COVID-19, Traffic, Travel, and Pollution

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This article explores the differential impacts of recent “stay-at-home” orders on mobility, economic activity, and pollution across the state. Data reveal decreases in travel, with evidence of recovery prior to the orders’ relaxation, but no compelling evidence of PM2.5 reductions.

COVID-19, and the associated public health response, has generated an economic slowdown of historical proportions. California was one of the first states to issue “stay-at-home” orders. On March 13, most schools in the state’s two largest metropolitan areas closed. On March 16, seven counties in the San Francisco Bay Area issued “shelter-in-place” orders, and on March 19 the governor issued a statewide “stay-at-home” order. The first loosening of the statewide order did not occur until May 8.

I explore the differential impacts of these orders on mobility, economic activity, and pollution across the state. An immediate impact of stay-at-home orders and social distancing guidelines is to reduce mobility and economic activity. California, however, contains almost 40 million residents and features an economy with rich variation that would qualify as the world’s fifth largest were it a standalone country. Thus, there is substantial heterogeneity in industry composition, occupation, demographic characteristics, and population density across the state, and we should not expect policies to have identical impacts across the state’s different regions.

In this article, I explore the impacts of stay-at-home orders across four broad areas of the state: the San Francisco Bay Area, the Los Angeles area, the Sacramento Valley, and the San Joaquin Valley. The former two areas are dense, urban areas with employment concentrations in trade, information technology, professional and business services, and leisure and hospitality. The latter two areas are geographically broader, contain some of the most productive agricultural land in the nation, and have major cities—Sacramento and Fresno—with employment concentrations in government, education, and health services.

Trends in Travel

I begin by examining the impact of stay-at-home orders on highway miles traveled. The California Department of Transportation (Caltrans) maintains a rich network of sensors on state highways. There are nearly 40,000 sensors installed to monitor traffic across the state’s 380,000 lane-miles of highways. These sensors register, in real time, the number of vehicles that cross the sensor and the speeds at which they travel.

Caltrans divides the state into twelve districts, so for convenience I analyze data by Caltrans district. In particular, I focus on four districts representing the majority of the state’s population: the San Francisco Bay Area (District 4); the Los Angeles area (Districts 7 and 12); the Sacramento Valley (District 3); and the San Joaquin Valley (Districts 6 and 10). Loosely speaking, the San Francisco Bay Area is bounded by Sonoma, Contra Costa, and Santa Clara counties; Los Angeles consists of Ventura, Los Angeles, and Orange counties; the Sacramento Valley stretches from Butte County to Sacramento County; and the San Joaquin Valley stretches from San Joaquin County to Kern County.

Figure 1 plots the weekly year-over-year percentage change in vehicle miles traveled (VMT), measured across all Caltrans sensors in a region. The figure begins at the week of March 1–7, 2020 and continues to the week of May 3–9, 2020 (10 weeks in total).

Initial highway travel in all four regions demonstrates annual growth vis-a-vis the same week in 2019—during March 1–7, VMT was 2% higher in Los Angeles (relative to the same week in 2019), 3% higher in San Francisco and the Sacramento Valley, and 5% higher in the San Joaquin Valley. By the week of March 8–14, however, all areas reported lower VMT than the same week in 2019, and by March 15–21 travel fell by double-digit percentages year-over-year. During the first several weeks, travel fell fastest in

