Appendix A: REMI Baseline Adjustments for the 2016 AQMP

(Preliminary Draft as of March 10, 2016)

Introduction

The 2016 AQMP uses SCAG's 2016 growth forecast of employment, population, and other socioeconomic variables as inputs for baseline emissions inventories. For consistency, the employment and population forecasts from SCAG at the sub-county level for the South Coast region are also used to define the baseline forecast for the 2016 AQMP socioeconomic impact assessment. SCAQMD staff economists use the Regional Economic Models Inc. (REMI) model to simulate the potential socioeconomic impacts of air pollution control policies.

An audit of SCAQMD's socioeconomic analysis methods by Massachusetts Institute of Technology recommended further evaluation of the inconsistency between the REMI and SCAG forecasts (Polenske et al., 1992). A study was commissioned for the Center for the Continuing Study of the California Economy (CCSCE, 1994) to determine the sources of inconsistency between these forecasts. A three-step process was recommended to ensure consistency between REMI and SCAG forecasts: (1) they should use the same U.S. projections for population and employment, (2) they should use the same birth rates by age cohort; and (3) they should use similar rates of growth for employment projections.

The REMI model comes with default datasets for employment and population. These employment and population projections are consistent with SCAG at the national level, but differ for the South Coast region. Thus, the REMI regional baseline needs to be updated in accordance with the employment and population forecasts from SCAG. The following sections describe the data and method used to accomplish the updates in the REMI model, as well as the update results and any potential implications due to the updates performed.

Employment Baseline Adjustment

Data

The employment forecast in the REMI model and that from SCAG differ both in their data sources and their forecast of employment levels into 2031. The REMI model uses employment and compensation data from Bureau of Economic Analysis (BEA) for its historical employment series in the 21 sub-county regions contained in the model.[i] For employment projections, REMI bases its national forecast on the 2012-2022 Employment Outlook published by the Bureau of Labor Statistics (BLS), along with short-term final demand forecast by the Research Seminar in Quantitative Economics (RSQE). The national forecast is then converted to regional forecasts using historical patterns.[1] In comparison, SCAG's employment forecast is based on data

[1] REMI documentation ("Data Sources and Estimation Procedures. PI+ v1.7") and in consultation with REMI technical staff.

published by the California Employment Development Department (EDD) and the BLS. The base year of SCAG's forecast is 2012. The 2012 employment level is benchmarked to the corresponding historical data in the Current Employment Statistics (CES), and all future years forecast was projected based on a shift-share calculation of national employment forecasts and refined by inputs provided to SCAG by their local jurisdictions.

There are several differences between the BEA and the EDD/BLS CES data. The BEA employment data uses additional data sources to estimate employment in the farm sector, private households, private schools, and other sectors such as railroad operations. The BEA data also include federal military jobs and estimates of the self-employed based on tax records. In contrast, the BLS data report only civilian payroll employment. For transportation modeling purposes, SCAG arrived at its total employment projections by adding self-employment by sector based on the American Community Survey's Public Use Microdata Samples (ACS PUMS). This method results in much lower estimates of the self-employed than reported in the BEA data, as indicated by a comparison of the 2012 data.

Method

SCAG staff provided a forecast of levels of employment by sector for each of the 21 sub-county regions used within the REMI model from the 2016-2040 RTP/SCS[ii] for 11 years between 2016 and 2031, in addition to the 2012 base year.[2] These provided data are based on a conversion from SCAG's forecast which is for 13 sectors by Transportation Analysis Zone[3] (TAZ). The conversion was performed in consultation with SCAQMD staff so that the industry sectors and geographical boundaries are both well aligned with those in the REMI model. As part of this conversion, SCAG provides a forecast of the Public Administration sector (NAICS 92), which includes federal civilian employment[4] and local & state government employment, as well as public school employment. REMI handles these employees with separate categories for federal civilian and local & state government workers. In order to get an applicable growth rate to for the REMI model, the Public Administration category is allocated into federal civilian and state and local government based on the relative employment from REMI annually. Military and Private households worker forecast are not provided by SCAG, SCAQMD staff instead uses the forecast from REMI. For years that are missing from the provided forecast, linear interpolation is used to estimate employment for those years.

