy inputs (coal, natural gas, and refined petroleum products) are converted from model units (dollars) to energy and emissions units using conversion factors. In

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7 REMI offers a different product, Tax-PI, which evaluates "the total fiscal and economic effects of tax policy changes" (http://www.remi.com/products/tax-pi) but there is no reference to the use of this model in any state agency SRIAs.

reference to both this category of assessment and fiscal effects, it should be noted that BEAR is the only one of these models that simulates emission trading, including Cap and Trade, offsets, and their fiscal implications for GGRF and other initiatives.

Table 5: Summary of Model Reporting Variables

	RIMS	IMPLAN	REMI	BEAR
Employment	Yes	Yes	Yes	Yes
Household Consumption/Income	No/No	Yes/Yes	Yes/Yes	Yes/Yes
Gross Output	Yes	Yes	Yes	Yes
Investment	No	No	Yes	Yes
Government Spending/Revenue	No/No	No/Yes	Yes/No	Yes/Yes[8]
Energy System Detail	No	No	No	Yes[9]
GHG Emissions	No	No	No	Yes[10]
Disadvantaged Community Impacts	No	No	No	Yes[11]

8 See e.g. Roland-Holst: 2012
9 See e.g. Roland-Holst et al: 2016c
10 See e.g. Roland-Holst et al: 2016b
11 See e.g. Roland-Holst et al: 2016d

Chapter 4: Model Simulation Comparison

The objective of this chapter is to compare and contrast the results of several identical scenarios across the four models. Results are evaluated for two main scenarios: a baseline comparison and a computer efficiency standard. The baseline comparison only applies to the two dynamic models, REMI and BEAR, since the two I-O models do not produce dynamic baseline results.

Baseline Comparison

The California Department of Finance generates economic and demographic projections twice a year that can be used to calibrate baselines for dynamic economic impact models. This "conforming forecast" is meant to assure that models use similar assumptions for GDP growth rates and projections for population growth. The forecasts generated by DOF extend from 2015-2020. REMI projections extend to 2060 and BEAR projections are modified based on the specific analysis. For comparison, results below show a 2015-2030 projection for the REMI and BEAR models.

Figure 1 shows projections for several macroeconomic aggregates, including real GDP California labor force, total employment, and personal income. The real GDP projections indicate that the REMI and BEAR models forecast lower real GDP growth rates than the DOF forecast. Over 2015-2020, REMI projects growth of approximately 2.2% per year and BEAR projects growth of approximately 2.82% per year. These are consistent with DOF's 2016 near-term projections of approximately 2.7% per year.[12] In the long-run, REMI and BEAR more closely resemble recent national averages, with BEAR projecting growth at the high end of the post-recession national average and REMI projecting growth at the low end of the post-recession national average (Figure 2).

Projections for the labor force and California employment conform much more closely to DOF's forecast (Figure 1). In terms of the California labor force and employment projections, there is some discrepancy between the levels projected by REMI and the DOF forecast, although the growth rates are generally similar. This difference is a result of how jobs are defined and measured. Jobs in REMI included full and part-time employment, while DOF's job estimates are measured as full-time equivalents.

