Economic Impact of California's Citrus Industry

Bruce A. Babcock

School of Public Policy

UC Riverside

Funding for this study was provided by the Citrus Research Board.

Table of Contents

Key findings

- The value of California citrus production in the 2016-17 marketing year was $3.389 billion.

- The total economic impact of the industry on California's economy in 2016-17 was $7.1 billion

- The California citrus industry added $1.695 billion to California's state GDP in 2016.

- Estimated full time equivalent jobs in the California citrus industry in 2016-2107 totaled 21,674.

- Estimated wages paid by the California citrus industry income in 2016-17 totaled $452 million.

- A 20% reduction in California citrus acreage would cause a loss of 7,350 jobs, $127 million in employee income, and reduce state GDP by $501 million

Economic Impact of California's Citrus Industry

Introduction

A key factor explaining why California continues to be an economic success story is the flexibility that comes with the great diversity of economic activities that take place in the state. From manufacturing to information technology, education, aerospace and health care, California leads or is among the leaders in states with a large number of industries. This diversity means that the state's economy is not especially vulnerable to downturns in any one single industry.

One often-overlooked contributor to the diversity of California's economy is agriculture. California's farmers produced about $49 billion worth of agricultural commodities in 2016. These commodities in turn are the reason why California has such a large food and beverage processing industry. Together agriculture and closely-related industries account for about one million jobs in California which represents about 6% of total employment.

California citrus is a major contributor to the economic value of the agricultural sector. Oranges, mandarins, lemons, and grapefruit, accounted for 2.4% of total crop acres in the state and generated 6.8% of total crop revenue in 2015. However, the contribution of California's citrus industry to California's economy is much larger than just the value of its sales. The application of management skills and capital equipment to efficiently utilize land and water to produce high quality citrus generates upstream and downstream jobs and income that magnify the importance of citrus production beyond its farm value.

The trends seem to favor continued health for California's citrus industry. The grower value of production expressed in constant 2016 dollars has increased 53% since 2007 from $1.478 to $2.26 billion. However, inflation-adjusted production costs have also increased over this time period. A portion of the increased production costs have been driven by increased demands by government in the form of new regulations. The pace of new regulations has not slackened with new food safety and labor rules to be phased in over the next few years. California's citrus industry also faces increased costs associated with efforts designed to prevent huanglongbing (HLB) from spreading into commercial groves. If the ongoing prevention efforts are not successful, then the industry faces the difficult task of trying to determine how it will operate in the presence of this devastating disease.

The purpose of this paper is to provide estimates of the contribution of the California citrus industry to California's economy. A forthcoming companion report will assess the impact of government regulations and regulations associated with control of HLB on that contribution and to the industry's future prospects. Attempts to forecast future events, are of course, speculative by their nature. But given that new regulations have already been passed and are currently being phased in we can make informed estimates of their likely impact on the citrus industry. In addition, wherever HLB has established in a region, it has not been eliminated or controlled so we know that costs associated with HLB are likely not going to decrease in the next few years. The forthcoming paper will examine these issues.

Measures of Economic Contribution

The economic contribution of California's citrus industry to the state can be measured in different ways. A brief exploration of the different measures is helpful to fully understand the importance of the citrus industry to California. I begin this discussion using data on California agriculture rather than just citrus.

The size of California's economy is most often measured by state gross domestic product. In 2016, California's state GDP totaled \$2.6 trillion. This means that \$2.6 trillion was either earned by workers as wage income or earned by individuals or businesses as business profits before depreciation or paid as a business tax. The contribution to state GDP of goods-producing industries like agriculture is measured using value-added data from the Department of Agriculture and the Census Bureau.[1] Agricultural value-added is calculated using data on farm receipts and expenditures. USDA estimates that value-added of California agriculture was $25.4 billion in 2016.[2]

Using agriculture's direct contribution to California's GDP understates its economic importance to the state because it ignores the dependence of other sectors of the economy on farm output. For example, California's large food and beverage manufacturing industry is located in the state largely because California's farms produce so much. The industry employs more than 234,000 people and generates $15.7 billion in employment earnings. This compares to farm employment of 241,000 individuals and earnings of $15.9 billion.[3] Other industries are also dependent on agriculture, including those that provide agricultural inputs and that transport farm production and food products made from California farm production.

