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ALSO IN THIS ISSUE

A Progress Report on California's Sustainable Groundwater Management Act

Arthur R. Wardle, Paige Griggs, and Ellen Bruno

Regions of California will face significant reductions in water use in the coming years. This article provides an update on the progress made thus far towards implementing the Sustainable Groundwater Management Act (SGMA). We discuss the composition of newly formed groundwater agencies and their proposed management actions. These actions may have substantial implications for the economic costs of SGMA.

The California Aquaduct bifurcates as it travels into Southern California.

CA Department of Water Resources

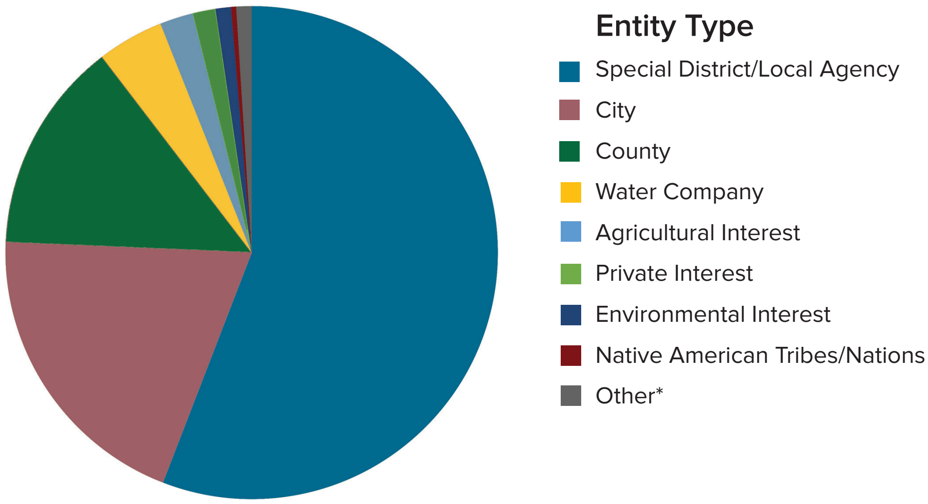
Groundwater accounts for 38 percent of California's water use on average but faces persistent drawdown from pumping in excess of replenishment. The Sustainable Groundwater Management Act of 2014 (SGMA) requires local agencies to develop plans ensuring the future sustainability of their underlying aquifers. Before SGMA, groundwater was free to extract (aside from pumping costs) for overlying landowners in almost the entire state.

The California agricultural industry depends heavily on access to this water, especially during droughts, when access to groundwater can serve as insurance against surface water shortages. The challenge facing agencies implementing SGMA is how to bring groundwater extraction back to sustainable levels while minimizing costs to current users. The stakes are high—the Public Policy Institute of California projects that poorly designed groundwater management could cut crop revenues in the San Joaquin Valley, a major region for the entire country's food production, by 17 percent.

The magnitude of SGMA's economic impact will depend heavily on the management actions taken by Groundwater Sustainability Agencies (GSAs). Under SGMA, GSAs are formed by pre-existing local agencies and charged with developing and implementing groundwater sustainability policies. Like any other government agencies, GSAs operate within a pre-existing political climate and are beholden to the interests of those they represent. It is fair to expect that the management actions taken by GSAs will be influenced by the composition of their local area's agriculture, the number and types of coordinating agencies, and other political and economic factors.

The Department of Water Resources (DWR) splits California's aquifers into 515 "subbasins," which were prioritized according to existing overdraft issues and projected water demand factors. The law requires groundwater basins designated as high- or medium-priority to have formed GSAs by June 2017, adopt a Groundwater Sustainability Plan (GSP) by January 2022 (2020 for basins in critical overdraft), and achieve groundwater sustainability by 2042. Lower-priority basins have later deadlines. Apart from these

Figure 1. GSA Seats Held by Entity Type for all High– and Medium–Priority Subbasins



Note: *Other includes federal agencies, universities, at-large seats, etc.

Source: Authors' compilation from DWR SGMA Portal and GSA websites

requirements, the law itself provides little guidance, leaving substantial flexibility for achieving compliance.

The full impact of SGMA will take decades to realize, but these earlier deadlines provide insight into how California's GSAs are forming and what kind of management actions they are considering. GSA and GSP submissions reveal a diversity of approaches being undertaken throughout the state.

The Boards of Groundwater Sustainability Agencies

GSAs, the chief entities responsible for developing GSPs and making progress toward sustainability, are formed by pre-existing local agencies with water or land-use responsibilities. Any such agency overlying a groundwater basin was eligible to form a GSA, and many elected to partner (via joint powers agreements or memoranda of understanding) and form multi-agency GSAs. GSAs pursuing the partnership route formed boards, with substantial leeway to design board representation as they pleased. Some GSAs granted board seats to non-agency partners, like water companies, private well stakeholders, or environmental organizations.

Data on the makeup of medium- and high-priority GSA boards are accessible from the SGMA Portal, maintained by the DWR, and from the GSAs' own websites. GSAs entered into the portal are linked to a single subbasin, but some GSAs overlie multiple subbasins and therefore have multiple entries. Collapsing these GSAs into single entities leaves 224 distinct agencies, 155 of which are single-agency GSAs, the remainder being multi-agency collaborations. Multi-agency GSAs contain an average of 6.51 board seats.

Figure 1 shows the breakdown of who holds GSA board seats (treating single-agency GSAs as a single "board seat" belonging to the forming agency). Board representation patterns are similar between high- and medium-priority basins. The majority of GSA board seats are held by special districts and local water agencies. Special districts, including reclamation, water, and irrigation districts, are local government entities created under state law to administer specific public services. An irrigation district, for instance, maintains irrigation canals and distributes surface water. Since groundwater and surface water systems interact, and these agencies have established relationships with agricultural groundwater users, it is no surprise that these agencies are most frequently taking up the GSA mantle.

Cities and counties are the next most common GSA participants. Both cities and counties control community water systems in different parts of the state, and therefore have a natural interest in the future of groundwater availability. Counties have an extra role under SGMA implementation as the backstop GSA for any basin areas left unmanaged by the formation of other GSAs.