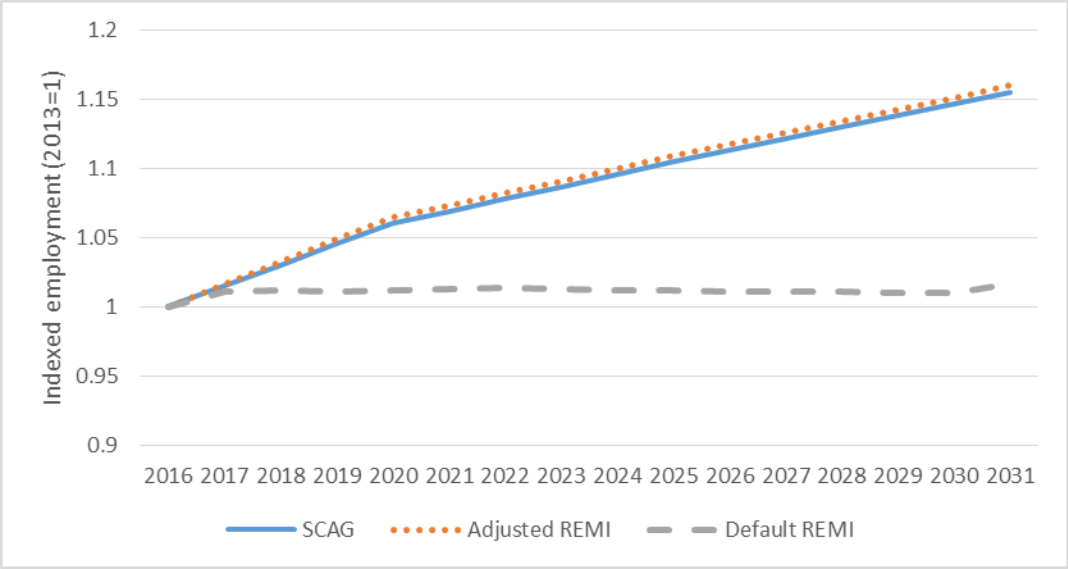
From these employment data, the yearly growth rate is calculated between 2013 and 2031 for each sub-county and each industry sector. These SCAG employment growth rates are then multiplied by the corresponding REMI employment level in 2013, the last year of historical data in the REMI model. This results in an employment forecast which begins with REMI's base employment level in 2013, but which grows at the rate forecasted by SCAG. This adjusted

[2] The years of employment and population data provided are 2012, 2016-2023, 2025, 2026, and 2031. 2012 is the base year of analysis in both 2016 AQMP and 2016 RTP/SCS. Other years, except 2016, are the milestone years for air quality attainment demonstration.
[3] TAZs are generally equivalent to census block groups, and there are a total 11,267 TAZs in all of the SCAG counties except Catalina Island.
[4] Post office workers (NAICS 491) are also included here.

employment forecast is entered into the REMI model using the Employment Update function. As illustrated in Figure *1*, the overall growth rate is different by about 0.5% only between the SCAG and the adjusted REMI forecasts, and it is considerably more optimistic than the default REMI forecast. By 2031, the difference in the updated and default levels of overall employment reaches 14 percentage points. The 2016-2031 employment growth rates by county and by sector can be found in Tables Table *1* and Table *2*, respectively.

There are several technical constraints to directly apply SCAG's projected level of employment in REMI's Employment Update function. First, there are large differences in estimates of self-employment between those obtained from ACS PUMS and those from BEA. Secondly, regional allocation of jobs from aggregation of SCAG's TAZs and REMI's method may differ. These technical constraints cause significant differences in the employment levels between REMI and SCAG forecasts. The large differences cause errors in the REMI model when SCAG employment levels are directly used in the Employment Update function. The employment growth rate method follows that done in the previous AQMP (2012), but is enhanced to include growth rates by both sub-county and detailed 70 sector based on statistics directly projected by SCAG. Additionally, growth rates are calculated annually instead of for five-year periods.

