

Supplementary Information for: Economic cascades and the costs of a business-as-usual approach to COVID-19

Peter D. Roopnarine^{*1}, David Goodwin², Maricela Abarca¹, and Joseph Russack¹

¹Institute for Biodiversity Sciences and Sustainability, California Academy of Sciences, 55 Music Concourse Dr., San Francisco CA 94118

²Department of Geosciences, Denison University, Granville OH 43023, USA

Supplementary Information

^{*}proopnarine@calacademy.org

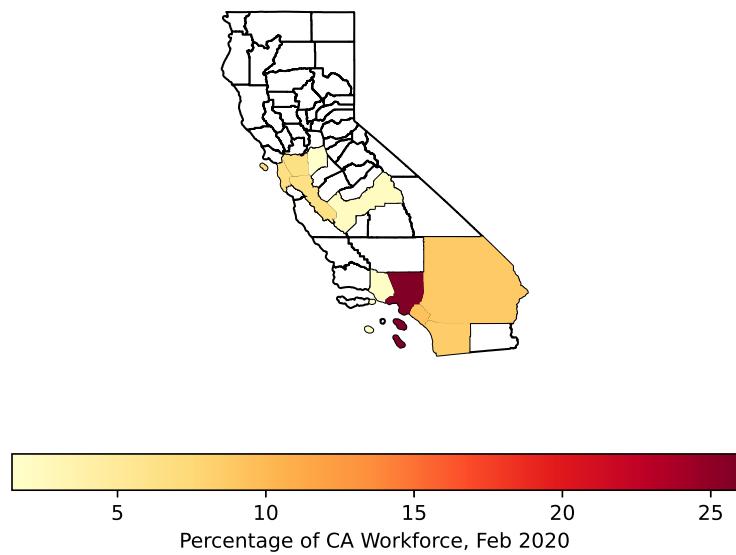


Figure S1: Map of California counties. Colored counties are those included in this study; the color scale indicates a county's representation in the California workforce.