Only public agencies with water or land-use responsibilities are eligible to form GSAs themselves, but the law allows collaborative GSAs to involve other people or organizations on their boards. These seats make up a small percentage of GSA board representation. In the most common arrangement, board formation documents specify a set of organizations (such as farm bureaus for agricultural seats or conservation NGOs for environmental seats) that can make nominations. The remainder of GSA board members then select a colleague from those nominations.

Only three GSAs, all of which are multi-agency partnerships, include formal representation for Native American tribes. Access to groundwater for federal reservations is guaranteed by federal law, and tribal land is exempted from requirements to form GSAs under SGMA. Still, underground aquifers flow between reservation land and non-reservation property, leaving a clear role for Native American participation in SGMA governance.

As an illustrative example of how GSA boards look throughout the state, consider the Kings subbasin of the San Joaquin Valley, host to eight separate GSAs. Of these, three are controlled by a single entity: James Irrigation District, Consolidated Irrigation District, and Tulare County. The remaining

GSAs have boards ranging from five to seven seats. The McMullin Area GSA, a Joint Powers Authority, has a five-seat board with two seats for the Raisin City Water District, one for the Mid-Valley Water District, one for the County of Fresno, and a final seat for a "white area" (land unserved by irrigation districts) stakeholder, appointed by the County of Fresno. This division of power, with water districts playing a dominant role, is typical.

Though nothing beats full and formal representation, GSAs are statutorily required to consider their decisions' impacts on all stakeholders. Many GSAs are forming advisory committees to formally seek input from various stakeholders. And, of course, special districts, cities, and counties are themselves local governments, with representatives voted into office in part by the broad set of stakeholders affected by SGMA.

Nonetheless, final decision-making authority rests in the hands of GSA boards, which are skewed towards existing agricultural interests. Many water-focused special district officials in California are elected by landowners only, reflecting their historically limited role as agricultural water suppliers. Whether and to what extent this impacts GSAs' choice of management actions is an ongoing topic of our research.

Collaboration on Groundwater Sustainability Plans

The first major deliverable for newly-formed GSAs is a Groundwater Sustainability Plan (GSP), which describes the current state of groundwater overextraction, projects future water budgets, and details management actions to bring extraction back to sustainable levels. Only GSAs in critically overdrafted basins were required to submit GSPs by January 2020; remaining high- and medium-priority basins have a January 2022 deadline. Not all high- and medium-priority basins will submit GSPs because some basins have pre-existing groundwater management plans, pre-existing adjudications of water rights, or proof of long-term extraction with a sustainable yield.

SGMA requires GSAs within the same basin to collaborate and ensure compatibility of their GSPs, but many GSAs took this further by collaborating on a single GSP, reflecting the complexity of preparing the multi-hundred-page documents. The 92 unique GSAs participating in California's high- and medium-priority GSPs grouped to form 43 GSPs. Of these, 29 were produced by a single GSA, and 14 were inter-GSA collaborations.

Demand Management Proposals in GSPs

Management actions in GSPs can be roughly split into two categories: supply augmentation and demand management. Supply augmentation seeks to resolve overextraction by making more groundwater available, often by direct recharge using wastewater or provision of new surface water sources to displace groundwater use. Supply augmentation schemes have an obvious role to play in SGMA compliance, but there is simply not enough unaccounted for surface water for supply augmentation to bear the full brunt of bringing basins back to sustainable levels.

Demand management seeks to achieve sustainability by limiting extraction. There are a variety of policymaking tools that constitute demand management. For example, fees on extractions change the decision calculus for groundwater extractors by imposing a price on groundwater use, and efficiency incentives can provoke users to invest in infrastructure improvements.

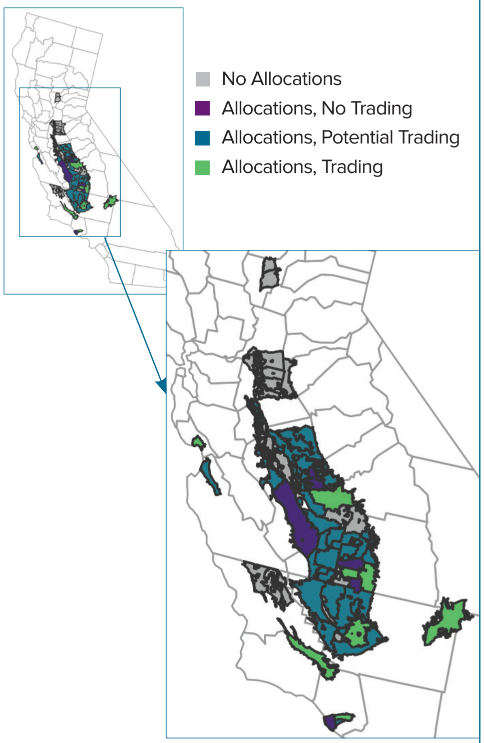
A pair of market-based policies favored by water economists are water allocations and trading, which can guide cost-effective solutions in environments where regulators lack key information. Under these systems, extractors with low-value products (e.g., alfalfa) can benefit by selling water allocations to users with higher-value products (e.g., almonds), maximizing the total value of water use while compensating the extractors that give up water. Investments in more efficient irrigation are naturally incentivized under allocation and trading since farmers can benefit from selling (or no longer needing to purchase) any water saved. In theory, the voluntary adjustments made under an allocation and trading scheme minimize the losses associated with reaching sustainability.

Contrast this with outright pumping restrictions, broadly scorned by water economists, which completely prevent users of groundwater from pumping under some specified set of circumstances. These policies risk preventing extractors from accessing water even when it is critically important, such as when a long-lived orchard is threatened by drought. Under pumping restrictions without the possibility of trading, orchards with decades of productive life left in them can wither, while much lower-value groundwater uses continue in the same neighborhood.

Supply augmentation is ubiquitous in GSP project proposals, but demand management is far more variable, as previously reported by the Public Policy Institute of California for GSPs in the San Joaquin Valley. In the following analysis, demand management refers to groundwater allocations, fees or taxes, restrictions on pumping, efficiency incentives, and land fallowing programs. It does not include merely monitoring extraction, supply augmentation, or improving efficiency of agency-owned infrastructure.

The demand management section of many GSPs are speculative, outlining potential actions rather than a

Figure 2. Allocation and Trading Programs in GSAs with GSPs



Source: Author's compilation from DWR SGMA Portal

well-defined set of programs the GSAs will definitely pursue. This makes it difficult, even with GSPs in hand, to say exactly how many GSAs will undertake any given demand-management action. For instance, only 24 GSPs (roughly half) include definite demand-management actions, but 41 GSPs (almost all!) include at least the possibility of demand management.