Figure 1: Employment Growth, 4-county SCAQMD region, 2016-2031



Results and Implications

Examining Table 2, which shows the 2016-2031 employment growth rates by industry for the 4-county region, we can see REMI's and SCAG's forecasts differ. Some of the sectors with largest differences in employment growth forecast are the telecommunications and apparel manufacturing sectors which differ by 53 and 47 percentage points, respectively. On average the SCAG growth rate is greater than REMI's over the 2016-2031 time period: SCAG projects 10

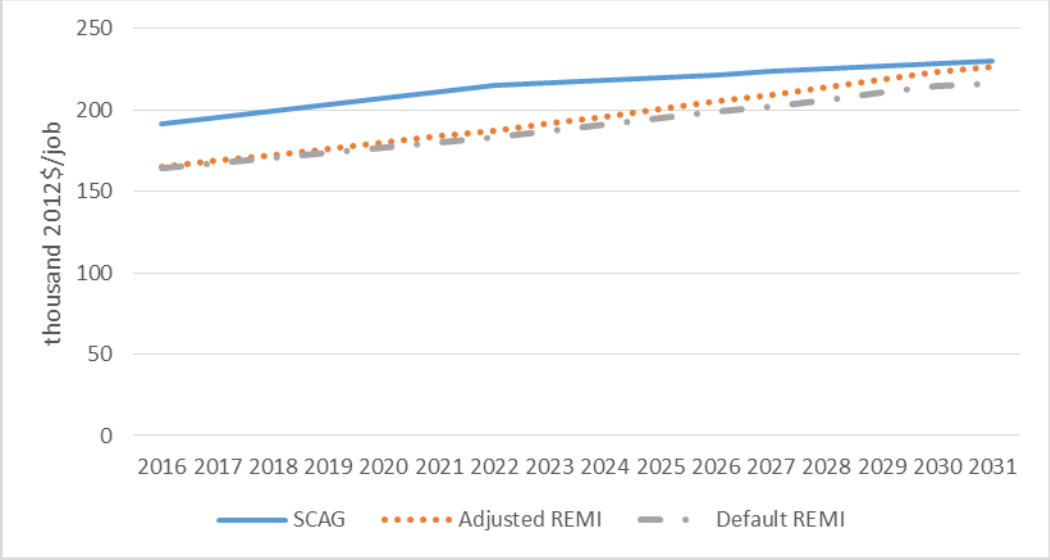
percentage point higher growth in Los Angeles County, 9 percentage points higher growth in Orange County, 35 percentage points higher growth in Riverside County, and 27 percentage points higher in San Bernardino County. For the overall four-county South Coast basin, SCAG predicts 14 percentage points higher growth than REMI.

Changing the employment forecast in REMI not only changes the levels of employment, it may also change the output and the labor productivity (measured in $/job), the latter of which is a major parameter that affects a policy's job impact in REMI. The labor productivity is determined according to the simplified production function (equation):[5]