12 DOF's near-term projections were recently revised downwards to 2.2%

Figure 1: Baseline Real GDP and Labor Force Comparison

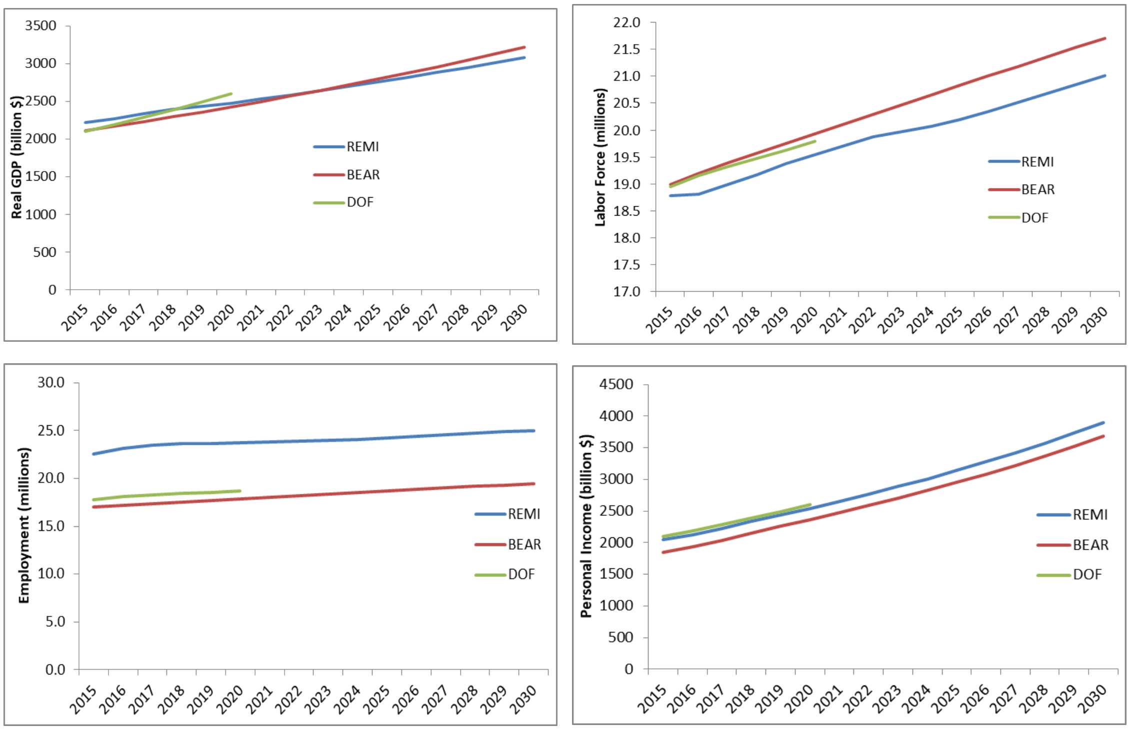
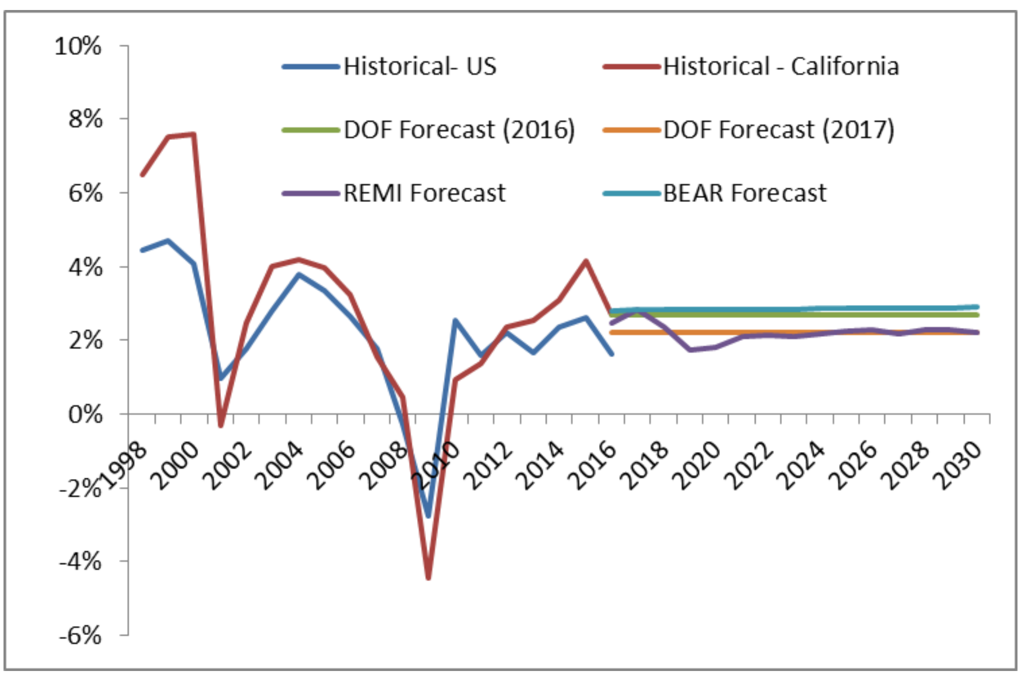