Demand management takes on different forms across GSPs. Figure 2 shows which GSAs are at least considering an allocation scheme and, among those GSAs, the status of trading allocations. Of the 27 GSPs considering an allocation scheme (14 are definite), 19 GSPs are also considering creating a market for trading that allocation. Allocation without trading does provide some needed certainty to groundwater extractors, but it stops short of maximizing the groundwater's value since lower-value extractors cannot make deals with higher-value users. In subbasins without trading, farmers with high-value, thirsty crops may face shortages.

Pumping restrictions, which prevent groundwater users from accessing additional water under specific circumstances no matter what the marginal value of that water might be, are less common. Only 21 GSPs consider them, and many are limited to drought conditions. Some GSPs list pumping restrictions as a backstop option—considered only when all other management actions have failed to achieve sustainability.

Fees and taxes are another common demand-management measure, with 40 GSPs considering some kind of fee. However, not all fees manage demand equally. While a tax on irrigated acreage can raise necessary revenues for a GSA, it does not alter an irrigator's pumping decisions in quite the same way as a direct tax on pumping. A farmer facing a tax on irrigated acreage can make some adjustments, like reducing the size of their farm or replacing some portion of it with crops that do not require irrigation. These are major adjustments, and will only be undertaken with particularly low-value or high-cost crops that cannot bear the tax. Taxes on pumping, on the other hand, directly incentivize all farmers to make marginal improvements to the efficiency of their irrigation systems. In aggregate, these smaller changes can help regions adapt to lower groundwater availability with fewer farm closures. Many GSPs are vague about how exactly their taxes or fees might be structured, but 24 consider fees for groundwater extraction specifically.

Conclusion

Substantial portions of California's land, including as much as 10–20% of the Central Valley's irrigated acreage, could be fallowed due to SGMA. The management choices selected by GSAs will ultimately determine how much land comes out of production, with economic implications for the entire regional economy. Well-designed management actions can temper these transitions, just as poorly conceived actions can aggravate and multiply losses.

Research on the political economy of SGMA and how existing interests and institutions are influencing management choices is an area of continuing research. Preliminary data collection shows the dominant role of existing, water-focused special districts in GSA boards, the ubiquity of supply augmentation, and the developing landscape of demand management.

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For additional information, the authors recommend:

Conrad, E., J. Martinez, T. Moran, M. DuPraw, D. Ceppos, and W. Blomquist. 2016. "To Consolidate or Coordinate? Status of the Formation of Groundwater Sustainability Agencies in California." Stanford Water in the West report.

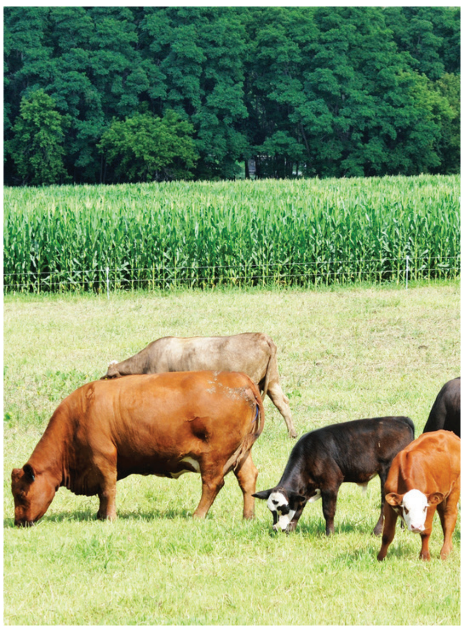
Escriva-Bou, A., E. Hanak, and J. Medellín-Azuara. 2019. "A Winning Approach for Managing Groundwater in the San Joaquin Valley." Public Policy Institute of California blog.

Jezdimirovic, J., E. Hanak, and A. Escriva-Bou. 2020. "What's the Plan to End Groundwater Overdraft in the San Joaquin Valley?" Public Policy Institute of California blog.

COVID-19 Relief Programs Have Kept U.S. Farm Income High but Shortchanged California Producers

Aaron Smith

Since 1950, the only years with higher real net farm income than 2020 were 1973–74 and 2011–14. This high income was facilitated by two waves of COVID-19 relief payments totaling $23.8 billion. A third wave is set to occur in 2021. Most of these payments were determined by seemingly arbitrary formulas and were only weakly tied to pandemic-induced losses. Corn, soybeans, cattle, and milk are the four largest value commodities in the country and they received a disproportionately large share of payments. Specialty crops and dairy, which California specializes in, received some support, but much less as a percent of gross farm income. Congress has allocated a further $13 billion to farmers for COVID-19 relief, most of which is slated to go to the major row crops, livestock, and biofuels.



Producers in both corn- and soybean-focused states, such as Iowa and Illinois, and cattle- and milk-focused states, such as New York and Wisconsin, received the high CFAP payment rates.

The federal government has taken significant actions to mitigate the effects of COVID-19 on the economy. Congress has passed two large bills, the $2.2 trillion CARES Act in April 2020, and the $900 billion Coronavirus Response and Relief Supplemental Appropriations Act (CRRSAA) in December 2020. These laws provided direct payments to farmers, ostensibly as compensation for losses due to the pandemic. In this article, I analyze these payments and how they were distributed across farm types and across states. Farmers were also eligible for the same programs open to all Americans, such as cash payments, unemployment insurance, and paycheck protection loans; I do not discuss those programs in this article.

