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ALSO IN THIS ISSUE

Agricultural Groundwater Management in California: Possible Perverse Consequences?

Louis Sears, David Lim, and C.-Y. Cynthia Lin Lawell

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The sustainable management of groundwater resources for use in agriculture is a critical issue in California and globally. Increasing competition for water from cities and environmental needs, as well as concerns about future climate variability and more frequent droughts, have caused policy-makers to look for ways to decrease the consumptive use of water.

The recent rain notwithstanding, California is experiencing its third-worst drought in 106 years. From 1960 to the present, there has been significant deterioration in the groundwater level of the Central Valley of California, making current levels of groundwater use unsustainable. Groundwater management is particularly important in California as the state produces almost 70% of the nation's top 25 fruit, nut, and vegetable crops. Most crops in California come from two areas: the Central Valley, including the Sacramento and San Joaquin Valleys; and the coastal region, including the Salinas Valley, often known as America's "salad bowl." Farmers in both areas rely heavily on groundwater. Understanding the economics of sustainable agricultural groundwater management is particularly timely and important for California, as legislation allowing regulation of groundwater is being implemented gradually in California over the next several years.

Possible Perverse Incentives from Policy

Incentive-based water conservation programs are extremely popular policies for water management. Farmers can receive a subsidy for upgrading their irrigation systems; less groundwater is "wasted" through runoff, evaporation, or drift; marginal lands can be profitably retired; and farmers can choose whether to participate. However, such policies can have perverse consequences.

In many places, policy-makers have attempted to decrease rates of groundwater extraction through incentive-based water conservation programs. Between 1998 and 2005, the state of Kansas spent nearly $6 million on incentive programs, such as the Irrigation Water Conservation Fund and the Environmental Quality Incentives Program, to fund the adoption of more efficient irrigation systems. Such programs paid up to 75% of the cost of purchasing and installing new or upgraded irrigation technology, and much of the money was used for conversions to dropped nozzle systems. These policies were implemented under the auspices of groundwater conservation, in response to declining aquifer levels occurring in some portions of the state due to extensive groundwater pumping for irrigation.

In California, the State Water Efficiency and Enhancement Program (SWEEP) provides financial assistance in the form of grants to implement irrigation systems that reduce

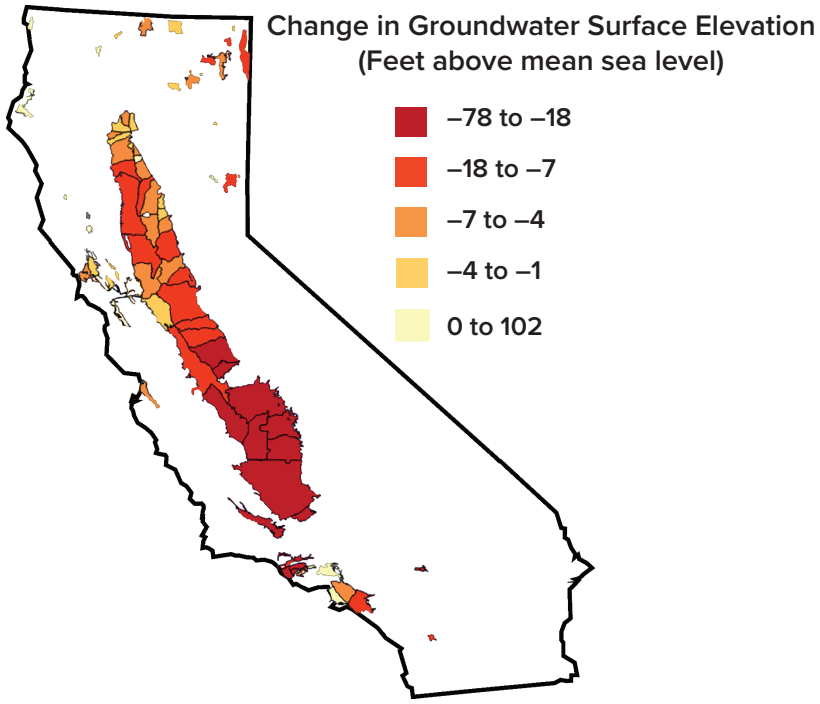

Figure 1. Decline in Groundwater Levels in California Since 2011, by Administrative Basin

Data source: California Department of Water Resources

greenhouse gases and save water on California agricultural operations, including evapotranspiration-based irrigation scheduling to optimize water efficiency for crops; and micro-irrigation or drip systems. San Luis Canal Company in the San Joaquin Valley offers $250 per acre to encourage the transition to pressurized irrigation systems.

Similarly, though funding for this order was not passed, under the Water and Energy Saving Technologies Executive Order B-29-15, the California Energy Commission, California Department of Water Resources, and California State Water Resources Control board were to provide funding for innovative technologies, including rebates for conversion from high-pressure to low-pressure drip irrigation systems.