$$Y = LP * E, \qquad (1)$$

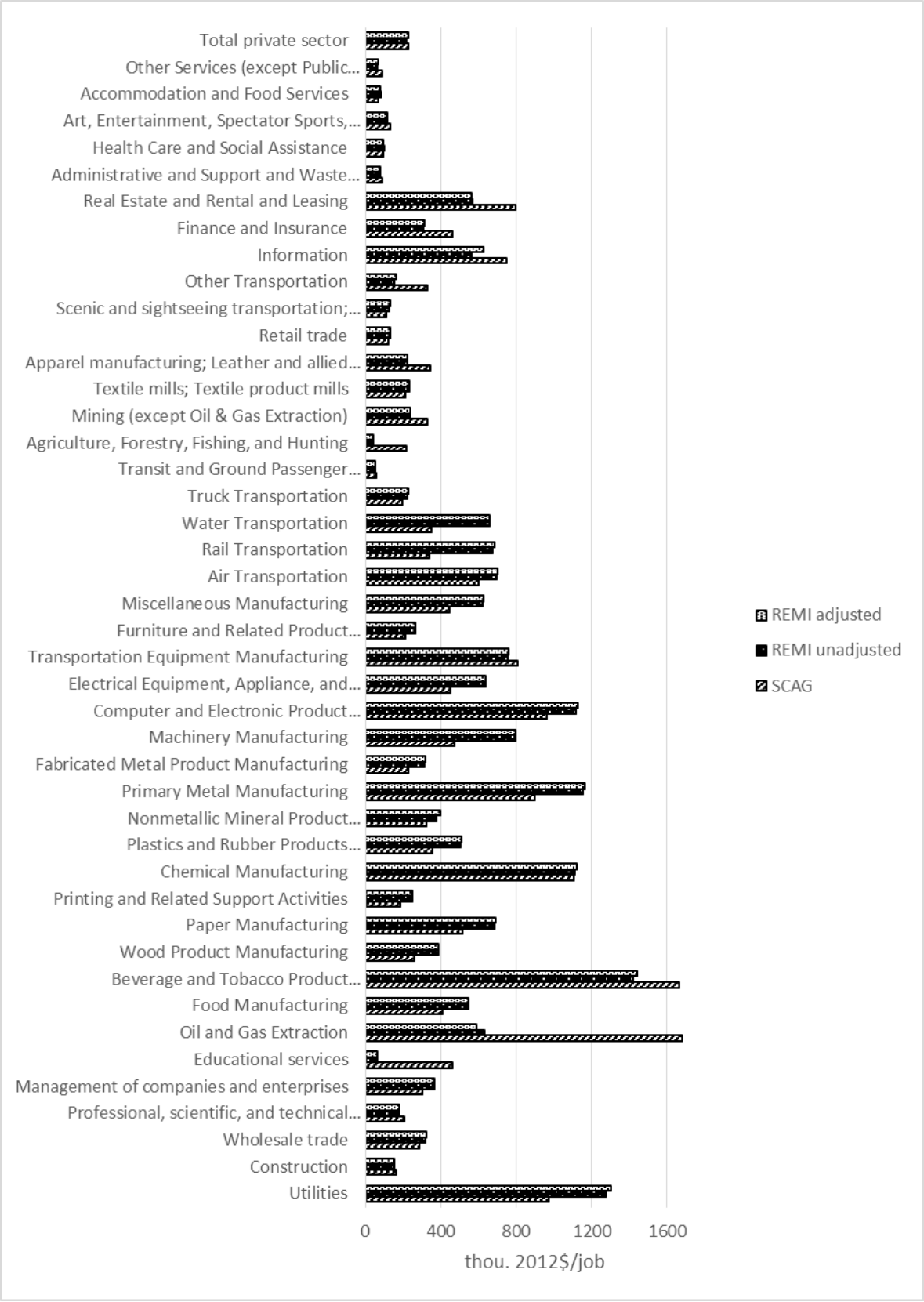
where Y is output in dollars, LP is the labor productivity, and E is the employment level. According to REMI technical staff, the Employment Update function changes E from its REMI defaults to E' which reflects SCAG's growth rate, and an algorithm changes Y. The percent change in Y is less than the percent change in E for some industries and more for others. Therefore, the labor productivity may increase or decrease from the default values in REMI as a result of this employment update. As an empirical matter for this version of the REMI model, on average, the ratio of the percentage change in output and percentage change in employment is approximately 1, which indicates that, on average, the labor productivity remains close to the REMI defaults. Any difference in labor productivity as a result of this employment update is shown in Figure 2. It can be seen that the difference is the largest in years further into the future. The by-sector differences in labor productivity in 2031 are shown in Figure 3.