Figure 2: Real GDP Growth Projections



Computer and Display Energy Efficiency Standard

We simulate the impact of a recent energy efficiency regulatory program put forward by the California Energy Commission that sets energy use standards for computers, computer monitors, and signage displays. Energy Commission staff estimated that the program would save household and businesses approximately 2.3 terawatt hours per year once fully implemented, which translates into approximately $350 million/year in electricity savings for California electric power consumers. The regulatory requirements were also estimated to increase costs for computer and display manufacturers and these costs were assumed to be fully passed along to residential and business consumers.

This regulation was originally analyzed using the BEAR model and in this section we conduct similar simulations for the other three economic impact models. To the extent possible, inputs and assumptions were harmonized across the various models.

Table 6 shows the expected cost and savings schedule for the regulation. For both households and businesses, reduced spending on electricity outweighs the increase in computer and display costs (except for the 2018, first year of implementation).

Table 6: Energy Efficiency Projected Costs and Savings

	2018 ($M)	2019 ($M)	2020 ($M)	2025 ($M)	2030 ($M)
Household Spending on Electricity	-36	-74	-113	-197	-199
Household Spending on Computers and Displays	43	43	42	41	40
Business Spending on Electricity	-46	-94	-144	-250	-253
Business Spending on Computers and Displays	62	62	61	60	58

Source: Energy Commission Staff

In the REMI and BEAR models there are specific policy variables that can be adjusted for each of the cost and savings categories outlined in

Table **6**. In both of these models, the net change in household spending on electricity and computer/displays was reallocated to other consumption goods and services according to the base year consumption shares of those alternative expenditures. For example, in 2030 California households are projected to save $159 million due to the efficiency regulation ($199 million in electricity savings - $40 million in higher computer/monitor costs). This $159 million is diverted by consumers to other consumption goods and services according to baseline expenditure shares.

Because the IMPLAN and RIMS II models are static I-O models, a sample year was chosen to evaluate economic impacts. For this study, the costs and savings from 2030 were chosen in order to reflect a point in the future when the regulation was fully implemented.

Macroeconomic Impact Comparison

Macroeconomic results from the computer and display standard reveal large differences across a wide range of economy-wide economic metrics (Table 7). 2030 was chosen as the variable reporting year in order to facilitate comparison between the dynamic models and the static I-O models. Aggregate employment effects are generally similar between BEAR and IMPLAN models, which are both much larger than the REMI employment results. The REMI model shows a positive employment effect but negative output and real GDP. This is due to the employment intensity of different sectors in REMI. Based on the employment intensities discussed in Chapter 2, sectors that expand relative to the baseline in the REMI model have higher employment intensities than sectors that contract, relative to the baseline.

The varying real GDP growth rates indicate that the energy efficiency policy could have quite different impacts on economic growth, depending on which model is chosen to do the assessment. For the I-O models, economic growth is simply driven by the multiplier effect of net positive (energy savings - adoption cost > 0) expenditures. In the BEAR model, there are both sectoral multiplier effects and important substitution and income/employment effects from household consumption reallocation. Because a majority of of baseline household and enterprise expenditure goes to services, more labor intensive and less import-dependent than technology, expenditure shifting in BEAR leads to net positive GSP and employment from the efficiency standard. The decline in real GDP in the REMI model, as shown in the following section, appears to be driven by a large decline in manufacturing output.

Table 7: Summary Results for SB617 Variables

	IMPLAN	RIMS II	REMI	BEAR
Employment (jobs)	5,149	2,163	1,176	5,525
Real GDP ($million)	391	-36.8	-8	636
Output ($million)	606	-59.5	68	1,189
Personal Income ($million)	269	46.7	69	652
Investment ($million)	N/A	N/A	-8	124

Output and Employment by Sector

The aggregate results shown above can be decomposed by sector in order to better understand the drivers of the macroeconomic impacts.