However, although they are extremely popular policies for water management, we find that policies that encourage the adoption of more efficient irrigation technology may not have the intended effect. Irrigation is said to be "productivity enhancing"; it allows the production of higher-value crops on previously marginal land. Thus, a policy of subsidizing more efficient irrigation technology can induce a shift away from dry-land crops to irrigated crops. They may also induce the planting of more water-intensive crops on already irrigated land, as by definition, more efficient irrigation increases the amount of water the crop receives per unit extracted.

Similarly, land and water conservation and retirement programs may not necessarily reduce groundwater extraction, although they are billed as such. An example of a land retirement program is the Conservation Reserve Program (CRP). The CRP was created by the federal government in 1985 to provide technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. These programs include payments to landowners to retire, leave fallow, or plant non-irrigated crops on their land. Such programs operate on an offer-based contract between the landowner and the coordinating government agency. The contractual relationship is subject to asymmetric information, and adverse selection may arise because the landowner has better information about the opportunity cost of supplying the environmental amenity than does the conservation agent. There is substantial evidence that farmers enroll their least productive, least intensively farmed lands in the programs while receiving payments higher than their opportunity costs, thus accruing rents. It is quite unlikely that an irrigated parcel, which requires considerable investment in a system of irrigation (which, in turn, enhances the productivity of the parcel), will be among a farmer's plots with the lowest opportunity cost and thus enrolled in the program. Instead, farmers may opt to enroll non-irrigated plots in the CRP program, which does not have any effect on the amount of irrigation water extracted.

In our previous study, which has been featured in such media outlets as the *New York Times*, the *Washington Post*, *Bloomberg View*, and AgMag Blog, as well as in a previous issue of *ARE Update*, we focus on incentive-based groundwater conservation policies in Kansas and find that measures taken by the state of Kansas to subsidize a shift toward more efficient irrigation systems have not been effective in reducing groundwater extraction. The subsidized shift toward more efficient irrigation systems has in fact increased extraction through a shift in cropping patterns. Better irrigation systems allow more water-intensive crops to be produced at a higher marginal profit. The farmer has an incentive to both increase irrigated acreage and produce more water-intensive crops.

We find similar results in our analysis of the effects of land and water conservation and retirement programs on groundwater extraction. Theoretically, we know that because the programs are offer-based, farmers will enroll their least productive land. Our empirical results support this conclusion; we find essentially no effect of land conservation programs on groundwater pumping, which occurs, by definition, on irrigated, and thus, very productive land.

Our result that increases in irrigation efficiency may increase water consumption is an example of a rebound effect, or "Jevons' Paradox," which arises when the invention of a technology that enhances the efficiency of using a natural resource does not necessarily lead to less consumption of that resource. William Stanley Jevons found this to be true with the use of coal in a wide range of industries. In the case of agricultural groundwater, we find that irrigation technology that increases irrigation efficiency does not necessarily lead to less consumption of groundwater. In particular, if demand is elastic enough, the higher efficiency technology operates at a lower marginal cost, and the higher efficiency technology increases revenue, then irrigation efficiency will increase applied water.

In California, SWEEP grant funds cannot be used to expand existing agricultural operations or to convert additional new acreage to farmland, which may limit how much a farmer can respond to the increased irrigation efficiency resulting from SWEEP grant funds to increase irrigated acreage. However, by lowering the marginal cost of irrigation, SWEEP grant funds may encourage farmers to continue irrigating more marginal lands. Furthermore, this increased efficiency may allow farmers to continue growing more water-intensive crops, even as groundwater becomes more scarce. Thus, SWEEP funds could make farmers in water-stressed locations less sensitive to existing price signals as groundwater becomes scarce, and may slow their adjustment to depleting groundwater stocks over the long term.

The California Department of Agriculture and the California Department of Water recently introduced a pilot program within SWEEP that incentivizes joint action by farmers and larger water suppliers to implement more efficient irrigation technology in return for an agreement to halt the use of groundwater for agricultural purposes. However, this program may be used most by farmers and water suppliers who rely relatively little on groundwater as a source. In this case, while irrigation may become more efficient, this may have little effect on groundwater use, the target of the policy. As a result, the costs of the program may unfortunately exceed its benefits.

Thus, when designing policies, policy-makers need to be wary of any potential unintended consequences. Incentive-based groundwater conservation programs are a prime example of a well-intentioned policy gone awry.

Conclusion

Incentive-based groundwater conservation programs are a prime example of a well-intentioned policy that may have perverse consequences, meaning that they may actually increase rather than decrease groundwater extraction. When designing policies and regulation, policy-makers need to be aware of the full range of implications of their policy, including any potential perverse consequences.

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How Large are the Economic Benefits of Rural Electrification?