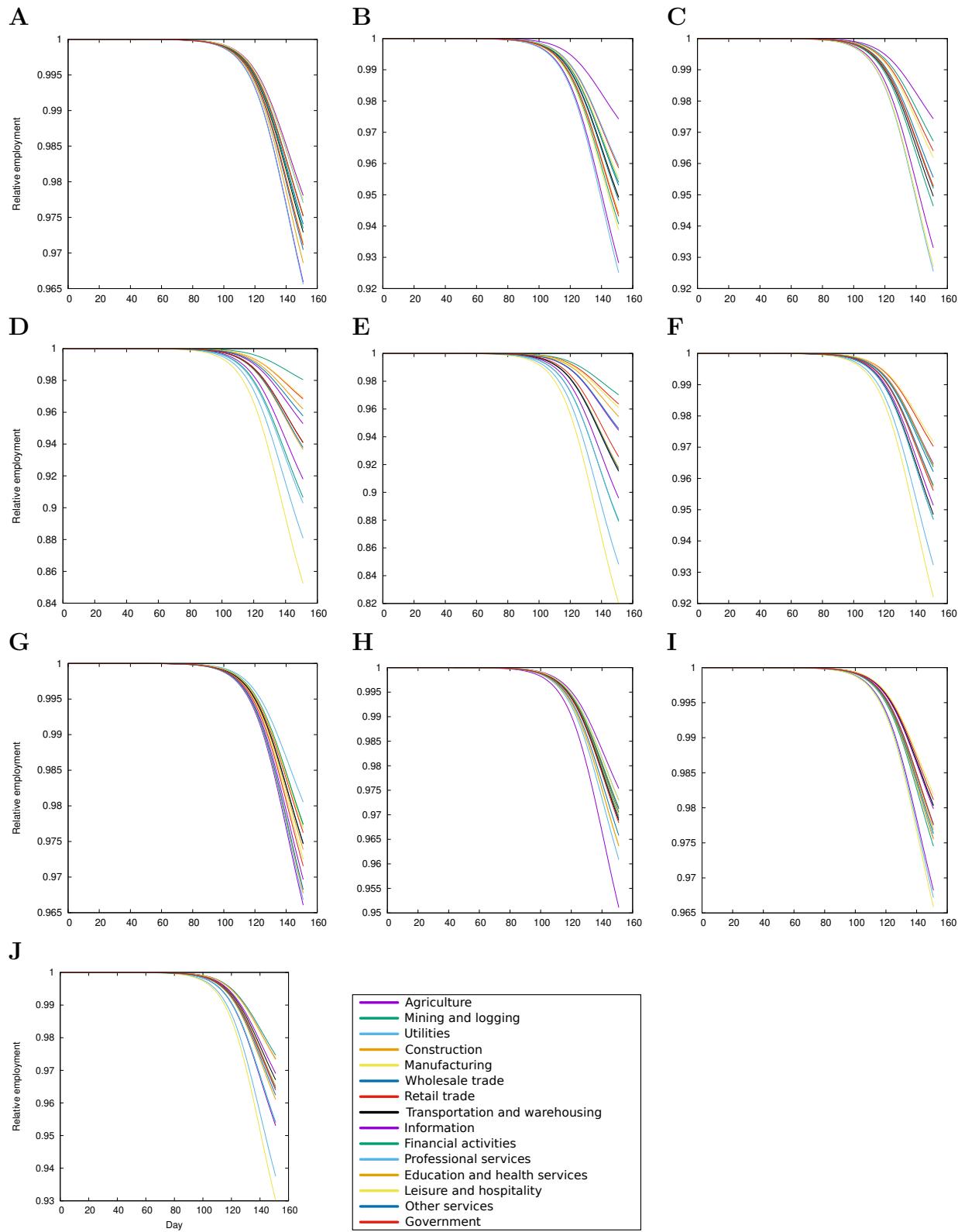


Figure S2

Figure S2: Relative employment decline per sector per SES. (A)-(J) respectively: Oakland-Berkeley-Livermore, San Francisco-San Mateo-Redwood City, San Jose-Sunnyvale-Santa Clara, Stockton-Lodi, Fresno, Oxnard-Thousand Oaks-Ventura, Los Angeles-Glendale-Long Beach, Anaheim-Santa Ana-Irvine, Riverside-San Bernadino-Ontario, San Diego-Carlsbad. The Manufacturing sector experiences the sharpest declines in SESs that are most vulnerable to cascading unemployment (D-F).