Table 8 and

Table 9 disaggregate employment and gross output by sector. Several important observations should be noted. First in the I-O models, all employment and output effects are positive across the board except for the electric power (utility) sector. This implies that, in the absence of any economy-wide resource constraints or trade-offs, the induced effects resulting from the redistribution of household and business income would outweigh the direct and indirect effects of lower electric power demand. The REMI and BEAR models reveal more complex substitution patterns, with some sectors increasing output and employment and others decreasing output and employment. These patterns are the result of more complex producer behavior, where input choices are changing in response both to demand shifts and price changes. At the same time, consumer behavior shows expenditure bundles changing due to both price and income effects. Compared to REMI, the BEAR model shows much larger sectoral effects in both the positive and negative direction. These more dramatic trade-offs result from a more complete specification of model closure, or balancing conditions on public and private income expenditure and income, savings and investment, and border trade.

The gross output decomposition results are also important to understand in terms of energy consumption and emissions. Even though there is a reduction in electric power sector output due to the energy efficiency standard, output in other sectors more than offsets the lower electric power demand, i.e. net macroeconomic growth leads to higher state energy use. Depending on the emissions intensity of different sectors, this could reflect energy consumption rebound effects that either offset or augment the energy use reductions from the electric power sector. In the BEAR model, for example, manufacturing output increases substantially, which is likely to offset some of the emissions reductions from the electric power sector. In the REMI model, manufacturing output declines, having the opposite effect.

Of course, changes in the electric power portfolio will combine with energy demand to determine the ultimate emissions effects of these policies, not to mention their implications for emissions trading schemes or the revenues accruing thereto. BEAR is the only framework among those considered here that can assess these factors.

Table 8: Employment Impacts by Industry in 2030 (jobs)

<table>
<tr><th></th><th>IMPLAN</th><th>RIMS II</th><th>REMI</th><th>BEAR</th></tr>
<tr><td>Ag, Forestry, Fishing, and Related Activities</td><td>42</td><td>81.6</td><td>4</td><td>207</td></tr>
<tr><td>Mining</td><td>-12</td><td>6.1</td><td>3</td><td>20</td></tr>
<tr><td>Utilities</td><td>-124</td><td>33.6</td><td>-71</td><td>-224</td></tr>
<tr><td>Construction</td><td>178</td><td>108.5</td><td>15</td><td>200</td></tr>
<tr><td>Manufacturing</td><td>189</td><td>652.1</td><td>-102</td><td>918</td></tr>
<tr><td>Wholesale Trade</td><td>174</td><td>136.4</td><td>41</td><td>-498</td></tr>
<tr><td>Retail Trade</td><td>790</td><td>235.2</td><td>277</td><td>964</td></tr>
<tr><td>Transportation and Warehousing</td><td>167</td><td>109.6</td><td>42</td><td>-1545</td></tr>
<tr><td>Information</td><td>78</td><td>270.7</td><td>22</td><td>-195</td></tr>
<tr><td>Finance and Insurance</td><td>219</td><td>239.7</td><td>70</td><td>2123</td></tr>
<tr><td>Real Estate and Rental and Leasing</td><td>543</td><td>670.2</td><td>79</td><td>-1294</td></tr>
<tr><td>Professional, Scientific, & Technical Services</td><td>292</td><td>313.8</td><td>44</td><td rowspan="2">-390</td></tr>
<tr><td>Management of Companies and Enterprises</td><td>69</td><td>40.8</td><td>10</td></tr>
<tr><td>Administrative/Waste Management Services</td><td>338</td><td>157.3</td><td>78</td><td>-128</td></tr>
<tr><td>Educational services; private</td><td>107</td><td>149.0</td><td>40</td><td>-1842</td></tr>
<tr><td>Health Care and Social Assistance</td><td>645</td><td>790.9</td><td>247</td><td>11094</td></tr>
<tr><td>Arts, Entertainment, and Recreation</td><td>137</td><td>122.1</td><td>47</td><td>-1821</td></tr>
<tr><td>Accommodation and Food Services</td><td>578</td><td>45.8</td><td>179</td><td>1102</td></tr>
<tr><td>Other Services, except Public Administration</td><td>392</td><td>518.3</td><td>194</td><td>-1312</td></tr>
<tr><td>Government Services</td><td>347</td><td>-</td><td>0</td><td>-1854</td></tr>
</table>

