

Water and Jobs: The Role of Irrigation Water Deliveries on Agricultural Employment

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Decreased irrigation water deliveries from the federal and state water projects are shown to have a significant negative impact on agricultural employment in California's Central Valley.



Movable pipe sprinklers are used to irrigate a lettuce field in California. The importance of irrigation water for agricultural employment has spawned much debate in recent years.

The past several years have been tumultuous ones for California water agencies and farmers who rely on water exports from the Delta. Since 2005, water exports from the Delta have been reduced by drought and environmental restrictions. The loss of water supply has had economic consequences for farmers and those who make their living as farm workers. In this paper, we present the results of a statistical test of the hypothesis

that higher deliveries to water districts in a given county lead to higher employment, provide estimates of the size of this effect, and characterize the uncertainty around the estimates. Based on this analysis, we estimate that water delivery reductions in 2009 caused a loss of approximately 5,000 farm jobs in the San Joaquin Valley relative to the year 2005.

Approach

When seeking to identify a relationship, such as the one between Delta water exports and farm jobs, it is important to control for the influence of confounding variables. This principle can be illustrated using a simple example: total production of a commodity, such as a crop, in a market-based society is the sum of each farm's production. Profit-maximizing farms decide on the optimal output by setting marginal cost equal to marginal revenue, which is equal to price if the market is competitive. Therefore, a variable beyond their control, the market price, as well as other exogenous factors (e.g., prices of inputs such as the wage rate) determine the optimal use of inputs to produce the optimal amount and mix of crops.

Total demand for farm labor at a given farm therefore depends on the prices of outputs, the wage rate, the prices of other inputs, and other exogenous factors, such as weather and water deliveries. If employment is significantly more sensitive to wages and input prices than to water deliveries, the effect of wage variations may swamp the smaller, but still significant, effects of variations in water deliveries in terms of total employment. In order to detect

the weaker signal, one needs to control econometrically for other confounding factors, either directly or via a fixed effects strategy, to be able to extract the effect of smaller factors from the noise caused by large confounding factors.

In the present case, the coefficient of interest is the effect of a change in Delta water deliveries on changes in employment. In order to arrive at such a coefficient, one should statistically compare employment in areas receiving water deliveries, which vary from year to year, to employment in areas, which do not receive such deliveries as a control group.

Counties differ in characteristics, which do not vary across time (e.g., soil characteristics, physical location). Further, there are certain factors that affect all counties contemporaneously (e.g., changes in relevant exchange rates, global commodity prices, oil price shocks, wages, and prices of other inputs). One has to account for this fact statistically in order to prevent these effects from confounding the estimated impact of water deliveries on employment. Further, there may be other factors varying at the county level over time, which are correlated with water deliveries and, if not controlled for directly, may contaminate the estimated effect of deliveries on employment.

Economists and statisticians have developed now-standard methods for performing such analyses. Known generally as panel estimation techniques, they involve creating a set of fixed effects to screen out factors that vary across regions (counties in this instance) and among years. The researcher estimates a model that includes the variable of interest together

Table 1. Summary Statistics on Employment and Delta Exports by County

County	Total Employment ------(1,000 Jobs)-----	Farm Employment	Acres Harvested (1,000 acres)	Total Delta Deliveries (1,000 acre-feet)
Fresno	338	31	1,252	1,093
Kern	254	17	834	1,011
Kings	41	5	516	305
Merced	74	10	522	150
San Joaquin	208	14	521	40
Stanislaus	163	12	422	88
Tulare	141	19	763	5

with the time- and location-specific fixed effects. What remains after removing the influence of the fixed effects is the influence of the variable of interest, in this case Delta export deliveries by county. Factors which influence employment and are correlated with deliveries which differ across time and space need to be controlled for explicitly, not via a simple fixed effect.

Failing to control for the confounders through a fixed effects strategy will lead to biased and/or inefficient (i.e., imprecisely estimated) coefficients. One could estimate this equation on a sample containing just the counties receiving deliveries or a sample of counties receiving deliveries and include counties that do not receive deliveries as a control group. We show that the estimation results are robust to using either sample. In the first sample, the identifying source of variation is within county time series variation. For the larger sample, it is within county variation relative to the control group county variation, which identifies the coefficient of interest.

Data

The data used in the analysis are comprised of an annual panel data set covering the years 1980 to 2000. Counties used in the analysis, which receive irrigation water from either the Central Valley Water Project (CVP) or State Water Project (SWP) are the following: Fresno, Kern, Kings,

Merced, San Joaquin, Stanislaus and Tulare. Six California counties that do not receive Delta water deliveries were used as a control group to capture the effects of general changes in the agricultural economy: Madera, Imperial, Monterey, Sutter, Yolo and Yuba. The data period covered by the analysis evidences significant variation both in employment and water deliveries. It also includes one of the largest droughts in recent memory—the drought of 1987–1992.

The employment data at the county level are publicly available, and were obtained from the Bureau of Economic Analysis (BEA). For the employment data series, farm workers are defined to include anyone who works in the direct production of agricultural commodities, including crops and livestock (SIC codes 01 – 02). Government water delivery data include both state deliveries from the SWP and federal deliveries from the CVP. The state water delivery data come from the California Department of Water Resources’ Bulletin 132 and the Kern County Water Agency. The federal water deliveries data are from the Bureau of Reclamation.