Figure 1. Change in Highway Vehicle Miles Traveled

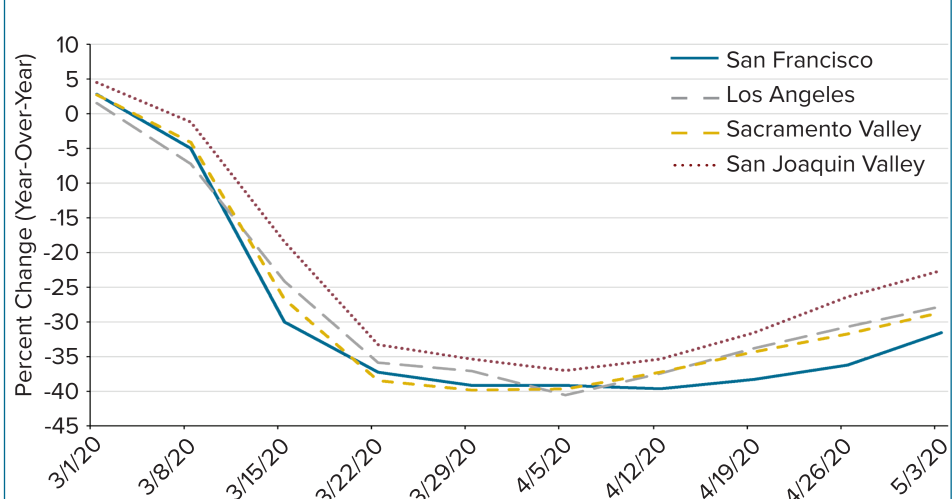
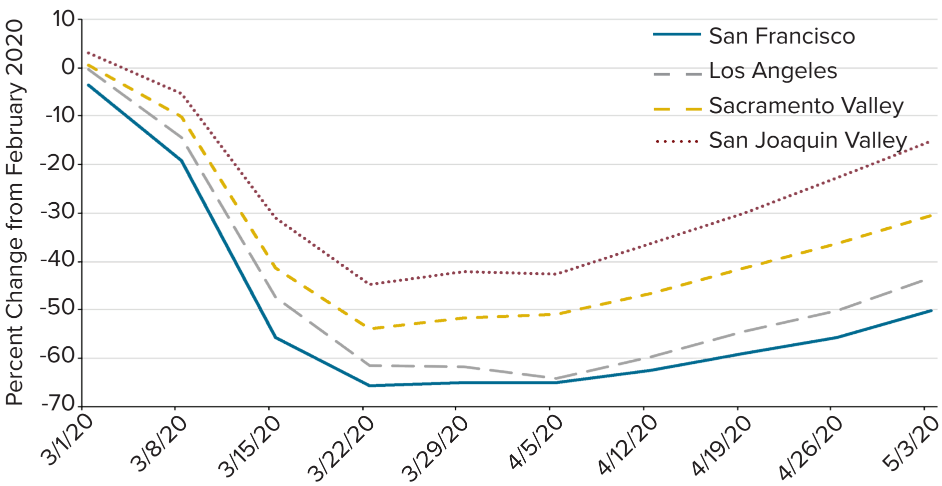


Figure 2. Change in Driving Routing Requests



the San Francisco Bay Area—consistent with the area's "shelter-in-place" order on March 16 that predated the statewide order by three days.

Highway travel bottomed out in all four regions during the period from March 22 to April 12. The year-over-year drop approached or reached 40% in the San Francisco, Los Angeles, and Sacramento Valley regions. The San Joaquin Valley was slightly less affected, but nevertheless declined by 37% year-over-year at its nadir. These patterns suggest that the stay-at-home order had deep impacts regardless of an area's population density or industry mix.

Although the first loosening of the statewide order did not occur until May 8, at the end of the figure's time series, travel began to recover at least one month prior. This recovery suggests that households' reactions to the stay-at-home order evolved over time. In some cases, household tasks or work that had been postponed during the first weeks may have eventually become necessary. In other cases, households may have learned over time about activities that were still allowed, or they may have determined that enforcement was lax. Regardless, highway travel in the San Joaquin Valley recovered quickest, down only 23% year-over-year by May 3–9. Highway travel in the San Francisco Bay Area recovered slowest, down 32% year over year by May 3–9.