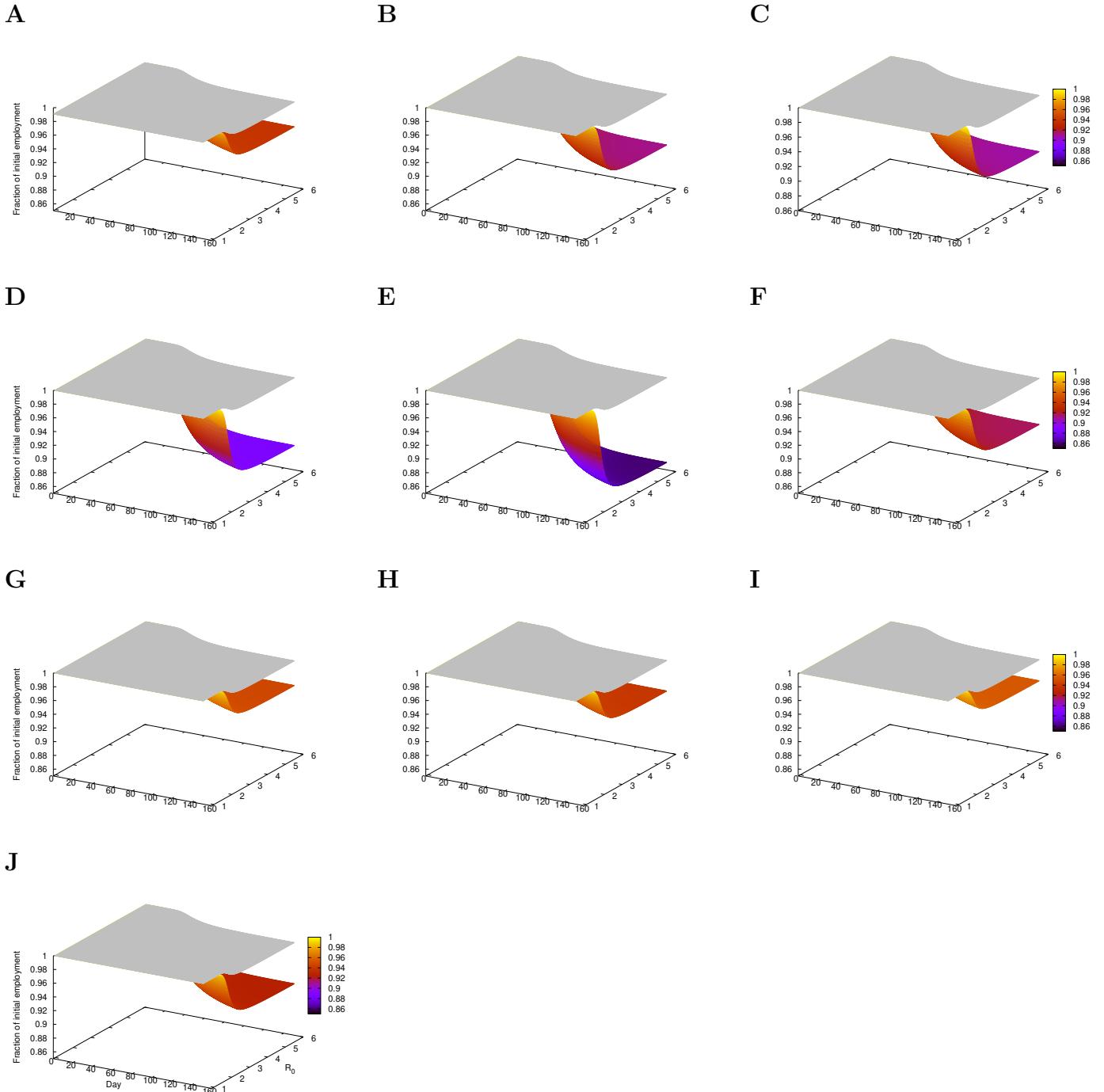


Figure S3: Total dynamics of all sectors for each SES over a R_0 range of 0.9-6.0. Upper grey surface is disease-caused losses, and lower surface shows the resulting economic cascades. Color spectrum is the fraction of initial total employment (February, 2020). See Fig. S2 for key to plots.

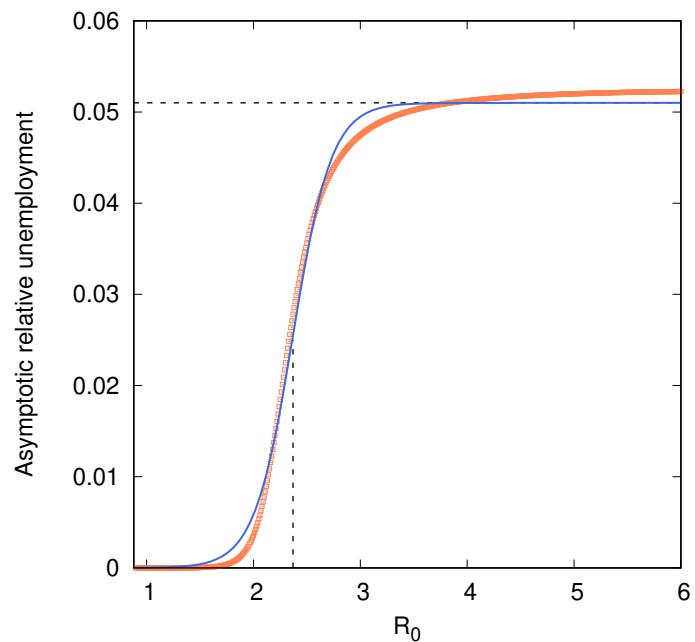


Figure S4: Logistic function (blue line) fit to unemployment at day 151 for a range of R_0 values. Unemployment is expressed as a fraction of initial employment (red line). Horizontal dotted line is the asymptotic value, and vertical dotted line is the value of R_0 at which the rate of increase of final unemployment is increasing most rapidly.