The dependence of other California industries on agricultural production means that any change in agricultural production has both direct and indirect impacts on the state's economy. Analysts typically use various economic multipliers to capture the broad economic impact of an industry to a state. The output multiplier captures the impact of a change in the value of agricultural output on the change in total economic activity in the state. An output multiplier of 0.7 means that $700,000 worth of economic output outside agriculture is created per $1 million

---

[1] See "Gross Domestic Product by State Estimation Methodology" US Department of Commerce, Bureau of Economic Analysis. 2006.
[2] See USDA-ERS tables available at https://data.ers.usda.gov/reports.aspx?ID=17830#P18185a947f584db5a405671ce25f340f_5_109iT0R0x5
[3] Employment and earnings data obtained from US Bureau of Economic Affairs, state income and employment database.

change in agricultural activity. The labor income multiplier captures the impact on total labor income from a change in labor income in agriculture. A labor income multiplier of 0.6 means that if $1 million more in labor income is paid in agriculture then an additional $600 thousand in labor income is generated in related industries. A value-added multiplier of 1.3 means that $1.30 of value added is created in related industries per dollar of value added increased in agriculture.

The various multipliers are used to estimate the economic effects of a change in the value of agricultural output and employment. The direct effects are simply the effects in agriculture itself, whether it be value of output, employment, labor income, or value added. The indirect effects are the impact that a change in agriculture has on related industries that supply agriculture or that depend on agricultural output. The induced effects are those effects that are caused by California households spending the money that they earn in agriculture or related industries. Adding together the direct effects, the indirect effects, and the induced effects thus provides the total impact that agriculture has on California's economy.

Data on output, value added, employment, and labor income along with estimates of the various multipliers are needed to determine the total economic impact of an industry in California. What also is needed is the particular policy scenario to be analyzed. Two types of policy scenarios are most typically analyzed using multipliers. The first is to estimate the impact of a new industry or investment that is proposed in a region. The economic impact of the new industry is measured relative to the economic situation that currently exists. The second type of policy scenario is to measure the economic contribution of an existing industry relative to the economic situation that would exist if the industry did not exist.

One issue that arises with using multipliers to estimate the economic impact of either gaining a new industry or losing an industry is that the multipliers used in the analysis represent existing inter-industry dependencies. In the case of a wholly new industry locating in a region, these dependencies do not exist so existing estimates of multipliers do not exist. In the case of losing an industry, any new inter-industry connections that form will potentially offset a portion of the negative impacts from the lost industry.

Sources of California Citrus Data

California citrus data are collected by the California Department of Agriculture (CDFA) in collaboration with the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA). An annual citrus summary report is released by NASS in August or September of each year.[4] This August report contains data from the most recent production year. For example, the August 2017 report contains data from the 2016/17 production year. CDFA releases a report that covers all agricultural production in California.[5] The CDFA report contains state-wide citrus data consistent with the NASS citrus report, although the CDFA report contains data from the previous year. In addition, the CDFA report provides data at the county level that is based on county commissioner reports.

The county level citrus data in the CDFA report are reported by county commissioners. The NASS data are collected by statistical surveys. Thus the two data sources do not necessarily measure the same thing. For example, on page 4 of the CDFA 2017 report, the total value of oranges produced in California in 2015/16 is reported as $826.294 million, which is identical to that reported in the NASS report. However, according to the CDFA report, county commissioners report that the two top navel orange countries, Tulare and Kern, produced together $998.041 million worth or navel oranges. The difference between the two data sets is at

[4] Citrus Fruits 2017 Summary. USDA-NASS. ISSN: 1948-9046, August, 2017.
[5] California Agricultural Review: 2016-2017. California Department of Agriculture Office of Public Affairs.

least partly explained by different definitions of value. As stated on page 18 of the CDFA report, fruit value from county commissioner reports is an FOB value which means the fruit has been packed and is ready to be shipped. The aggregate state data in the CDFA report that is consistent with the NASS data is fruit delivered to the packinghouse door which is fruit that has been harvested and transported to the packer. The difference in these two values is the value of FOB. I attempt a reconciliation of these two data sources in this report.