While the Caltrans sensor network is impressive, it has limitations. First, approximately 30% of sensors are out of service at any given time, causing Caltrans to impute some data. The nature of these imputations is such that they understand changes in travel during unusual events, such as COVID-19. Second, the sensors only cover major highways, with no coverage of arterial roads. If short trips were differentially impacted relative to long trips, this lack of coverage may skew the observed pattern. Finally, since the sensors measure vehicles rather than travelers, they provide little insight to changes in transit ridership, and no insight to changes in walking.

Thus, I supplement the Caltrans data with data from Apple Maps Mobility Trends Reports. These data report changes in routing requests by region, relative to a baseline of February 2020. Routing requests are reported for driving, transit, and walking; for brevity, I combine the latter two categories to a single measure.

The Apple data provide an alternative perspective on mobility. Since they represent routing requests, they are weighted more heavily towards less routine trips; most drivers do not need routing requests when traveling to work, for example (though in some cases they may activate them for traffic information). If less routine trips are less essential, then they may exhibit larger declines when stay-at-home orders are in effect. Apple's coverage areas are less comprehensive than Caltrans', however, and coverage in the Sacramento Valley is limited to Sacramento, while coverage in the San Joaquin Valley is limited to Fresno and Bakersfield.

Figures 2 and 3 plot weekly percentage changes in driving and transit/walking routing requests respectively, relative to the average week in February 2020 (Apple has not released 2019 data, preventing year-over-year comparisons). The overall shape of the patterns is similar to that in Figure 1, with declines that predate the official order, and recoveries that begin during

Figure 3. Change in Transit and Walking Routing Requests

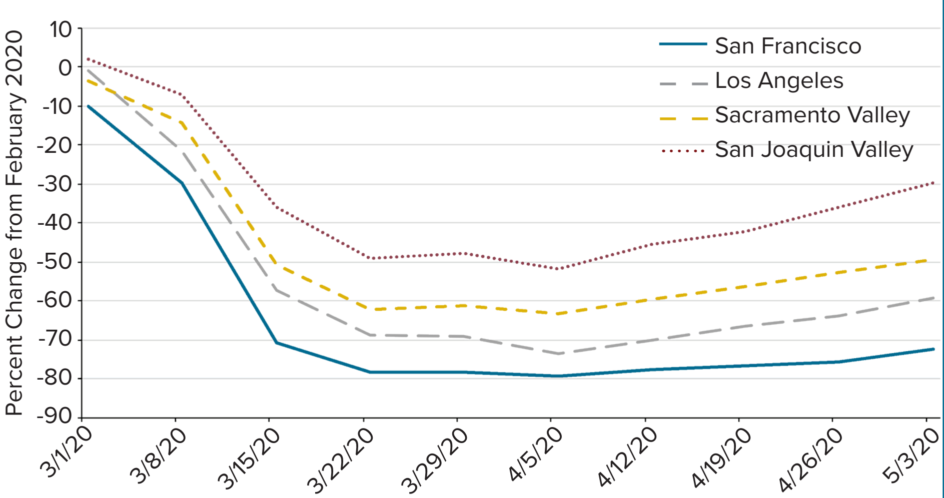
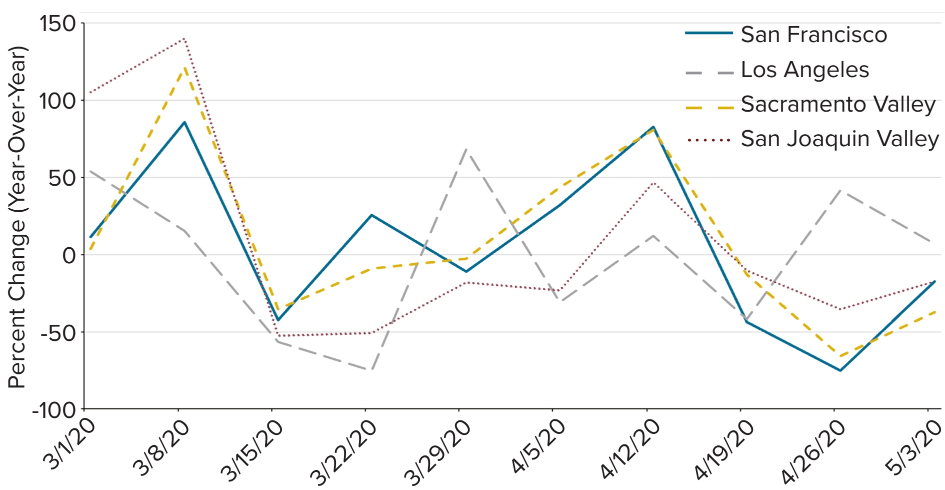