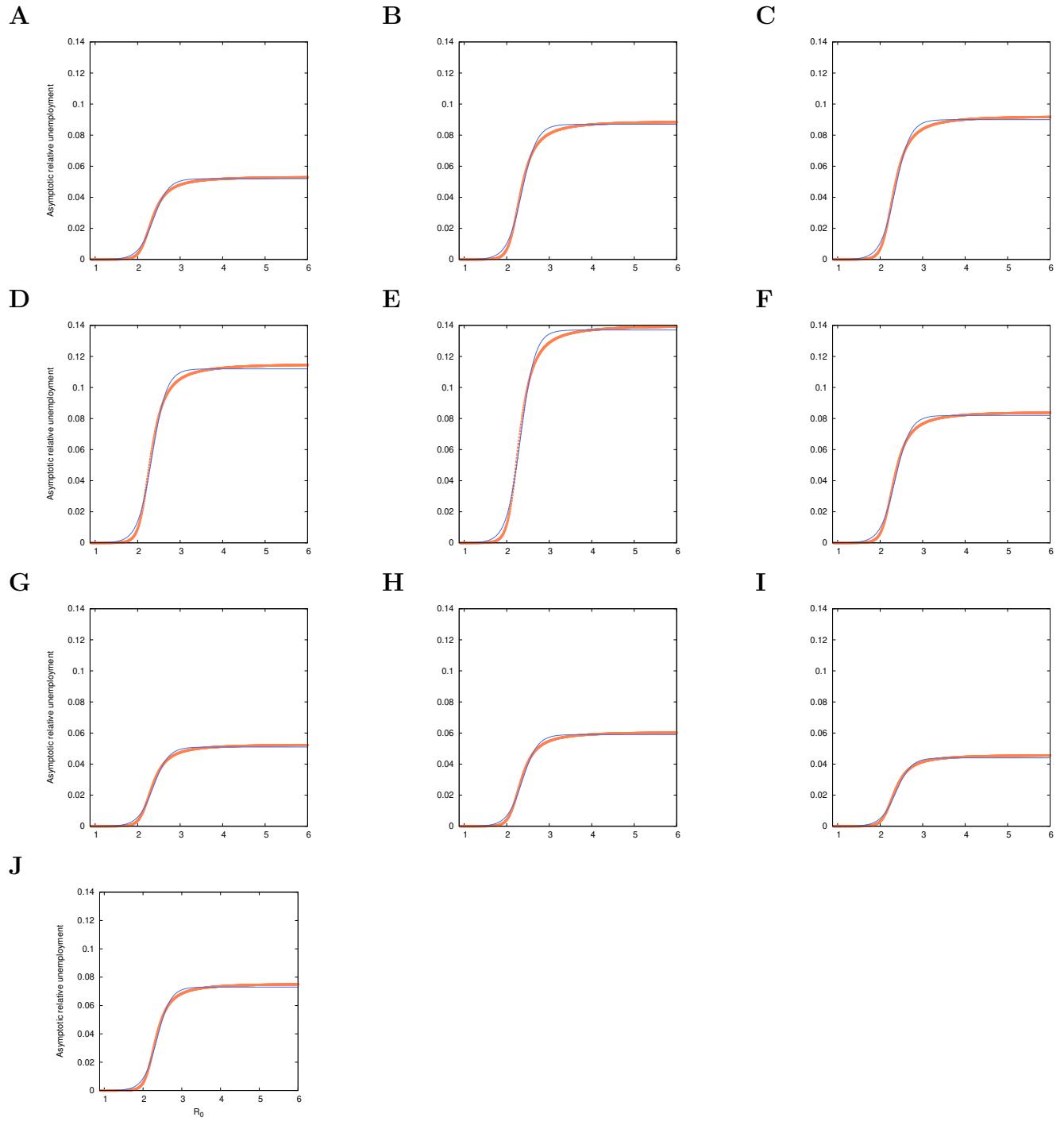


Figure S5: Fitted logistic plots, as explained in Fig. S4, for each SES. Key to SES plots as given in Fig. S2.