Private sector data about the citrus industry are also available. One report used to help reconcile CDFA county level data with NASS state level data was published by Rabobank.[6] This report is relied on to help reconcile CDFA county data with NASS data.

Destination of California Citrus

The value of citrus grown in California changes as fruit moves along its supply chain. Value is added when fruit on the tree is harvested and then again when it is transported to the packing house. Once at the packing house fruit is either packed for the fresh market or it is aggregated and sent to the processing market. The proportion of California citrus that is packed for the fresh market is shown in Figure 1 for the three most recent years for which data are available. Across the three years an average of 80% of oranges and grapefruit, 75% of lemons, and 70% of mandarins have gone to the fresh market. These data verify that California growers send a high proportion of their citrus to the fresh market.

Fresh market fruit has a higher value than fruit that is processed. More care needs to be taken with fresh fruit so there are higher costs associated with its handling. Processing fruit typically is fruit that does not meet fresh market quality standards. Its sales price is therefore

[6] Rabo AgFocus – November 2015. Available to subscribers only at https://research.rabobank.com/far/en/sectors/regional-food-agri/us-citrus.html

lower than fresh market fruit. In addition, processing fruit is typically identified early in the packing process so a portion of the costs associated with packing fresh fruit are not incurred with processing fruit.[7]

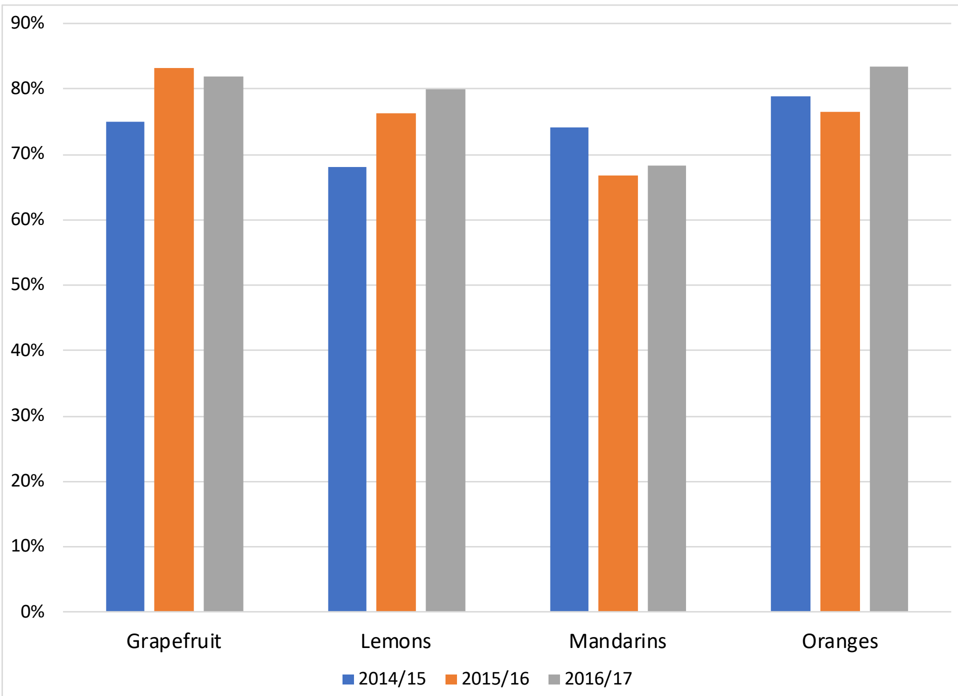

Figure 1. Proportion of California Citrus Packed for Fresh Market

Source: Citrus Fruits 2017 Summary. USDA-NASS. ISSN: 1948-9046, August, 2017.