Fiona Burlig and Louis Preonas

Universal access to energy is a policy goal for many countries around the world, but little is known about the economic impacts of connecting rural villages to the electricity grid. We estimate the effects of a policy that expanded energy access in over 400,000 villages in India. Contrary to previous evidence, we find that electrification yields at most only modest economic benefits.

Approximately 1.1 billion people around the world still lack access to electricity. These people are overwhelmingly rural, and live almost exclusively in Asia and Sub-Saharan Africa. In recent years, developing countries have made large investments to extend the electricity grid to the rural poor. This is not surprising, given that electrification is widely touted as an essential tool to help alleviate poverty and spur economic progress. While access to electricity is highly correlated with GDP at the national level, there exists limited evidence on the causal effects of electricity access on rural economies.

Our study examines the effects of India's national rural electrification program, which expanded electricity access in over 400,000 villages. We find that the program caused statistically significant and economically meaningful increases in electricity consumption, which are measurable from space. However, we find, at most, small changes to economic outcomes, including employment, asset ownership, the housing stock, household wealth, and school enrollment, and can statistically reject even modest effects.

Taken together, these results suggest that the causal impact of large-scale rural electrification on economic development may be substantially smaller than previously thought. This contrasts with previous research that has tended to attribute large economic impacts to rural electrification, in part because it is difficult to disentangle the impacts of electricity access from general economic growth.

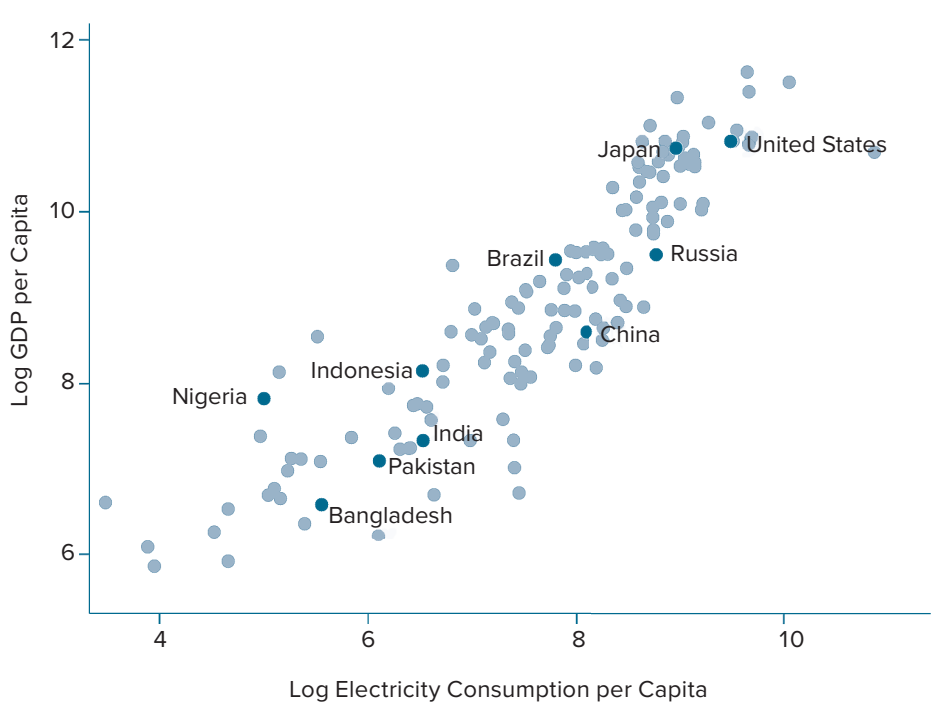

Figure 1. Positive Correlation between Electricity Consumption and GDP Per Capita

Source: World Bank Tables

India's National Electrification Program

In this study, we leverage a unique "natural experiment" – India's electrification program had a built-in cutoff, whereby villages with 300 or more inhabitants were eligible for electrification, and villages of fewer than 300 people were ineligible. This enables us to compare outcomes in villages just below this arbitrary cutoff to villages just above the cutoff, which are similar along all other dimensions, to estimate the causal effects of electrification on development.

We first demonstrate that the electrification program led to meaningful increases in electricity access among eligible villages. To do this, we use data from satellite images of nighttime brightness, which serve as a well-known proxy for electricity consumption. Figure 2 compares the average nighttime brightness of barely eligible villages to that of barely ineligible villages. Average brightness is noticeably greater for villages to the right of the 300-person eligibility threshold, and this result is robust and statistically significant.

We use nighttime brightness data from at least three years after most electrification projects were completed. This shows that the program yielded sustained increases in electricity consumption. Our estimates are consistent with changes in brightness associated with the addition of nine new streetlights – a sizeable increase in 300 person villages, especially since

the electrification program did not add new outdoor lighting. Instead, these increases in luminosity come from lighting in public spaces, households, and businesses consuming more electricity. If this effect were driven by household electrification alone, these results would be consistent with 68% of households receiving new electric connections under the program. This suggests that the electrification program led to meaningful increases in electricity access throughout eligible villages.