Figure 4. Change in Particulate Pollution (PM2.5)



the first half of April. The depth of the declines, however, is deeper than in Figure 1, and the differential impacts across regions are starker.

The changes in driving routing requests, plotted in Figure 2, reveal a drop of up to 65% in the San Francisco Bay Area, and a drop of up to 64% in the Los Angeles area. Driving routing requests in the Sacramento Valley (Sacramento) dropped only 54%, and they dropped only 45% in the San Joaquin Valley (Fresno and Bakersfield). These trends suggest that non-routine trips were less affected in the Central Valley; by the week of May 3-9, routing requests in the San Joaquin Valley were down only 15% relative to February.

The changes in transit and walking requests, plotted in Figure 3, reveal differential impacts across the regions. San Francisco experienced the largest declines in transit and walking requests, followed by Los Angeles, Sacramento (Sacramento Valley), and Fresno and Bakersfield (San Joaquin Valley). This ordering mirrors the general perceived quality of the transit systems, as well as the walkability of the respective regions. When transit services are less comprehensive or lower quality, a higher proportion of riders are typically "transit dependent," (i.e., not riders by choice). A logical explanation for the patterns in Figure 3 is that riders in the Central Valley are less likely to have alternative transportation choices and thus had less scope to substitute away from transit during the pandemic.

My final analysis examines changes in air pollution. Real-time air quality data come from the PurpleAir sensor network. PurpleAir sells inexpensive air quality sensors to consumers and businesses, and customers can share the data from these sensors online. I took a random sample of five outdoor sensors from each of the four regions (20 sensors in total) and downloaded data from March 1 to May 9 in 2019 and 2020.

Figure 4 plots the weekly year-over-year percentage change in average fine particulate concentrations (PM2.5), measured across five sensors per region. PM2.5 levels are higher in 2020 than in 2019 for the first two weeks of March and appear to fall across all four regions when the stay-at-home order begins (March 15-21). Nevertheless, PM2.5 levels fluctuate substantially from week to week, and then display a mixture of positive and negative growth (vis-a-vis the same week in 2019). Overall, there is no compelling evidence of PM2.5 reductions while the stay-at-home order is in effect.

The absence of a stark decline in pollution may be surprising given the sharp drop in travel and existing air quality issues in the San Joaquin Valley. There are several mitigating factors to consider, however. First, vehicles are not believed to be the primary source of particulate matter (PM) in California; the Environmental Protection Agency has listed residential wood combustion as the largest single source. Since stay-at-home orders induce people to remain home, residential wood combustion may increase. Other pollutants, such as carbon monoxide, are more affected by vehicle travel, but these are not reported in real time, and are not the primary pollutant in the Central Valley. Second, PM can travel great distances; recent studies have found that a significant fraction of PM in California has traveled from as far as China. Finally, PM levels in California tend to be low in spring regardless.

In conclusion, the stay-at-home order substantially reduced mobility across four major regions of California. The reductions were more pronounced in the urban coastal areas of San Francisco and Los Angeles than in the inland Sacramento and San Joaquin valleys. Mobility began increasing in all areas several weeks prior to the first relaxation of the stay-at-home orders, with the fastest increases appearing in the San Joaquin Valley. The stay-at-home order has not visibly reduced particulate pollution, suggesting that improvements in San Joaquin Valley air quality cannot come from vehicle restrictions and regulations alone.

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