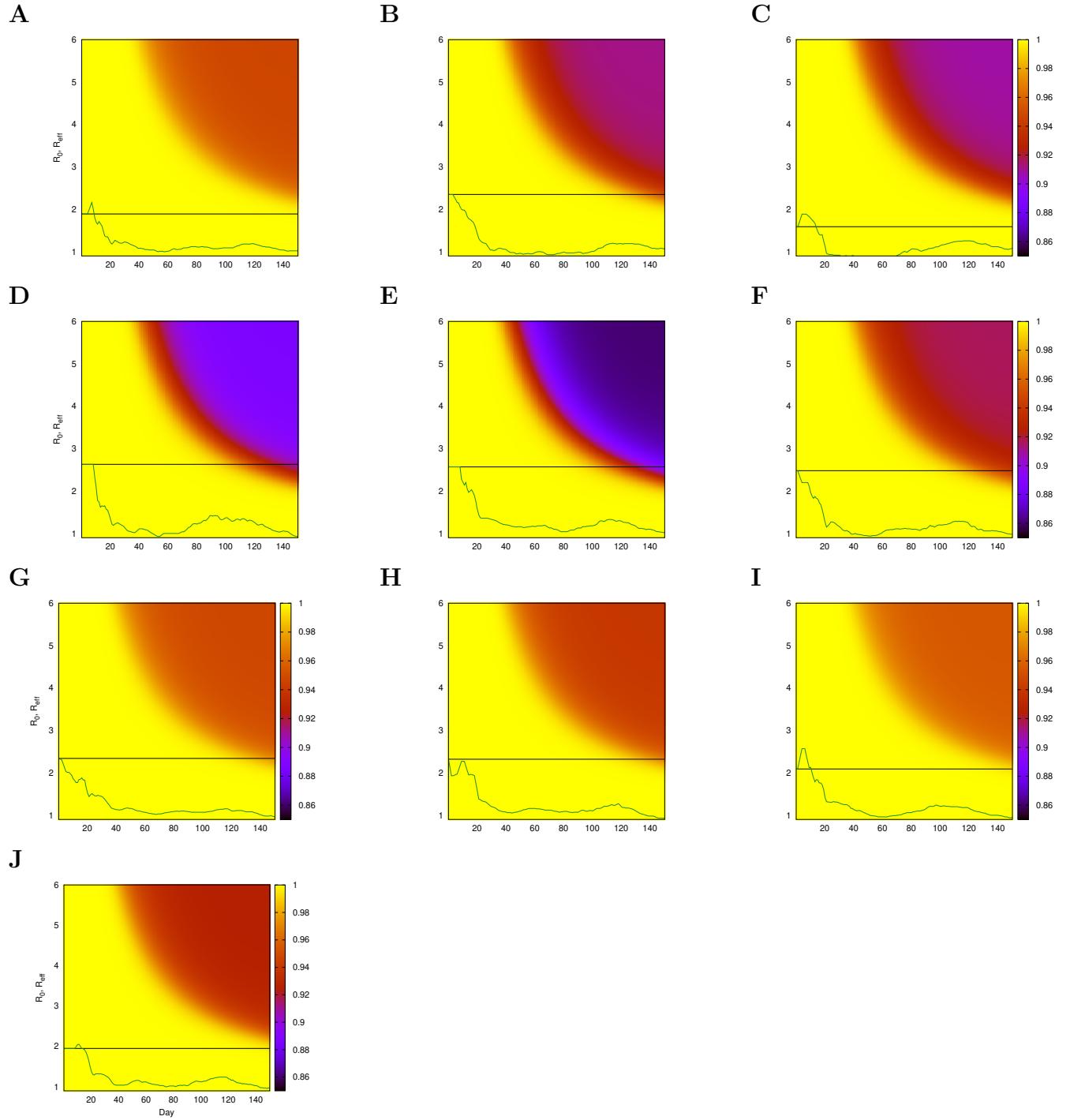


Figure S6: R_0 and R_{eff} trajectories superimposed on business-as-usual model forecasts of SES relative unemployment (color spectrum). R_0 trajectories (straight black line) indicate model outcome if transmission rates on March 1, 2020 had remained unchanged, whereas R_{eff} trajectories (green lines) show actual SES histories. Key to SES plots as given in Fig. S2.