Figure 2: Labor Productivity, 2016-2031 for the 4-county SCAQMD region



[5] This is the inverse of a simplified version of equation 2-5 from PI+ v1.7 Model Equations documentation. http://www.remi.com/download/documentation/pi+/pi+_version_1.7/PI+_v1.7_Model_Equations.pdf

Figure 3: Labor Productivity in 2031 by Industry for the 4-county SCAQMD region[6]



It is important to note that the labor productivity shown as the "adjusted REMI", while on average close in value to "Default REMI," it is different than the labor productivity that SCAG uses. REMI does not provide a function that allows users to update both employment and labor productivity (or both employment and output).

One of the important implications of the changes in the modeled labor productivity with respect to either the unadjusted REMI or SCAG values is that it affects the magnitude of employment impacts that will be simulated by the REMI model. To understand this by examining direct employment effects,[7] we can solve Equation 1 for employment, *E*:

$$E = EPV * Y, \quad (2)$$

where $EPV = LP^{-1}$ is the employees per dollar of output. Totally differentiating (2):

$$dE = EPV * dY. \quad (3)$$

Then from (3), for some change in output, $dY \neq 0$, and some *EPV'*>*EPV*, then $|dE'| > |dE|$. In other words, a policy that directly or indirectly changes output will have an amplified employment impact with a greater *EPV* (lower *LP*) and dampened one with a lower EPV (greater LP).

Therefore, when the REMI model with the adjusted baseline results in a lower (higher) labor productivity, employment impacts will be greater (less) than those that would be predicted by the REMI model with the default baseline. Similarly, the generally higher labor productivity in the original SCAG projections would imply that, the job impacts simulated by the REMI model with the adjusted baseline would be larger in magnitude when compared to the impacts derived from applying directly SCAG's labor productivity. As an example, using the different estimates of labor productivity for the apparel manufacturing; leather products sector in 2031, a policy that caused a $10 million decrease in output, would result in a *direct* employment effect of 30 predicted jobs foregone using SCAG's labor productivity and 47 predicted jobs foregone using the lower labor productivity values in either adjusted or unadjusted REMI baselines.[8]

Population Baseline Adjustment

Data

The default population forecast embedded in the REMI model is based on the demographic assumptions used in the U.S. Census Bureau's national population projections and refined with region-specific parameters, including birth, death, and international migration rates.[9,iii] In comparison, SCAG's sub-county population forecast is based on the projections developed for

[7] There are also indirect and induced effects.
[8] Based on labor productivities of $0.343, $0.220, and $0.221 million/job, respectively. This example is based on fixed input-output relationship. There would also be indirect effects, as this industry's intermediate demands change; the employment effects of these changes would also differ across SCAG and REMI.
[9] REMI documentation ("REMI PI+ v1.7: Demographic Component of the REMI Model") and in consultation with REMI technical staff.

its 2016 Regional Transportation Plan/Sustainable Community Strategies at the TAZ level. The projections considered various data sources, including those published by the U.S. Census Bureau and the California Department of Finance, and refined with local inputs.[iv] The TAZ-level population projections by gender, race/ethnicity, and age cohort are then aggregated to the 21 sub-county regions and transmitted to the SCAQMD, specifically for the use in the REMI sub-county model which was custom built for the South Coast 4-county region (REMI PI$^+$ v1.7.3).