Value of California Citrus

The objective of this report is to determine the economic contribution of the California citrus industry. A key determinant of this value is revenue generated from citrus sales. The appropriate point in the supply chain at which to calculate revenue from fruit destined for the fresh market is after it has been packed and sold. Because a large proportion of California citrus is consumed outside of the state, it would not be appropriate to measure revenue at the retail level. The most

[7] See Berk, Z., chapter 7 in *Citrus Fruit Processing* Academic Press, Elsevier, London. 2016.

appropriate value of fruit destined for the processing market is the price of fruit delivered to processing plants. Any cost incurred at the packinghouse and transportation costs from the packinghouse to the processing plant would be included in this price.

Ideally then, the value of California citrus harvested in a year would be the value of citrus packed and sold for delivery to the fresh market plus the value of citrus purchased by processing plants. As shown in Figure 1, NASS reports quantities of each type of citrus that is destined for fresh and processing markets. However, NASS does not report the average prices received for California fresh citrus vs. California citrus that is processed because of confidentiality concerns. NASS does not even report average prices received or total state value for California lemons and mandarins.

As stated previously, CDFA reports values for each California citrus type based on reports from California county agricultural commissioners. According to the CDFA, county commissioners report FOB values of California citrus. The NASS data is the value of citrus that has been harvested and delivered to the packinghouse. Table 1 compares the NASS value data with the county commissioners' value data as reported by CDFA. The difference between the two values is a measure of the value that citrus gains from the packinghouse. The implied packinghouse value per box of citrus can be calculated by dividing the Table 1 value difference between CDFA and NASS by the number of boxes that are sold. Production levels as measured by NASS are reported in Table 2. The implied packing house values are reported in Table 3.

Table 1. CDFA and NASS Citrus Values for 2015 and 2014

	CDFA 2015	NASS 2015	CDFA 2014	NASS 2014	Difference 2015	Difference 2014
			$ million			
Oranges	1,502.5	826.0	14,25.9	773.0	676.5	749.4
Lemons*	805.2	701.6	772.3	635.1	103.6	668.7
Mandarins*	969.7	461.1	1,030.1	414.8	508.6	521.5
Grapefruit	79.3	67.6	82.1	50.4	11.7	70.4

Source: Citrus Fruits 2017 Summary. USDA-NASS. ISSN: 1948-9046, August, 2017; California Agricultural Review: 2016-2017 and 2015-16. California Department of Agriculture Office of Public Affairs.
*NASS value of lemons and mandarins calculated by multiplying California's share of total US production by the total US value of production.

Table 2. Fresh and Processed Citrus Sales in 2015 and 2014

	2015		2014		Total	
	Fresh	Processed	Fresh	Processed	2015	2014l
			80 pound boxes.			
Oranges	44,800	13,700	38,000	10,200	58,500	48,200
Lemons	16,000	5,000	20,600	5,500	21,000	26,100
Mandarins	14,500	7,200	13,880	4,820	21,700	18,700
Grapefruit	3,160	640	3,600	1,200	3,800	4,800

Source: Citrus Fruits 2017 Summary. USDA-NASS. ISSN: 1948-9046, August, 2017.

Table 3. Implied Packinghouse Values for Citrus

	$/Box – all boxes		$/box – fresh boxes only	
	2015	2014	2015	2014
Oranges	11.56	15.55	15.10	19.72
Lemons	4.93	25.62	6.48	32.46
Mandarins	23.44	27.89	35.08	37.57
Grapefruit	3.08	14.67	3.70	19.56

Source: Calculated by taking the difference in CDFA and NASS values from Table 1 and then dividing by the number of boxes in Table 2.

The two implied values reported in Table 3 for each citrus type and year differ by whether the Table 1 difference in reported citrus values are divided by total production in Table 2 or by production sold in the fresh market. Production destined for the processing market does enter the packing house to be washed and sorted but it is not packed further. Thus, dividing packinghouse value by all production that enters the packinghouse underestimates per-box value whereas dividing only by fresh production likely overestimates value.