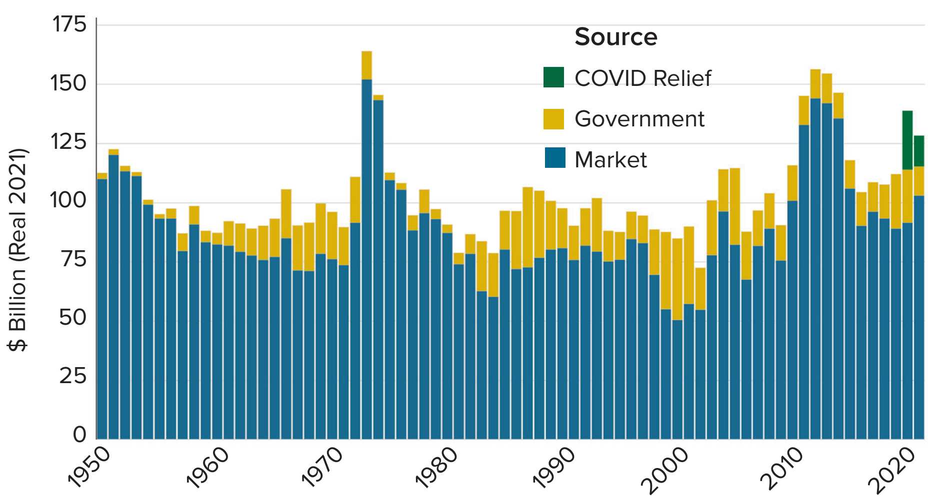
Three Waves of Farm COVID Relief

Direct farm support for COVID relief has come in three waves. First, using funds allocated in the CARES Act, the USDA implemented the Coronavirus Food Assistance Program in May 2020. This program, known as CFAP1, distributed $10.6 billion to farmers. Then, in September 2020, USDA implemented CFAP2 using funds from the CARES Act and the Commodity Credit Corporation, distributing a further $13.2 billion. Finally, the CRRSAA allocated an additional $13 billion for agricultural producers.

To put these numbers in perspective, Figure 1 shows net cash farm income in the United States since 1950. Farm income boomed in 1973–74 and 2011–14 due to high prices. Since 2015, it has averaged just over $100 billion per year. The coronavirus relief payments helped to increase provisional farm income in 2020 to its highest level since 2014. It is projected to be almost as large in 2021.

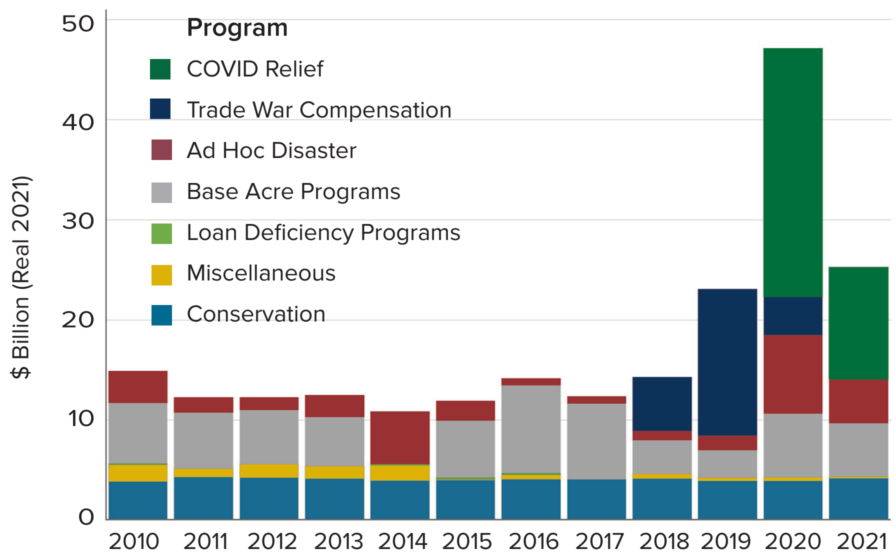
In an average year in the last decade, direct government payments contributed about 10% of net farm income in the United States. Figure 2 shows that just under half of these payments come through conservation programs. A similar component comes from base acre programs, which pay farmers based on historical plantings. Compensation for the trade war with China caused government payments

Figure 1. U.S. Net Cash Farm Income, 1950–2021



Source: USDA, Economic Research Service

Figure 2. Government Payments to Farmers, 2010–2021



Source: USDA, Economic Research Service

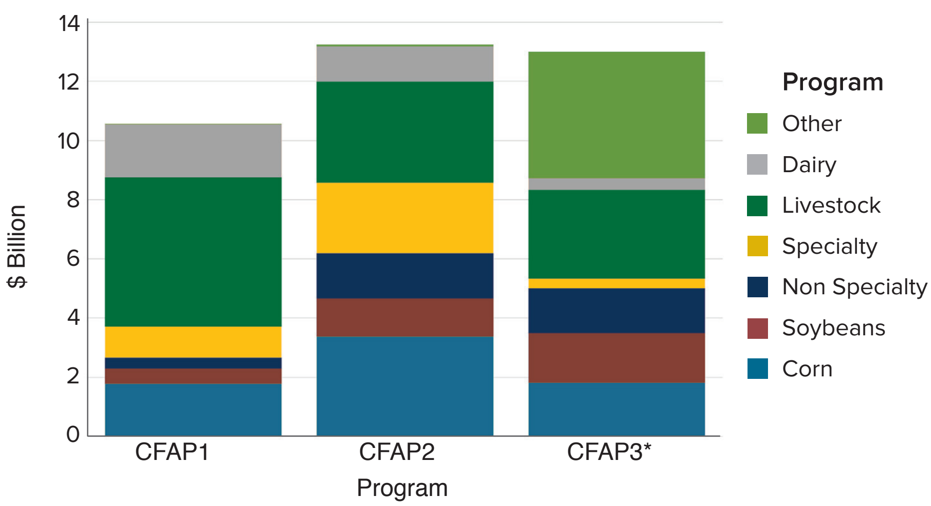
to increase in 2019 and the CFAP programs propelled government support for agriculture to its highest levels ever in 2020.

Figure 3 breaks the CFAP program payments down by commodity group. In CFAP1, 80% of the payments went to either corn, dairy, or livestock (mostly cattle). Specialty crops received 10%.

Corn farmers received twice as much money from CFAP2 as CFAP1, and soybean producers also received substantially more. The non-specialty category, which includes row crops other than corn and soybeans, also received more from CFAP2 as the payment formula moved in their favor.

The CRRSAA allocates $13 billion for agricultural production, including $11.2 billion specifically allocated to the Office of the Agriculture Secretary for distribution. Specific provisions include payments of $20 per acre to growers of corn, soybeans, and other non-specialty crops and $3 billion for supplemental payments to livestock producers who were forced to euthanize livestock or poultry due to the COVID crisis.