Electricity and Economic Outcomes

Next, we use the same strategy to test for the effects of electrification on economic outcomes. We collect detailed administrative data on a wide range of economic indicators, and we test a variety of channels through which electrification might be expected to produce economic impacts. We test whether electrification led to changes in:

- Employment in microenterprises, if electrification spurs entrepreneurship and new business growth
- Employment in agriculture, if electrification increases farm productivity or mechanization
- Female employment, if electrification improves women's empowerment
- Asset ownership, if electrification causes households to purchase new appliances
- Housing stock, if electrification causes households to invest in improved roof or floor materials
- Poverty rate, if electrification helps to move households out of poverty
- Household income, if electrification yields new income-generating opportunities

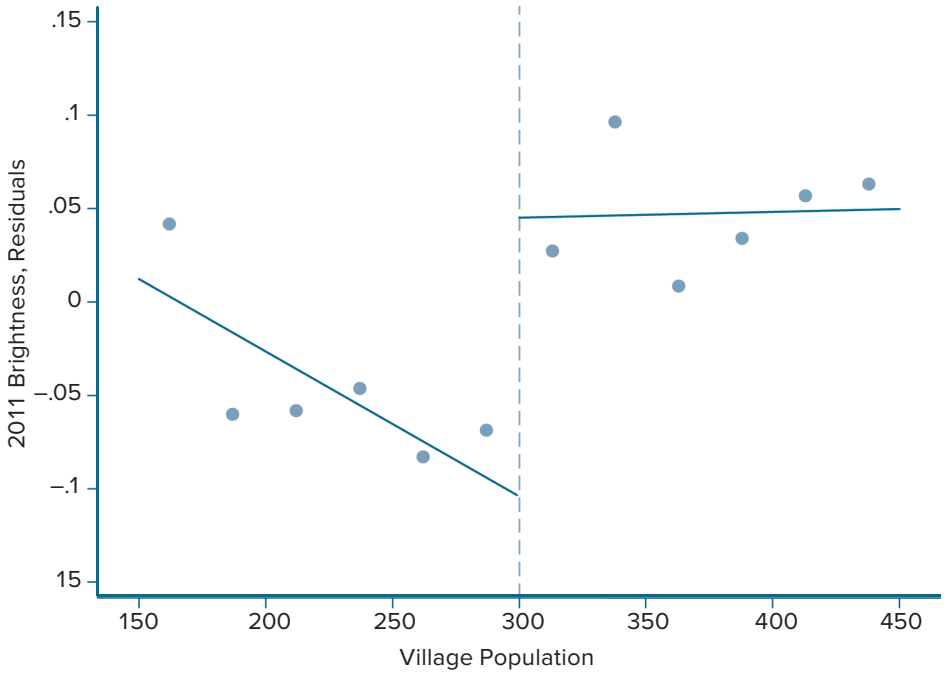

Figure 2. Electrification Leads to Meaningful Increases in Energy Consumption

Source: Authors' calculations

- School enrollment, if electrification facilitates better study habits, improves in-classroom learning, or affects the number of years of schooling children receive.

Figure 3 summarizes the results for 11 selected economic outcomes. We find that electrification led to only modest changes in employment for both men and women; ownership of a variety of household assets; poverty and household income; and school enrollment. The bars represent the effect size for each outcome, in units of standard deviations of each variable, while the solid line in the center of each bar represents the 95% confidence interval for each estimated effect. We can statistically reject improvements greater than 0.26 standard deviations, across all economic indicators that we observe.

Taken together, these results suggest that while the Indian electrification program substantially increased the provision and consumption of electricity, electrification did not lead to economically meaningful impacts among the wide range of outcomes that we can measure.

India is subject to major electricity shortages, and any benefits of electrification could potentially be undermined by low-voltage electricity or frequent power outages. In order to confirm that poor power quality is not driving our results, we separate states into two groups: those with above-average vs. below-average power reliability. As expected, the increase in nighttime brightness is much stronger in states with above-average reliability. However, our estimated economic impacts remain very similar across both groups. This suggests that even in states with relatively high-quality electricity supply, the economic impacts of electrification remain small.

It is also possible that the benefits of electrification take many years to accrue. Our main results rely on economic data from between three and five years after villages were targeted by the electrification program. If we restrict our analysis to include only the earliest villages to receive treatment, we find very similar economic impacts. This suggests that even in the medium-term, the economic effects of electrification are quite small.