More problematic is the inconsistency in the implied values across the two years, particularly for lemons and grapefruit. Packinghouse value will not vary by a factor of four or five across years. For example, the implied packinghouse value for all produced lemons in 2015 was $4.93 per box whereas the implied value is $25.62 per box in 2014. One explanation for such large discrepancies may be that county commissioners' may be reporting value according to a calendar year and NASS reports production on a marketing year.

In November of 2015 Rabobank released a market report on U.S. citrus and estimated the cost of moving delivered citrus (oranges, mandarins, and lemons) through the packing house and getting it sold and ready to deliver. This report offers an independent check on the magnitude of the implied values in Table 3. The cost per carton as estimated by Rabobank is $4.85 per 38-pound carton for oranges; $1.53 per five-pound carton for mandarins; and $6.10 per 38 pound carton for lemons. On a cents per pound basis this translates to 12.8, 30.6, and 16.1, cents per pound for oranges, mandarins, and lemons respectively. Applying these per-pound values to a 80 pound box yields values of $10.24, $24.48, and $12.84 for oranges, mandarins, and lemons respectively. The Rabobank estimates of packinghouse value for oranges and mandarins are roughly consistent with the 2015 "$/box – all boxes" implied values in Table 3. But the large difference in implied value of lemons in Table 3 makes the Table 3 value difficult to use.

An alternative estimate of the packinghouse value can be obtained from cost of production data published by UC extension. These are packinghouse charges that are deducted from final sales data that determines net returns to growers. The 2015 UC Extension Cost of Production Report for oranges has a charge of $2,688 per acre to pack 686, 37.5-pound cartons. This translates to $8.36 per 80-pound box, which is substantially less than the Table 3 values and the Rabobank value. The 2015 UC Extension Cost of Production Report for lemons has a charge of $3,443 per acre to pack 1139, 37.5-pound cartons. This translates to $6.45 per 80-pound box, which is also substantially less than the Rabobank value. Furthermore, the UC Extension orange packinghouse value is greater than the lemon value, whereas the Rabobank per-box value of oranges is less than the lemon value. UC Extension does not publish a mandarin cost of production report.

An alternative estimate of packing house value can be inferred from citrus price data contained in the NASS annual summary publication. NASS reports monthly prices for FOB packed fresh citrus for California oranges and lemons, and for U.S. grapefruit. NASS bases their estimates of monthly prices on surveys of packinghouses.

The difference between the FOB price and the NASS price for fruit delivered to the packinghouse door is a measure of the value added by packinghouses. The average difference in the price of California navel oranges in 2016/17 as reported by NASS is $9.73 per box, or 12.16 cents per pound. The average difference in the price of California lemons in 2016/17 as reported by NASS is $9.83 per box, or 12.26 cents per pound. And the average difference in the price of U.S. grapefruit across the 2015/16 and 2016/17 marketing years is $9.70 per box or 12.13 cents per pound. The average difference in the price of Florida mandarins during the 2015/16 and 2016/17 marketing years was $13.40 per box, or 16.75 cents per pound. No prices for California mandarins were reported. Given that California produced about 95% of U.S. mandarins in 2016-17, use of the Florida NASS value is not justified.

Taking into consideration the large discrepancy across years in the implied packinghouse value of citrus in the CDFA report, the seemingly low estimates derived from the UC cost of production publications, and the confidential nature of the Rabobank report, I base my estimate of packinghouse value on the NASS price data for oranges, lemons, and grapefruit and the Rabobank estimate for mandarins. But I first need to adjust these values to account for the proportion of fruit that is not packed for the fresh market. Fruit that goes to the processing market is washed and sorted and then sent to processors. Lacking a better estimate, I assume that the packinghouse value added to processing fruit is 40% of the value added to fresh fruit. The method I use to calculate the packinghouse value of California citrus is to multiply the resulting per-box estimates of packinghouse value for oranges, lemons, grapefruit and mandarins by the total number of boxes produced as reported by NASS. Because the implied per-box estimate of packinghouse value for oranges and mandarins in Table 3 is close to the NASS values when the "all-box" value is used, the Rabobank per-box value is applied to all California production to come up with a total value of California citrus. Table 4 presents my final estimate of California citrus value produced in 2016/17.