Figure 3. Coronavirus Food Assistance Program Payments to Farmers



Note: *Payments authorized under the December 2020 relief bill are labeled as CFAP3, although they have not yet been given that label by USDA.
Source: USDA CFAP Dashboards

The only components targeted specifically to specialty crops are $225 million for supplemental payments to producers and $100 million for Specialty Crop Block Grants. Provisions in the CRRSAA specify that CFAP3 include aid for biofuel producers who were affected by the decrease in ethanol consumption due to the pandemic-induced reduction in driving. It remains unclear how much of the remaining $4 billion will be allocated to biofuels versus other sectors, including specialty crops.

How Were CFAP Payments Determined?

For non-specialty crops including corn and soybeans, USDA designed CFAP1 around "unpriced" inventories held on January 15, 2020. Farmers could claim a certain payment for every bushel they had in storage on that date up to a maximum of 50% of the 2019 harvest. The payment rates varied by commodity; for corn it was $0.32 per bushel and for soybeans it was $0.45. It is unclear from the documentation how these rates were determined.

USDA defined unpriced inventory as "any production that is not subject to an agreed-upon price in the future through a forward contract, agreement, or similar binding document." The objective of excluding priced inventory was to avoid paying farmers who had hedged against price declines.

Livestock or specialty crops sold between January 15 and April 15, 2020 received payments equal to the quantity sold multiplied by the stated payment rate. The payment rate for almonds was $0.26 per lb. Farmers could also receive compensation for specialty crops that went unharvested or that were harvested and shipped but subsequently spoiled due to lost marketing channels.

CFAP2 was announced in September 2020, as the harvest for many crops was beginning. USDA tied the payments for non-specialty crops to the (i) price declines that occurred between January and July, (ii) 2020 plantings, and (iii) average yield according to crop insurance records. Corn and soybean prices declined by $0.73 and $0.72 per bushel in this period, which helped drive the high payments. Since August, corn prices have risen by $2 per bushel and soybean prices by $5, which has further increased farmer incomes.

In CFAP2, dairy received payments of $1.20 per hundredweight on estimated milk produced from April through the end of the year (less than 10% of the value), down from the CFAP1 payment of $4.71 for production in the first-quarter of 2020 (more than 25% of the value).

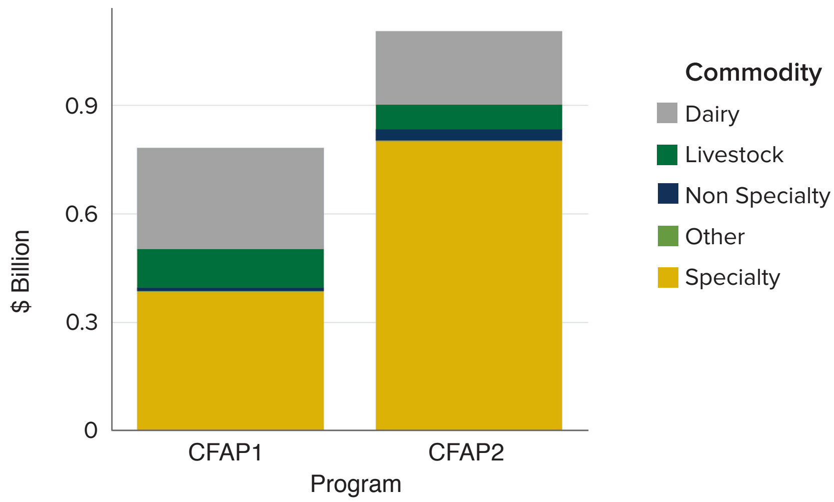
Specialty crops received much larger payments in CFAP2 than CFAP1. Rather than a payment rate that varied in a seemingly arbitrary way across commodities, USDA paid out a constant percentage of a farmer's 2019 sales for a large number of commodities.

California's Share

California grows very little corn and soybeans, but it has a large dairy industry and grows a very large amount of specialty crops. Thus, dairy and specialty crops dominate California's CFAP receipts, as shown in Figure 4.

In CFAP1, almond growers received $129 million and walnut growers $88 million, which is just over half the payments to California specialty crop growers. Pistachio's production in California is now almost three times as much as walnut production by value, so it is somewhat surprising that CFAP1 yielded only $22 million for pistachio growers. USDA provides no breakdown of CFAP2 specialty crop payments by commodity.

Figure 4. CFAP Payments to California Farmers



Source: USDA CFAP Dashboards

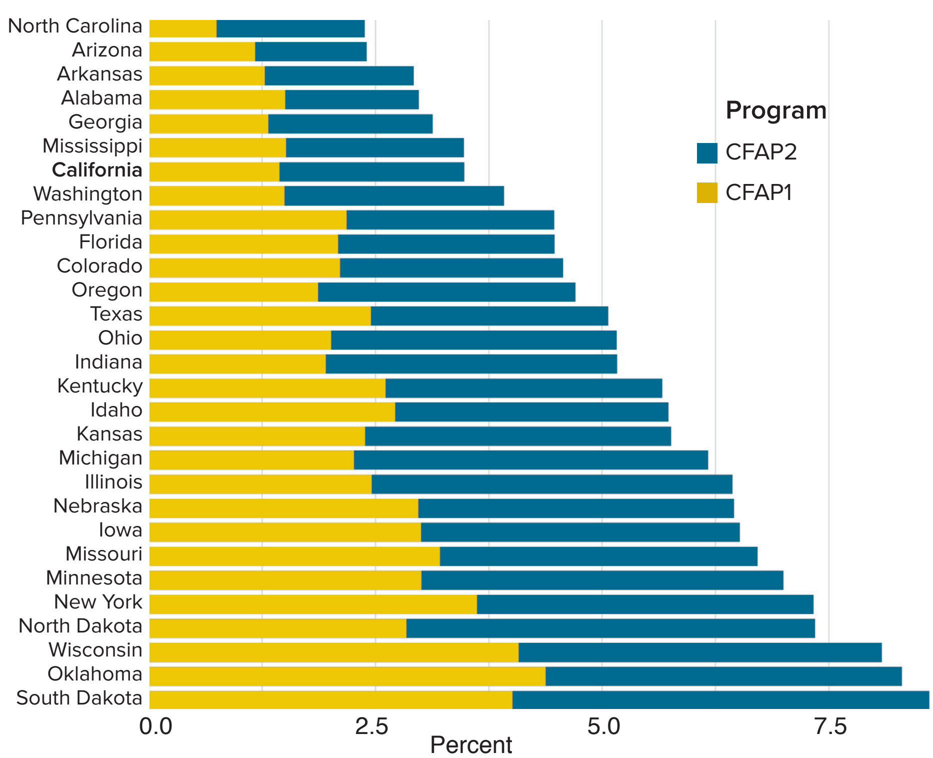
To understand the magnitude of these payments, it is useful to compare them to farm income. Figure 5 shows, for states with more than $5 billion in gross cash income, the magnitude of these payments as a percent of gross cash income on farms.