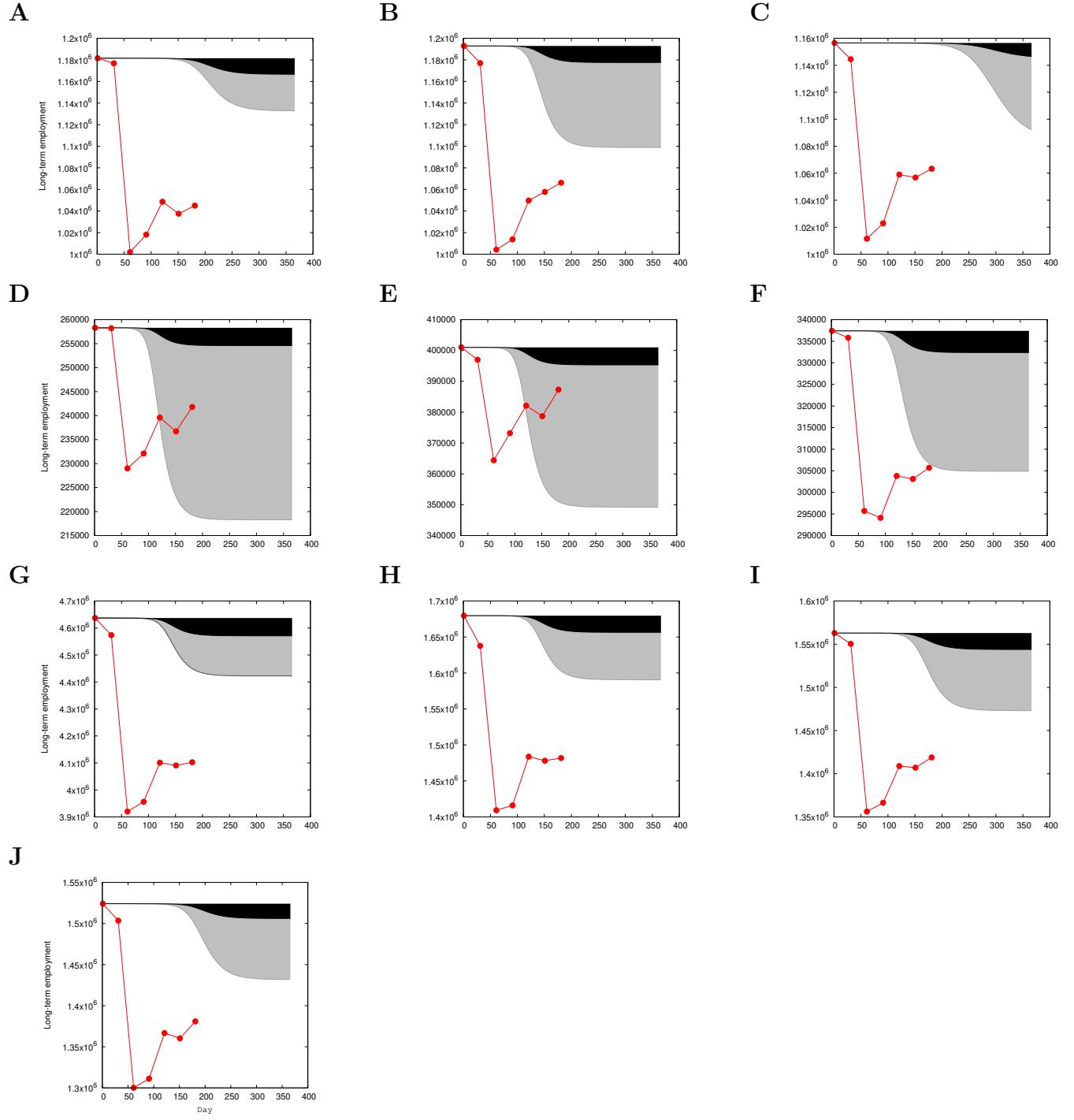


Figure S7: Comparisons of unemployment forecast by the business-as-usual model and actual unemployment of March to August, 2020. See text Fig. 4 for an explanation of the plots. Key to SES plots as given in Fig. S2.