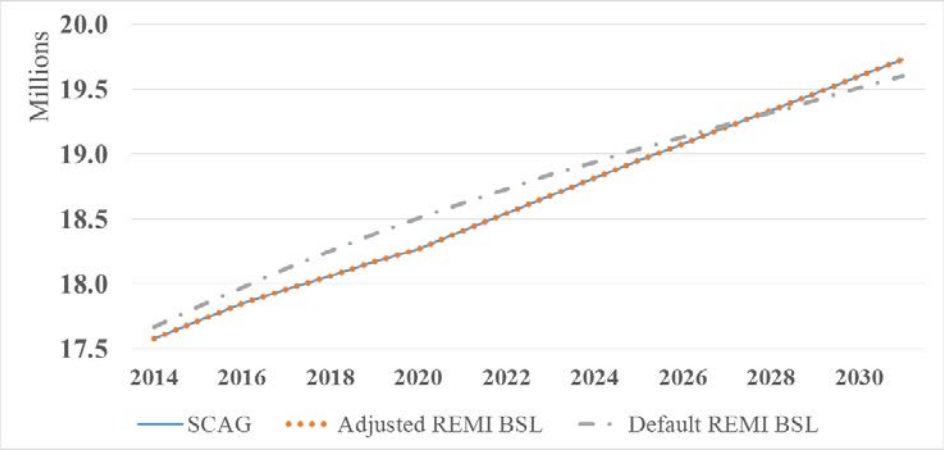
Method

SCAG staff provided sub-county sub-population projections for 11 years between 2016 and 2031, in addition to the 2012 base year. For years that are missing from the provided forecast, linear interpolation is used to estimate population for those years. The 2014-2031 data are transposed and entered into REMI using its Population Update function, concurrently with the Employment Update described above, to generate an alternative control scenario (i.e., baseline) that reflects SCAG's projections. The 2014-2031 data were used because the Population Update function allows users to adjust population for the forecast years, and the last historical year in REMI PI$^+$ v1.7.3 is 2013.[10]

Results and Implications

It can be seen from Figure 4 that the adjusted REMI baseline using SCAG's projections perfectly aligns with the projected total population for the 21 sub-county regions. Any discrepancies among all sub-county, sub-population groups appear infinitesimal for all years.

Figure 4: Population Forecasts, Total of 21 Sub-County Regions (2014-2031)



It should be noted that the Population Update function does not adjust birth rates by age cohort. Such adjustments were recommended back in 1994, largely due to the lack of detailed sub-population data table as needed to populate the REMI forecast. Therefore, cohort birth rates were used to generate the needed table. According to REMI technical staff, the REMI Population

[10] As REMI solves its model per time period, simulation results for years 2014-2031 will not be affected by maintaining the default REMI baseline for the historical and post-2031 years. (This is in contrast to an intertemporal forward-looking model.)

Update function treats the initial difference in 2014 between the adjusted and default REMI baselines as a decrease in the number of international migrants. Then, if the implied next-period population by the embedded demographic assumptions does not match up with that projected by SCAG, any remaining differences are again attributed to international migration. The process continues for all subsequent periods until 2031. Because economic behaviors do not differ by migrant status in the REMI model, this update procedure is not expected to cause any change in key parameter values that could influence simulation results, other than a different baseline population to compare to.

Tables

Table 1: Employment Growth Rates by County (% growth rate)

	2016-2031		
County	Default REMI	Adjusted REMI	SCAG
Los Angeles	1%	11%	11%
Orange	3%	12%	12%
Riverside	6%	42%	41%
San Bernardino	2%	30%	29%
4-county region	2%	16%	15%

Table 2: Employment Growth Rates by Industry for the 4-County Region

	2016-2031		
Industry	Default REMI	Adjusted REMI	SCAG
Utilities	-29%	15%	16%
Construction	34%	36%	36%
Wholesale trade	-7%	14%	15%
Professional, scientific, and technical services	16%	19%	19%
Management of companies and enterprises	-17%	19%	18%
Educational services	3%	19%	19%
Agriculture and forestry support activities	-14%	4%	4%
Oil and gas extraction	11%	6%	1%
Mining (except oil and gas)	3%	3%	3%
Support activities for mining	27%	2%	2%
Food manufacturing	-9%	4%	3%
Beverage and tobacco product manufacturing	-7%	7%	1%
Wood product manufacturing	4%	3%	3%
Paper manufacturing	-22%	-7%	-4%
Printing and related support activities	-23%	2%	1%
Petroleum and coal products manufacturing	-18%	-3%	-2%
Chemical manufacturing	-26%	-2%	-4%
Plastics and rubber product manufacturing	-27%	-3%	-3%
Nonmetallic mineral product manufacturing	14%	1%	1%
Primary metal manufacturing	-33%	1%	-1%
Fabricated metal product manufacturing	-8%	-4%	-4%
Machinery manufacturing	-29%	-3%	-2%
Computer and electronic product manufacturing	-18%	-5%	-4%