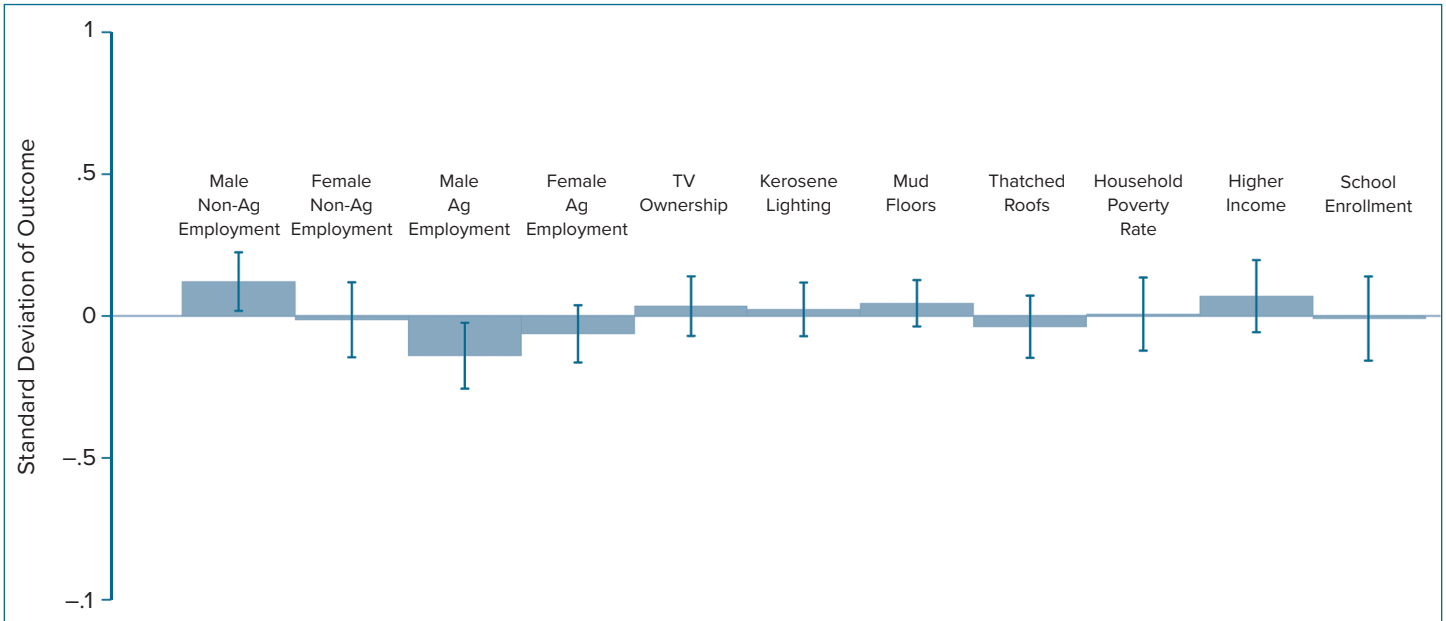

Figure 3. Electrification Leads to at best Small Impacts on Economic Indicators

Source: Authors' calculations

We might worry that our analysis of small villages close to the program's 300-person eligibility cutoff are not representative of the full range of Indian villages. However, we expand our analysis to include all villages within the scope of the electrification program, by using a second natural experiment: Indian districts were split into two largely arbitrary groups, and villages in the first group received electrification before villages in the second group. This allows us to compare "treated" villages in the first group to "control" villages of similar size in the second group. We find remarkably consistent results, with substantial increases in electricity consumption but only modest changes in economic indicators.

Policy Implications

What do these results mean for policy? We find that even though rural electrification led to meaningful improvements in energy access and consumption that are measurable from space, it caused at most modest changes in labor, income, household wealth, asset ownership, and education. These results come from the world's largest unelectrified population, and they likely apply to over 400,000 villages across rural India. They suggest that rural electrification may not be a silver bullet for reducing poverty or jumpstarting economic activity, and that medium-run economic outcomes alone likely do not justify the expensive investments required to electrify rural villages.

Nevertheless, electrification may still have large economic benefits that we cannot measure. In particular, while our study considers medium-run outcomes, we cannot observe long-run impacts. The economic benefits of electrification may only manifest after 10 or 20 years, and additional research is needed to evaluate these long-term effects. Furthermore, due to data limitations, we do not evaluate the impacts of electrification on "non-market" outcomes, such as happiness and stress. Some anecdotal evidence suggests that electrification may in fact have made rural Indians happier. We encourage future researchers to study such non-market impacts of rural electrification.

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Trade and Trade Policy Prospects for California Agriculture

Daniel A. Sumner and
William A. Matthews

California farms and allied industries supply food and other farm products to consumers all over the United States and the world. At the same time California agriculture relies on equipment, supplies and technology imported from many sources, while California consumers rely on imported foods, flowers, and other farm products. International connections permeate economic relationships in California agriculture. While new agreements can achieve additional gains from trade, there is also much to lose from destabilizing current agreements.