Table S1: Nonlinear regression coefficients of unemployment on day 151 on R_0 . The function is of the form $b_0/[1 + \exp[b_1(R_0 + b_2)]]$. $r^2 > 0.999$ and $p < 0.0001$ for all socio-economic systems (SESSs).

SES	b_0	b_1	b_2
Oakland-Berkeley-Livermore	0.052	-5.535	-2.371
San Francisco-San Mateo-Redwood City	0.087	-5.649	-2.357
San Jose-Sunnyvale-Santa Clara	0.090	-5.655	-2.356
Stockton-Lodi	0.112	-5.770	-2.341
Fresno	0.137	-5.869	-2.329
Oxnard-Thousand Oaks-Ventura	0.082	-5.646	-2.357
Los Angeles-Long Beach-Glendale	0.051	-5.537	-2.370
Anaheim-Santa Ana-Irvine	0.059	-5.561	-2.368
Riverside-San Bernardino-Ontario	0.044	-5.526	-2.372
San Diego-Carlsbad	0.073	-5.671	-2.361

Table S2: Coefficients of industrial sectors derived from principal components analysis of sector employment per SES. PC1 accounts for 79.09% of total variance among SESSs, and PC2 accounts for 10.49%.

Sector	PC1	PC2
Agriculture	-0.162	0.609
Mining & logging	0.137	0.639
Utilities	0.252	0.013
Construction	0.280	0.033
Manufacturing	0.263	0.014
Wholesale trade	0.280	0.130
Retail trade	0.286	0.126
Transportation & warehousing	0.216	0.156
Information	0.242	-0.286
Financial activities	0.277	-0.132
Professional services	0.273	-0.195
Education & health services	0.287	0.058
Leisure & hospitality	0.287	-0.008
Other services	0.289	-0.026
Government	0.280	0.144

Table S3: SES R_0 values on March 1, 2020. Values were estimated for multi-county SESs based on the largest county in the aggregate, indicated in the “County” column. In the case of the San Jose-Sunnyvale-Santa Clara SES, there is a large difference between Santa Clara and San Benito counties, 1.55 and 2.4 respectively. Those values were therefore combined as an average weighted by the population sizes of each county.

SES	County	R_0
Oakland-Berkeley-Livermore	Alameda	1.89
San Francisco-San Mateo-Redwood City	San Francisco	2.35
San Jose-Sunnyvale-Santa Clara	Santa Clara, San Benito	1.59
Stockton-Lodi	San Joaquin	2.63
Fresno	Fresno	2.57
Oxnard-Thousand Oaks-Ventura	Ventura	2.48
Los Angeles-Glendale-Long Beach	Los Angeles	2.34
Anaheim-Santa Ana-Irvine	Orange	2.32
Riverside-San Bernardino-Ontario	Riverside	2.09
San Diego-Carlsbad	San Diego	1.95

Table S4: Hospitalization and fatality rates for worker age categories.

Age range (yrs.)	Hospitalization rate	Fatality rate
≤ 17	0.000040	0.0020
18-49	0.000047	0.0027
50-64	0.000101	0.0295
≥ 65	0.000186	0.0880

Supplemental datasets

All supplemental datasets are available at <https://github.com/calacademy-research/Roopnarine-et-al>

Dataset S1 (Dataset_S1.xlsx): Number of employees per SES per sector per age category.

Dataset S2 (Dataset_S2.xlsx): Inter-industry weighted interactions, derived from the US inter-industry exchanges for 2019.

Datasets S3-S12 (Dataset_S3.zip, etc.): Simulation model output. Column headings: R - R_0 ; Day - simulation day; <sector name>_<1-4> - employment level per age category per sector; total sector employment levels; SIR model Susceptible, Infected and Removed levels; total SES unemployment; total losses to disease only.