CFAP1 and CFAP2 payments to California farmers in 2020 were about 3.5% of 2019 gross farm income. This is substantially lower than for corn belt states such as Iowa (6.5%) and Illinois (6.5%). States with large livestock industries, such as Wisconsin (8.1%) and Oklahoma (8.3%), have even higher percentages.

What Explains the Magnitude of CFAP Payments?

Cattle, milk, corn, and soybeans are the largest agricultural products in the

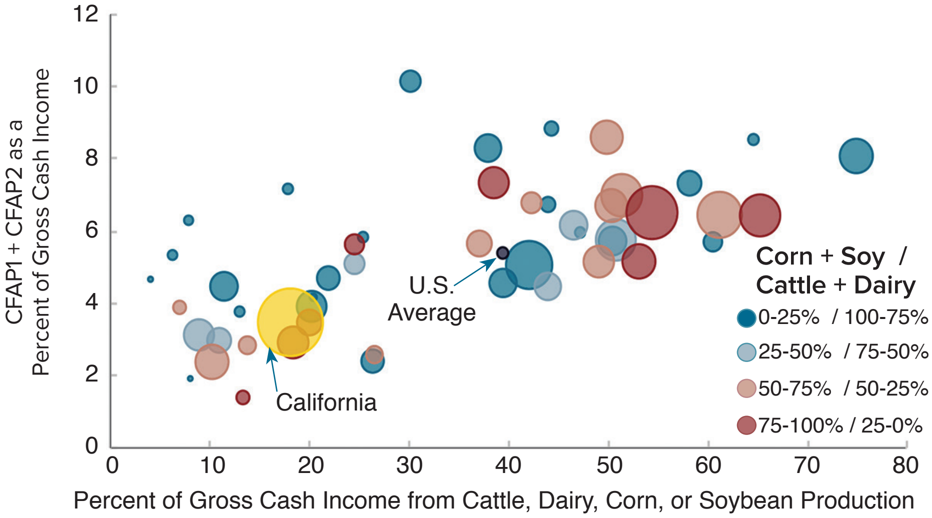
Figure 5. CFAP Payments to Farmers as Percent of 2019 Gross Cash Income



Note: The figure shows states with more than $5 billion in gross cash income in 2019.

Source: USDA, ERS and USDA CFAP Dashboards

Figure 6. CFAP1 and CFAP 2 Payments to Farmers as a Percent of 2019 Gross Cash Income



Note: * Colors indicate the proportion of the big four commodities' (corn, soy, cattle, and dairy) revenue that comes from soy and corn. Bubble size represents the relative difference in state's gross cash farm income.

Source: USDA, ERS and USDA CFAP Dashboards

U.S. by a significant margin. In 2019, sales of cattle and milk made up about 20% of gross cash income on farms; the next largest categories, hogs and chickens, were each less than 5%. Corn and soybeans also made up about 20% of gross cash income in 2019; the next largest categories, wheat and hay, were each less than 5%.

Figure 6 plots payments received under CFAP1 and CFAP as a percent of gross cash income against the proportion of gross cash income from the four big commodities. These payments totaled 5.5% of gross cash income in the U.S. as a whole. Larger dots indicate states with larger gross cash income.

If all commodities were compensated equally under CFAP1 and CFAP2, then the circles in Figure 6 would lie along a flat line at 5.5%. This is not the case. Most states with an above-average concentration in the big four commodities received more CFAP payments than average. The state with the highest concentration in the big four commodities is Wisconsin at 75%. The strong dairy industry in that state carries it above neighboring corn belt states. California gets less than 20% of its farm income from the big four, with dairy being the only one of the four with a substantive presence in the state.

The colors in Figure 6 indicate whether more big four revenue comes from corn and soybeans or from cattle and milk. Both corn-and soybean-focused states, such as Iowa and Illinois, and cattle-and milk-focused states, such as New York and Wisconsin, received high CFAP payment rates. It does not appear that payments systematically favored the two big crop commodities over the two big animal commodities.

The big four commodities apparently exert significant political power. A total of 21 states have a higher than average concentration of the big four commodities, and each one has two senators to advocate for the state's farmers. Many of the states with a low concentration of the big four commodities specialize in crop and animal products that few other states produce. These include tree nuts and grapes in California, cotton in Texas, rice in Arkansas and California, lettuce in Arizona and California, and grass seed in Oregon.

Conclusion

Two waves of COVID relief have arrived on agriculture's shores and a third is on the way. The first two waves propelled net farm income to its highest level since the boom years of 2011–14 and were particularly generous to cattle and to corn and soybean producers.

The third wave will arrive in 2021 with funds authorized in the CRRSAA. This legislation specifies payments of $20 per acre for the major row crops and significant funds for livestock. It specifies relatively little support for specialty crops, but the Secretary of Agriculture has about $4 billion still to allocate. Some of these funds are earmarked for biofuels.

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For additional information, the author recommends:

The figures in this article can be replicated using the R code at https://files.asmith.ucdavis.edu/govtsupport_CFAP.R
Data sources: USDA ERS Farm Income and Wealth Statistics; CFAP 1 dashboard, available at www.farmers.gov/cfap1/data; CFAP2 dashboard at www.farmers.gov/cfap/data.

Optimal Social Distancing and the Economics of Uncertain Vaccine Arrival

Terrence Iverson, Larry Karp, and Alessandro Peri

The current, increased optimism about the imminent arrival and distribution of a COVID vaccine in the U.S. leads to an increased optimal level of social distancing. Under current circumstances, a policy that seeks to protect the most vulnerable, while allowing the bulk of the population to carry on without restrictions would be disastrous; that policy might have been loosely justified early in the pandemic. An early vaccine arrival time, in general, has an ambiguous effect on optimal social distancing. However, we find that currently in the U.S., the early arrival time promotes stricter social distancing.