Table 9: Gross Output by Sector in 2030 ($ million)

	IMPLAN	RIMS II	REMI	BEAR
Ag, Forestry, Fishing, and Related Activities	8	9.5	1	51
Mining	-3	1.6	2	10
Utilities	-180	-761.3	-71	-354
Construction	32	17.1	14	56
Manufacturing	64	138.6	-158	533
Wholesale Trade	46	24.1	14	-171
Retail Trade	71	25.4	37	78
Transportation and Warehousing	22	16.0	7	-370
Information	47	50.5	25	-142
Finance and Insurance	52	50.2	18	856
Real Estate and Rental and Leasing	165	108.6	63	-294
Professional, Scientific, & Technical Services	50	48.1	11	-49
Management of Companies and Enterprises	18	7.8	4	0
Administrative/Waste Management Services	25	14.7	10	-54
Educational services	8	15.0	5	-316
Health Care and Social Assistance	64	98.3	32	1978
Arts, Entertainment, and Recreation	11	13.8	7	-222
Accommodation and Food Services	39	6.2	19	112
Other Services, except Public Administration	33	56.2	14	-129
Government Services	29	-	0	-383

Chapter 5: Implementation

As a practical matter, the four economic modeling tools reviewed here differ not only in methodology, but also in the way they can best be implemented for any given regulatory assessment. Implementation strategy begins with a choice between two alternatives - the agency can do its SRIA in-house, relying on its own staff (or an allied agency) or it can commission professional consultants to do the job. This basic “make or buy” decision will depend on the nature of the regulation, but more importantly on the agency itself, it’s overall need and capacity for economic policy research. As summarized in a separate set of guidelines (1 CCR § 2001-2003, Roland-Holst et al., 2016a), a complete and consistent SRIA implementation included data development, economic analysis, and results communication. To responsibly implement any of the methods we have been discussing here would require at least a graduate degree in economics, statistics, or an allied field. In this section, we summarize the main considerations informing this decision for each of the four methods. As a practical matter, we also recommend that agencies consult closely with DOF and their fellow public offices about SRIA experience and their options.

The linear models, RIMS and IMPLAN, are broadly similar in their skill requirements, very different in price, and moderately different in other implementation features. Because of the long history of input-output methods, there is abundant technical documentation available to aspiring users of either product. RIMS is the simplest conceptually and (by far) the least expensive, but it comes in a relatively “raw” form. This means RIMS users will have to develop supplemental data and add their own analysis and reporting frameworks. IMPLAN has user interface software and documentation that facilitate not only implementation but scenario analysis and reporting. This makes it attractive for individual and team adoption, but this comes at a price.

The REMI model has much more internal complexity, but this is significantly offset by a relatively detailed user interface. Documentation for the interface seems to support relatively rapid adoption, but the model cannot be user-modified and technical documentation of the model structure is incomplete. The latter can be a hindrance to results interpretation, and versions of the model are not, as far as we understand, responsive to individual client or project needs.

Any of the three previous approaches can be implemented internally or by commission to an outside consultant. The BEAR model, by contrast, is not for sale but supports SRIA assessment as a research service. Berkeley Economic Advising and Research works with individual agencies on each regulation, developing data inputs, scope, and reporting strategy to suit the assessment at hand. BEAR contracts for SRIA analysis also include expert support for private and public stakeholder engagement, results communication, expert testimony, etc.

Chapter 6: Conclusions

This report reviews the leading tools for economic modeling to support Standardized Regulatory Impact Assessment (SRIA), prescribed for California agencies by Senate Bill 617. Because of the scale and diversity of the state's public sector responsibility and action, regulations can be expected to exert pervasive influence across the economy and its diverse stakeholders. SB617 recognizes the importance of this by mandating ex ante regulatory assessment to identify potential benefits as well as adjustment challenges, supporting more effective targeting, public dialog, and adaptive policy making. The complexity of today's economy is such that policies based on intuition and rules of thumb are unlikely to approach optimality. For this reason, the Department of Finance has endorsed economywide modeling methods to support more rigorous and comprehensive SRIA assessment. The present review is intended to support more effective SB617 compliance by highlighting the practical characteristics of four approaches currently being implemented for SRIA work.