News and speculation about international trade prospects and policy have been everywhere for the past year or so, especially in the context of the Presidential election. This brief article highlights the role of international trade in the economics of California agriculture.

Given its unique set of commodities, much of what is produced in California seeks markets elsewhere. About 20% to 25% of the quantity of California farm production is exported, often in the form of processed products. About 60% to 65% of California production is shipped to the rest of the United States. The share exported varies from year to year, but differs even more from product to product. For example, essentially all cotton and most almonds are exported, whereas almost all the lettuce and other leafy greens, which are highly perishable, are destined for the United States (and to some extent Canada).

Export values and destinations for products from California farms and ranches are estimated every year by UC Agricultural Issues Center (as a part of an annual project with the California Department of Food and Agriculture) for more than 20 years. AIC uses Federal export data by detailed product code, port of export, and destination. Official data from Canada provide some information on the state of farm origin for U.S. products shipped there. USDA reports information on product compositions, which allows estimation of farm commodity inputs into processed products and mixtures. California agricultural industries supplement data from public sources. Table 1 provides some summary export data for ten major California farm products.

Many factors determine agricultural trade flows including crop yields, local and global market prices, exchange rates and consumer incomes and income growth. In addition, trade policy, including trade agreements, is vital for California agricultural trade. Every major export destination and every major source of imports have lower trade barriers and improved access to the U.S. market because of membership in the World Trade Organization and often bilateral and multilateral agreements. Often these agreements allow trade to cross national boundaries without taxes added at the border, which benefits both producers and consumers. Membership in trade agreements also allows an enforceable legal framework for dispute settlement and to head off potential trade conflicts before a dispute is formalized.

Of course, benefits of trade are not distributed uniformly across companies, workers or customers. As with most other economic activities, access to trade provides benefits to competitive suppliers and local customers who patronize efficient firms with access to the local market. Trade barriers that keep out competition can benefit farms and ranches that have higher costs, but penalize consumers of those products even more. Similarly, when California farm products gain better access to outside markets, local consumers often must pay more. Net benefits of open market access are often realized in the form of a more innovative and dynamic economy that

Table 1: California Agricultural Export Values and Ratio of Export Quantity to Farm Production, Top Export Commodities in 2015

Rank	Commodity	Export Value (in $millions)	Ratio of Exports to Production
1	Almonds	5,144	0.65
2	All Grapes	2,581	0.21
3	Dairy and products	1,632	0.29
4	Walnuts	1,485	0.60
5	Pistachios	848	0.90
6	Tomatoes, processed	813	0.27
7	Rice	751	0.51
8	Oranges and products	582	0.37
9	Strawberries	390	0.10
10	Seeds	340	–[1]
	Total of all agricultural exports	$20,687	0.39[2]

[1] Ratio of seed exports to production is not available.

[2] Ratio of total exports to production is an average of 53 principal commodities.

adapts to those productive activities to which it is best suited. But that does not mean that all producers, workers or consumers gain, especially during a period of intense adjustment.

For California, the most important "free trade agreement" has been that among the states of the United States. The U.S. Constitution prohibits states or local governments from enacting undue barriers to free flow of goods and services across jurisdictions. Such flow has allowed California agriculture access to 300 million customers and also allowed access to farm inputs and consumer products.

The most important international trade agreements for the United States were implemented many years ago and no new agreements have been successfully negotiated for almost a decade. Support in Congress dissipated to such an extent that both the Trans-Pacific Partnership (TPP) and the Transatlantic Trade and Investment Partnership (TTIP) lost support for implementation many months ago. These agreements would have been mildly positive for California agriculture and the California economy as were prior agreements.

The United States has now begun a new era of trade negotiations, with proposals for modifying existing agreements such as NAFTA and entering into new bilateral agreements. Four points are useful to understand prospects for California agriculture in this context.

First, no agreement is perfect in hindsight, and certainly each party to an agreement has a list of items that they would like to change ex post. That is true of NAFTA and all the other agreements. But finding overlaps and tradeoffs among the proposed changes is difficult. Successful renegotiations require that both parties benefit, which is why major amendments to agreements are rare. The exception is the multiple rounds of negotiations of the largest of multilateral trade deals, the General Agreements on Tariffs and Trade (GATT), which progressively opened markets globally over eight agreements from 1947 to 1995. Importantly, and to highlight recent difficulties, consensus to significantly amend the GATT has largely evaporated over the past 22 years, and there are few prospects for renewing those negotiations.

Second, new bilateral agreements, for example with Japan, the United Kingdom, and the growing economies of Southeast Asia, could be economically significant for California agriculture. The U.S. government would serve agriculture well by searching for ways to undertake such negotiations.