Amid the surging COVID-19 pandemic, governments over the past year have faced a difficult policy choice: How much, and for how long, should they restrict economic activities that allow the virus to spread? A stricter social distancing policy—stronger quarantine requirements or the closure of more public spaces—slows the spread of the disease but inflicts economic costs on society. Optimal social-distancing policies should balance the economic costs of restricting mobility against the resulting benefit of reduced mortality costs.

The many sources of uncertainty about COVID and the consequences of social distancing complicate the government's policy problem. A crucial source of uncertainty concerns the "arrival time" of a vaccine, defined as the time needed to develop and distribute a vaccine widely. With this definition, vaccine arrival ends the need for social distancing. Expert opinion concerning the arrival time of a vaccine changed rapidly during 2020. Early in the pandemic, most experts viewed a one-and-a-half to three-year horizon as plausible, and some worried that COVID-19 could turn out to be a disease, like AIDS or the common cold, for which a vaccine would prove elusive. In the end, the U.S. approved a vaccine just eleven months after the start of the pandemic, though there remains uncertainty about the amount of time needed for widespread distribution.

We show how optimal social distancing policy depends on beliefs about the vaccine's arrival time. We ask how policymakers should respond to increased optimism about the early arrival of a vaccine. Should this optimism make social distancing policy stricter or less strict?

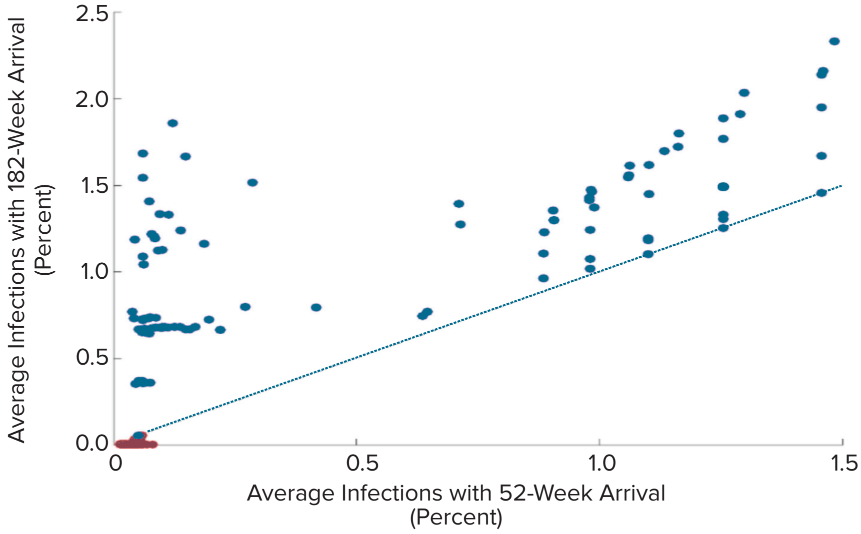
Mathematical models can discipline our attempt to answer such questions, helping to distinguish internally consistent and empirically grounded analysis from a merely plausible story. Fortunately, we have as our starting point a widely accepted model of disease contagion from epidemiology: the Susceptible-Infected-Recovered (SIR) model. This model, which is now routinely used by many economists working on COVID policy research, describes how individuals move from being initially susceptible to the virus, to becoming infected, to recovering—possibly, but not necessarily with immunity—or dying. We modify this familiar framework by treating the vaccine's arrival time as a random variable.

For COVID in the late 2020 and early 2021 U.S. context, we conclude that greater optimism leads to an optimal policy involving stronger social distancing. More generally, we show that greater optimism tends to increase optimal social distancing under a variety of circumstances (e.g., high costs of social distancing) that lead to high levels of infection. However, in circumstances that lead to low levels of infection, greater optimism tends to reduce the optimal level of social distancing.

We also evaluate proposals to move quickly to herd immunity. We focus on a best-case version of the Great Barrington Declaration (https://gbdeclaration.org/), which attracted considerable interest from the Trump administration in late fall 2020. The recommendation has two key features. First, it involves "targeted" instead of "uniform" policy. The former requires more vulnerable groups to adhere to stricter social distancing; uniform policy, in contrast, imposes the same level of social distancing on all groups, regardless of their risk factors. Second, it proposes that the vast majority of the population, those at lower risk, not be subject to any form of social distancing. The first feature is uncontroversial in principle, although there have been questions about its practicality. The second feature has attracted considerable controversy. Should society really require no social distancing for the bulk of the population?

When vaccine arrival remains far off, this proposal can be defended. Indeed, if mean vaccine arrival time is two years, the proposal performs almost as well as optimal uniform policy; however, it still leads to increased economic plus mortality costs of about $2 trillion compared to optimal targeted policy. Thus, early in the pandemic, when there was tremendous uncertainty and significant pessimism about the vaccine's arrival time, the proposal was plausible. But, if vaccine "arrival" is imminent—as in late 2020 and early 2021—then the policy is catastrophic. For the U.S., with a mean arrival time

Figure 1. Relationship Between Average Infection Rates and Expected Arrival Time



* Notes: Dots indicate average infection rate over the first year under two assumptions about mean arrival time: 52 weeks on the horizontal axis and 182 weeks on the vertical axis. The blue color indicates that a later expected vaccine arrival lowers optimal social distancing. The red color indicates the opposite.

of six months, 520,000 more of the vulnerable group (65 and over) die, 380,000 more of the less vulnerable group (under 65) die, and aggregate (economic + mortality) costs exceed $3 trillion. The assertion in the Great Barrington Declaration, that moving quickly to herd immunity will protect the vulnerable, is disastrously wrong: the vulnerable cannot be protected when infection levels are allowed to run extremely high.

U.S. policymakers care primarily about directly relevant policy advice, but economists are also interested in the underlying logic. Understanding this logic requires that we understand why, in general, the relation between social distancing and the vaccine's expected arrival time is ambiguous. The explanation turns on the fact that social distancing has two opposing effects. Stricter social distancing in the current period lowers the number of people who become infected in this period, thereby lowering the stock of infected people but also raising the stock of susceptible people in the next period. The reduction in the stock of infected people is a benefit to society because it lowers the probability of future infections, but the increase in the stock of susceptible people is a liability because those people remain vulnerable to future infection.