	2016-2031		
Industry	Default REMI	Adjusted REMI	SCAG
Electrical equipment and appliance manufacturing	-32%	-6%	-6%
Furniture and related product manufacturing	-6%	-1%	0%
Miscellaneous manufacturing	-34%	-2%	-1%
Air transportation	-36%	6%	5%
Rail transportation	-20%	31%	16%
Water transportation	9%	13%	5%
Truck transportation	-7%	12%	12%
Transit and ground passenger transportation	0%	10%	13%
Pipeline transportation	-37%	20%	13%
Couriers and messengers	-31%	14%	11%
Warehousing and storage	7%	27%	13%
Publishing industries, except Internet	-11%	10%	13%
Motion picture and sound recording industries	-15%	6%	9%
Broadcasting, except Internet	-11%	3%	7%
Telecommunications	-31%	22%	18%
Securities, commodity contracts, investments	-2%	16%	19%
Insurance carriers and related activities	1%	13%	11%
Real estate	0%	13%	8%
Administrative and support services	10%	23%	23%
Waste management and remediation services	-1%	31%	32%
Ambulatory health care services	19%	26%	26%
Hospitals	21%	20%	19%
Nursing and residential care facilities	13%	20%	22%
Social assistance	17%	25%	27%
Performing arts and spectator sports	-9%	8%	11%
Museums, historical sites, zoos, and parks	14%	12%	15%
Amusement, gambling, and recreation	3%	24%	14%
Accommodation	4%	11%	10%
Food services and drinking places	-2%	12%	12%
Repair and maintenance	-9%	20%	20%
Personal and laundry services	-10%	15%	14%
Membership associations and organizations	-4%	15%	14%
Forestry and logging; Fishing, hunting, and trapping	-11%	-21%	2%
Textile mills; Textile product mills	-37%	1%	7%
Apparel manufacturing; Leather and allied product manufacturing	-49%	-1%	-2%
Motor vehicles, bodies and trailers, and parts manufacturing	-10%	-2%	-2%
Other transportation equipment manufacturing	-24%	0%	3%
Retail trade	-7%	-10%	-9%

	2016-2031		
Industry	Default REMI	Adjusted REMI	SCAG
Scenic and sightseeing transportation; Support activities for transportation	1%	14%	14%
Internet publishing and broadcasting; ISPs, search portals, and data processing; Other information services	-23%	4%	8%
Monetary authorities - central bank; Credit intermediation and related activities; Funds, trusts, & other financial vehicles	-13%	12%	12%
Rental and leasing services; Lessors of nonfinancial intangible assets	7%	23%	12%

[i] Regional Economic Models, Inc. (REMI). Policy Insight® for the South Coast Sub-county (70 sector model) Version 1.7.3.
[ii] SCAG. 2016. "The 2016-2040 Regional Transportation Plan/Sustainable Communities Plan. Demographics & Growth Forecast". Southern California Association of Governments. Los Angeles, CA. December 2015 Draft.
[iii] Regional Economic Models, Inc. (REMI). 2015. "REMI PI+ v1.7: Demographic Component of the REMI Model."
[iv] SCAG. 2016. "The 2016-2040 Regional Transportation Plan/Sustainable Communities Plan. Demographics & Growth Forecast". Southern California Association of Governments. Los Angeles, CA. December 2015 Draft.