Third, threat of unilateral trade actions invites retaliation that raises the potential risk of severely damaging market access for California agriculture. For example, Mexico is the major export buyer of California dry milk powder, among other products, and is a major source of off-season fruits and vegetables. Besides affecting trade relationships, unilateral trade actions, including unilateral "renegotiations," reduces the prospects for successful negotiations of new agreements if unilateral actions cause trade partners to question U.S. reliability.

Finally, one of the most important principles of trade economics is that nations benefit from strong economies among their trading partners. Successful trade agreements stimulate economic growth among all partners and growth in one benefits the others. California does better when the rest of the U.S. economy does well and when major trading partners such as Canada, the EU, Japan, China, and Mexico do well. Actions that damage the economies of our trading partners are bad news for exports and even for imports.

In summary, there are opportunities for improving economic prospects for California agriculture. Improving export and import access are among those opportunities. Maximizing the value of access hinges on opening markets and growing markets among our trading partners.

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Effects of the Great Recession on the U.S. Agricultural Labor Market

Jeffrey M. Perloff

Wages of documented (legal) seasonal agricultural workers increased more during the last three recessions than did the wages of undocumented agricultural workers and low-skilled nonagricultural workers. Bonus pay and weekly hours also increased for some workers, so that the financial wellbeing of employed agricultural workers increased during these recessions. These recessions not only raised farmers' costs but increased their risk.

Recessions affect the hired agricultural workers' labor market differently than other labor markets that hire many immigrant workers, such as construction, hotel, and restaurant labor markets.

Effects of Recessions on Agricultural Labor Markets

We examined the effect of three recessions, 1990–1991, 2001, and 2008–2009 (the Great Recession) on agricultural wages and hours. We used data from the National Agricultural Workers Survey, a national, random sample of hired seasonal agricultural employees, who work primarily in seasonal crops.

Controlling for workers' demographic characteristics such as age, years of farm experience, job tenure, sex, knowledge of English, and whether they were Hispanic, we estimated the effects of these recessions on wages in various regions and crops. We separately examined the effects of recessions on documented and on undocumented workers' wages and hours.

Wage and Bonus Effects

Documented workers' hourly earnings rose 4.7% during the 1990–1991 recession, 3.8% during the 2001 recession, and 5% during the Great Recession. Hourly earnings for undocumented workers rose by 2.1% and 3.2%, respectively, during the 1990–1991 and 2001 recessions, but not during the Great Recession. Thus, not only do undocumented workers earn less than documented workers do in general, but their hourly earnings rose less during these recessions than did the earnings of documented workers. As a result, the wage gap between documented and undocumented workers widened during these recessions.

In addition to hourly earnings, 28% of surveyed workers receive bonus payments. For documented workers, the probability of receiving a bonus increased by 3.9 percentage points (11% relative to the mean) during the 1990–1991 recession only. Thus, this recession not only raised documented workers' hourly earnings, but it raised

Harvesting strawberries in the Salinas Valley of California

Photo by Jeffrey Perloff

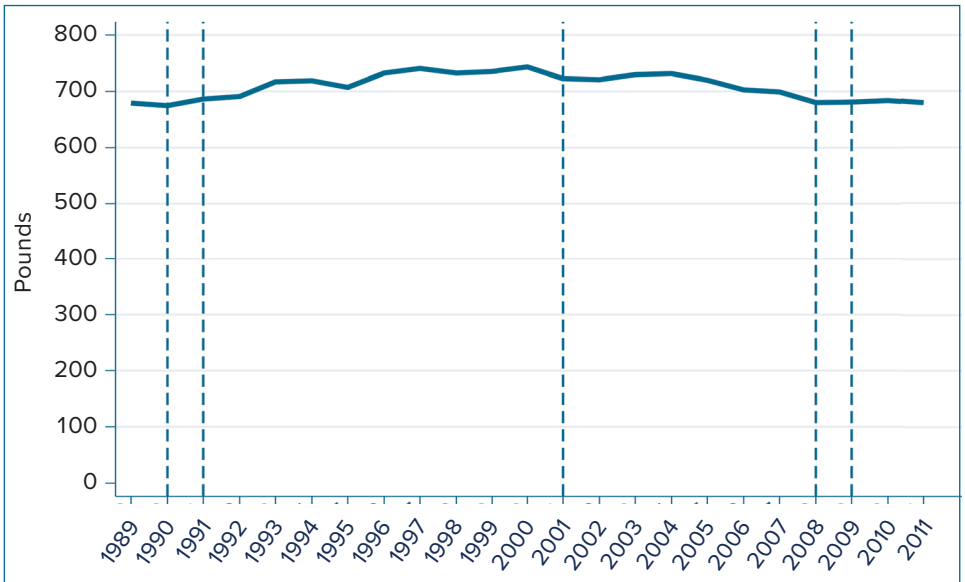

Figure 1. U.S. Per Capita Consumption of Fruits and Vegetables over Time

Source: www.ers.usda.gov/data-products/fruit-and-tree-nut-data/yearbook-tables.aspx

http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1212

the probability that they received a bonus.