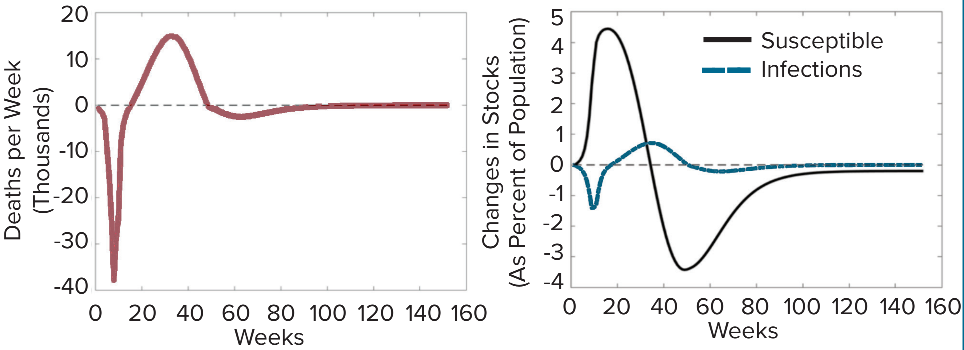
We refer to the future benefits associated with a reduction in the stock of infected people as the "infection channel" and the future liability associated with an increase in susceptible people as the "susceptible channel." The infection channel causes an earlier expected arrival time to lower optimal social distancing, while the susceptible channel has the opposite effect. The intuition for this result is that an earlier expected arrival time reduces the probability that society actually incurs the liability associated with the higher stock of susceptible: There is less time for those people to become sick with an earlier vaccine arrival. This reduction makes stricter social distancing relatively more attractive. Thus, when the susceptible channel is strong, an earlier expected arrival time increases optimal social distancing.

The net policy effect of the vaccine's uncertain arrival depends on the relative strength of these two channels; the relative strength depends on parameter values that reflect the actual or estimated U.S. experience and on current stocks of susceptible and infected populations. Important parameters include those that determine the economic cost of social distancing, the efficacy of social distancing, reinfection rates, and the transmissibility of the disease. For example, a high economic cost from reduced labor supply or a low valuation of mortality both lead to an optimal path for the economy in which infections are rather high. With high levels of infection, the susceptible channel dominates: here, the high stock of infected raises the probability that a susceptible person becomes infected, thereby raising the cost of having one more person being vulnerable to infection. In this setting, an earlier expected arrival time increases optimal social distancing because society is less worried about the potential liability being realized.

Our best estimates of parameter values and current stock levels place the United States in late 2020 and early 2021 into this category, where the susceptible channel dominates. As noted above, this conclusion implies that U.S. policymakers should restrict economic activities now more than ever because widespread distribution of a vaccine is imminent. Proponents of a rapid move to herd immunity (e.g., signatories of the Great Barrington Declaration) want to follow the opposite path.

But there are also plausible settings, e.g., with relatively low social distancing cost or relatively high mortality cost, where an earlier expected vaccine arrival time makes optimal social distancing policy weaker. In these circumstances, the optimal path of the economy keeps infections low, and the infection channel dominates. In the U.S., parameters consistent with this relationship may have been plausible early in the pandemic, especially if policy response had been effectively coordinated at the federal level. Now that U.S. infections are widespread and to a large degree out of control, that situation is implausible. In countries

Figure 2. Effect of a 10% Increase in Social Distancing on Mortality (left) and Stocks of Susceptible and Infected Populations (right)



Impulse response functions associated with a 10% increase in initial-period social distancing relative to the optimal path.

* Note: Simulations for our baseline model. The mean arrival time is 156 weeks.

where infection levels have been consistently kept low, including Vietnam and New Zealand, this description of the world is realistic.

Our paper uses both analytical and numerical models to develop the intuition above. Figure 1 illustrates a key feature of the relationship between the level of social distancing policy and the expected time of vaccine arrival. We numerically solve our quantitative model for over 1,000 combinations of parameters and for two expected vaccine arrival times, 52 weeks and 182 weeks. Each dot in Figure 1 shows, for a single combination of parameters, the first-year average infection level when the expected arrival time is 52 weeks (horizontal axis) and 182 weeks (vertical axis).

All of the blue dots lie above the 45-degree line, indicating that for the corresponding parameters, a later expected arrival time lowers optimal social distancing, thus increasing infections. The red dots lie below the line, indicating that a later expected arrival time increases optimal social distancing, thus lowering infection. The red dots are all very close to the origin; they correspond to parameters that maintain low infection levels. These results show that an earlier expected arrival time increases optimal social distancing in circumstances that lead to high levels of infection (the blue dots).

The left and right panels of Figure 2 trace the impact of a 10% increase in early social distancing relative to the original optimum, holding future policy fixed. Economists call these graphs "impulse response functions." This figure corresponds to the case where the susceptible channel is strong so that earlier expected vaccine arrival makes optimal policy stricter. The left panel shows that the stricter social distancing substantially lowers deaths in the short-run, followed by a smaller but longer-lasting increase in deaths.

To explain the dynamics, the right panel shows that while infections initially fall (the blue curve), the stock of susceptible rises (the black curve). Individuals who avoid infection in the short run also avoid the benefit of developing immunity and hence remain in the susceptible pool. A higher stock of susceptible is fuel for the fire of future infections. Some of this fuel ignites in subsequent periods, leading to a resurgence in infections and deaths.

The uncertainty early in the pandemic about when a COVID vaccine would be developed and distributed made it hard to determine the optimal level of social distancing. Throughout the pandemic, there were calls to move rapidly to achieve herd immunity; some claimed that such a policy would result in fewer deaths among the most vulnerable populations over the long run. Most public health experts were extremely critical of those proposals, although they attracted considerable interest by the Trump administration. By late 2020, the prospects for a vaccine were much brighter, and in December 2020, the U.S. approved the first one. In early 2021, there remains some uncertainty about the timing of widespread vaccine distribution, but this uncertainty is hugely diminished.

We have experienced increased optimism over time about the imminent "arrival" of a vaccine. But it is easy to imagine a world in which the scientific problem of developing the vaccine proved harder than originally thought. In that case, we would have become less optimistic over time. In general, the relation between the optimal level of social distancing and optimism about vaccine arrival depends on many features. For the current U.S. context, our research strongly suggests that increased optimism should be met with stricter social distancing.

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