Our overall conclusion is that no single approach is best in all circumstances. The right choice will depend on characteristics of both the regulation and its implementing agency. In some cases, we expect agencies might start with one approach and adapt on the basis of experience and evolving needs. We encourage interested agencies to examine the review in its entirety, but for convenience we summarize salient features of the four approaches below.

RIMS

Pros: RIMS is the simplest and by far the least expensive assessment resource in this review. Simplicity can facilitate adoption and allow relatively easy interpretation of results. The database itself can be purchased outright, for perpetual use, with occasional updates available at added cost.

Cons: Simplicity has advantages, but the methodology underlying both RIMS and IMPLAN, linear economic modeling analysis, is very limited in its capacity to explain economic behavior and important market characteristics. In particular, there is no accounting for price changes, technological change, or trade-offs due to constraints in the economy. RIMS is based on the narrowly defined input-output model, which only captures linkages between enterprise activities in the economy, with incomplete consideration of consumption that comprises more than half of Gross State Product. The current version of RIMS also contains little information on public-private sector linkage effects, an explicit SRIA requirement.

Conclusions: This approach is best used for indicative short term assessment. RIMS might be a useful entry-level tool to evaluate whether or not a regulation meets the SRIA threshold of $50 million aggregate impact on the California, but its conceptual weaknesses limit its capacity to produce a complete assessment. Implementing it for a SRIA will require significant effort to develop supporting narrative regarding omitted effects and restrictive assumptions.

IMPLAN

Pros: The IMPLAN database and software product are more fully featured. It includes a user interface to evaluate more complex linkage effects and compare alternative scenarios, and also provides some results reporting. IMPLAN can also be purchased on a one-time, perpetual use basis, with the opportunity to buy annual updates.

Cons: IMPLAN is significantly more expensive than RIMS, but subject to many of the same conceptual limitations, based on a linear paradigm of economic activity that was abandoned by academic and advanced agency researchers decades ago.

Conclusions: IMPLAN is relatively easy to use, somewhat more sophisticated than RIMS, but is also best suited to indicative, short term assessment. For a dynamic and innovative economy like California, it cannot be expected to credibly support medium and long term forecasting.

REMI

Pros: REMI is a more sophisticated modeling framework, including partial specification of economywide market interactions and constraints, consumer behavior, and resource constraints. The model is implemented in a detailed user interface that permits convenient scenario specification, comparison, and results communication. The REMI model and database can be purchased on a single-year licensing basis.

Cons: REMI does not have complete technical documentation, and to this extent it presents a "Black Box" to end-users. This can make it difficult to understand and explain estimated impacts and interactions. The model is also eligible for use only on a current version, annual basis, making results comparison over time difficult.

Conclusions: For agencies who want to internalize assessment capacity, and are willing to invest in permanent expert staff, REMI may be an appropriate choice.

BEAR

Pros: BEAR is the most advanced and detailed of the four assessment tools. It is a true general equilibrium model, capturing extensive linkages between public and private actors across the state economy. As summarized in Table 2 above, it also incorporates significantly more reporting detail, including emissions, electric power portfolio, vehicle fleet, and disadvantaged community characteristics.

Cons: Berkeley Economic Advising and Research, delivers SRIA assessment as a service, and the current version of the BEAR model is not for sale. This means SRIAs can be tailored to individual regulatory and agency needs, but the cost may vary. Single assessment cost may be higher with the other tools, but savings on long term commitments to recruit and retain technical staff can be much more expensive.

Conclusions: BEAR is best suited to regulations with larger and more extensive impacts across the economy, particularly when they may impact energy issues and/or important stakeholder groups. Because it represents the state-of-the-art in economic forecasting, and provides end-to-end expert support (data, analysis, results communication, stakeholder engagement), BEAR can also be more effective in responding to technical and legal challenges.

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