The probability that undocumented workers received a bonus increased by 3.3 percentage points (17% relative to the mean) during the 1990–1991 recession and rose by 6.0 percentage points (32% relative to the mean) during the Great Recession. Thus, undocumented workers may have received some additional compensation in the form of bonuses instead of increased wages.

Employers may have been more inclined to use bonuses to keep good undocumented workers. A one percentage point increase in the unemployment rate raised the probability of receiving a bonus by approximately 0.6 percentage points.

Hours Effects

When employers have difficulty recruiting workers, as during recessions, they employ workers for more hours per week to compensate. Weekly hours of documented workers rose by 0.75 hours during the 2001 recession, and by 0.68 hours during the Great Recession. Weekly hours for undocumented workers increased by 2.16 hours during the 1990–1991 recession and by 1.24 hours during the Great Recession—more than for documented workers.

Effects of Recessions on Nonagricultural Labor Markets

Do recessions have different effects in agriculture than in other sectors of the economy that employ many undocumented immigrants, such as construction, hotels, and restaurants? To answer this question, we used data from the Bureau of Labor Statistic's March Current Population Survey (CPS). (Due to data limitations of the CPS, we could look at the effects of only the two more recent recessions, 2001 and the Great Recession. Also, the CPS does not record whether an immigrant is undocumented or receives bonus payments.)

In none of these three sectors did either recession affect the wages of non-immigrants or of immigrants. Presumably, wages are sticky in these sectors, partially due to union and other contracts and minimum wage laws.

In addition, weekly hours for non-immigrant and immigrant workers in the hotel sector fell during the 2001 recession and for non-immigrant construction workers during the Great Recession. Overall, for most employed workers in these three sectors, weekly hours remained relatively constant during recessions.

An Explanation

What explains the different effects of recessions between agricultural and non-agricultural labor markets? The following is a plausible explanation.

The demand for seasonal agricultural products such as fruits and vegetables is not very sensitive to changes in income. Figure 1 shows that consumption of fruits and vegetables was relatively stable during the 1990–1991, 2001, and 2008–2009 recessions. Similarly, total agricultural output was relatively stable during these recessions. Thus, these recessions caused only a minimal leftward shift in the demand curve for agricultural workers.

In contrast, a recession causes a substantial shift of the labor supply curve to the left. Roughly half of hired, seasonal agricultural workers are undocumented. The Great Recession significantly reduced the number of new, undocumented immigrants entering the United States.

Passel, Cohn and Gonzalez-Barrera (2013) reported a large drop in the number of undocumented immigrants during the Great Recession relative to the recovery years afterward and to preceding years, which include milder recessions. They estimated that the number of undocumented immigrants rose monotonically from only 3.5 million in 1990 until it peaked at 12.2 million in 2007, over a 7% drop. However, the number of undocumented immigrants fell to 11.3 million by 2009 during the Great Recession (but rose slightly during the mild 2001 recession).

Consistent with these estimates, according to the Department of

Homeland Security's Office of Immigration Statistics, apprehensions by border patrol dropped from 876,803 in 2007 to 556,032 in 2009. Finally, the U.S. Department of Agriculture estimates that the number of full- and part-time agricultural workers was higher in 2007 (1.032 million) and 2010 (1.053 million) than in 2008 (1.003 million) and 2009 (1.020 million). That is, the number of workers in 2008 was 3% to 5% lower than in the years before and after the Great Recession.

Given a substantial leftward shift of the supply curve and only a minimal shift of the demand curve, agricultural workers' wages and the probability of receiving a bonus increase during major recessions. Weekly hours of employed agricultural workers increase to compensate for the reduced flow of new immigrants during major recessions. Thus, because both wages and hours increase, employed agricultural workers' wages rise.

Recessions have larger earnings effects for agricultural workers than for construction, hotel, and restaurant workers. In those markets, the leftward shift of the demand curve is much more substantial than for the supply curve. Thus, the wage would fall in those sectors were it not relatively sticky due to minimum wage laws and union contracts. Thus, the observed wage hardly changes in those sectors, but employment falls substantially.

Implications for Farmers

Labor supply falls during major recessions, which forces farmers to pay more per hour during recessions, and the thinner labor market makes finding workers when needed more difficult. Thus, recessions raise farmers' labor costs and increase their risk. If farmers in seasonal agriculture cannot find workers when they need them, their crops may be ruined.

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For additional information, the author recommends:

Maoyong Fan, Anita Alves Pena, and Jeffrey M. Perloff, "Effects of the Great Recession on the U.S. Agricultural Labor Market," *American Journal of Agricultural Economics,* 98(4), October 2016:1146-1157.

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