A Geographic Information System was used to allocate water deliveries to counties. We first took the intersection of the boundaries of each of the water districts and counties, and then calculated the acreage of the district-county intersection and divided that by the acreage of each of the districts.

We multiplied this ratio by the water deliveries in each water district and summed the share of water deliveries in the district-county intersection over counties. Thus, water deliveries are allocated to the county level according to the share of acres of each water district that falls within each county. Annual deliveries are reported in acre-feet. The data set also includes harvested acres for all crops by county. These data come from the Agricultural Commissioners’ Offices of Fresno, Imperial, Kern, Kings, Madera, Merced, Monterey, San Joaquin, Stanislaus, Sutter, Tulare, Yolo and Yuba counties for the years 1980 through 2000.

Table 1 displays average employment and water deliveries by county from 1980–2000. Fresno has the highest number of total employed workers and the highest number of employed farm workers, while Kings has the lowest in both categories. Merced has the highest percentage of employed workers in farming (13.5%), while San Joaquin has the lowest (6.7%). Fresno also has the largest area harvested (1,252,000 acres) while Stanislaus has the smallest (422,000 acres). Fresno has the highest average level of federal and state water deliveries from the Delta (1,093,000 acre-feet) and Tulare has the lowest (5,000 acre-feet). Kings has the highest Delta-deliveries-to-farm-worker ratio at 61 acre-feet per worker, and Tulare has the lowest at 0.3 acre-feet per farm worker. These large differences across counties show the importance of controlling for unobservable differences across counties via county-level fixed effects.

Results

Controlling for shocks affecting each county in a given year via year fixed effects, the influence of a one acre-foot drop in Delta exports on county employment is 0.00240 and is statistically different from zero at the 5% level. This coefficient implies that 417

additional acre-feet of deliveries are consistent with about one additional job in the county. To better control for the influence of macroeconomic trends in the agricultural sector, we estimate the same model but expand the sample to include control counties that do not receive deliveries from the Delta. In this model, the coefficient drops slightly to 0.00225 and is statistically significant at the 1% level. This more conservative estimate implies that 444 additional acre-feet of deliveries are consistent with about one additional job in agriculture.

The Bureau of Economic Analysis (BEA) shifted to reporting sectoral employment based on the Standard Industrial Classification (SIC) to reports based on the NAICS classification. The BEA provides a concordance to match industry descriptions between the two coding systems. We extend the sample to include the years 2001-2007 for which we have both deliveries data at the county level as well as employment data from the same source (BEA), albeit collected under the North American Industry Classification System (NAICS).

As we control for year fixed effects in our preferred specification, if there are year-to-year differences in employment that are due to the new classification, our method controls for these differences. The results are robust to including the NAICS data for the additional years, as the coefficient on Delta deliveries in the sample including the control counties is 0.00222, which is nearly identical to the coefficient estimated using the SIC-based data through 2000.

In order to calculate the job impacts of a reduction in Delta exports to the San Joaquin Valley, we use the year 2005 deliveries to each county as a baseline and calculate the predicted jobs in each county using the estimated coefficients. We then calculate the predicted number of jobs in each county from the deliveries coefficient based on the 2009 level of deliveries. The

estimated drop in direct farm employment is 4,965 jobs, which is equivalent

This more conservative estimate implies that 444 additional acre-feet of deliveries are consistent with about one additional job in agriculture.

to a 4.6% decrease. The 99% confidence interval around this estimate of jobs lost does not include “no jobs lost,” meaning there is less than one chance in one hundred that reductions in Delta exports did not decrease direct farm employment in the San Joaquin Valley in 2009 relative to 2005.

Our county-level model therefore is consistent with economically and statistically significant losses in employment in the agricultural production sector. While the model does not formally test the mechanism of how this occurs, one would expect that acreage planted to crops would decrease if deliveries are short, which would lead to lower labor requirements to service this smaller area. We therefore test whether deliveries are correlated with total acreage cropped in the seven counties in our sample receiving deliveries.

As one would expect, there is a strong and statistically detectable relationship between deliveries and area cropped in our sample. The model specifications are the same as those used for farm employment, only that we use total area cropped in acres as the left hand side variable. The estimated effect of Delta deliveries on farm acreage suggests that each additional 36.49 acre-feet of deliveries from the Delta are consistent with one additional acre cropped. This relationship is robust across specifications and always significantly different from zero at the 1% level of significance. This finding suggests that Delta exports affect cultivation (and fallowing) in a detectable and significant way.

Conclusions

There has been a lively debate surrounding the importance of irrigation water for agricultural employment. Using data on actual agricultural employment and deliveries from 1980–2007, we find that the number supported by the data is close to 5,000 jobs lost—due to water-delivery reductions in the Central Valley between 2005–2009, which is roughly a 5% decrease in direct agricultural employment in the Central Valley counties receiving deliveries. Our analysis suggests that the employment effects come from decreases in area planted in years with lower deliveries.

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