Table 4. Value of California Citrus

	NASS Value* ($'000)	Number of Boxes Produced ('000)	Value Added of Packinghouse ($/box)	Total Packinghouse Value ($'000)	Total Value ($'000)
Oranges	933,745	50,300	8.77	440,967	1,374,712
Lemons	715,633	20,500	8.65	177,333	892,966
Mandarins	535,196	23,900	19.83	473,908	1,009,104
Grapefruit	78,087	4,000	8.63	34,532	112,619
Total	2,262,661	98,700		1,126,740	3,389,401

*Value of citrus delivered to packinghouse.

Impact of Citrus on California's Economy

The Table 4 value of California citrus represents the revenue generated by citrus sales by packinghouses. This revenue is paid by either buyers of fresh-packed citrus or by citrus processors. A relatively small portion of the purchased citrus is destined for California consumers so the packinghouse sales point in the citrus supply chain is most appropriate for calculating the contribution of citrus to California's economy. The direct contribution of California citrus production on California's economy is $3.389 billion.

The $3.389 billion in citrus sales is distributed to all participants in the citrus supply chain up to and including the packinghouse. After paying citrus growers for the fruit, packinghouse employee costs, and other costs, packinghouse owners receive the remainder as pre-tax profits. Citrus growers use their payments from the packinghouse to cover their own payments to harvest labor, fuel, nutrient and chemicals suppliers, water suppliers, pre-harvest employees, machinery suppliers, and owners of land that is rented. Pre-tax grower profit is what remains after these costs are paid.

The citrus dollars that flow to the suppliers of goods and services used by citrus growers and packinghouses in turn generate their own economic activity. This second-round of economic activity is the indirect effect of California citrus production. The induced effect of California citrus production is the economic activity generated by households that spend the money paid to them for work in the citrus industry and for owning assets (land, buildings, machinery) used in the citrus industry. The total contribution of California citrus production equals the sum of the direct effect, the indirect effect, and the induced effect.

Indirect and Induced Economic Impact of California Citrus

IMPLAN multipliers measure the indirect effects of changes in the value of output in an industry. No IMPLAN multipliers are separately available for California citrus production. For fruit farming in California, the IMPLAN indirect multiplier is 0.445, which means that for every $1.00 change in the value of fruit, an additional 44.5 cents in economic activity is generated. Hodges, et al in their study of the Florida citrus industry use an indirect multiplier of 0.25.[8] But California citrus is managed more intensively than is Florida citrus. Therefore, a greater share of the value of citrus production in California is accounted for by purchased inputs. It is more appropriate to use the California fruit farming multiplier of 0.445 than the multiplier from the Hodges et al report. The IMPLAN induced effect multiplier for California fruit production is 0.568. To be consistent, I use this value for the induced effect multiplier used.

No IMPLAN multipliers specific to the California citrus packinghouse industry are published. Hodges et al estimate that the indirect multiplier of the Florida fresh citrus packinghouse industry is 0.2 and the induced effect multiplier is 1.133. The Hodges et al multiplier values for the processed fruit industry are 0.332 for the indirect multiplier and the

[8] Hodges, A.W., M. Rahmani, T.J. Stevens, and T.H. Spreen. "Economic Impacts of the Florida Citrus Industry in 2012-13." Food and Resource Economics Department, University of Florida. December 19, 2014.

0.719 for the induced multiplier. In the 2016-17 marketing year, 79% of California's citrus was packed for the fresh market and 21% was processed. I take a weighted average of the Hodges et al multipliers and use them here. The weighted average results in an average indirect multiplier of 0.228 and an average induced multiplier of 1.046 for California's packinghouse industry.

Table 5 reports the direct, indirect and induced economic contributions of California's citrus industry. Total direct value of California citrus production was $3.389 billion in 2016-17 from Table 4.. This value generated an additional $1.263 billion in economic activity from related business supplying material and services to the California citrus industry. An additional $2.464 billion in economic activity was generated by households spending income that they received from California's industry, making the total economic impact equal to $7.117 billion.

Table 5. Economic Impact of California's Citrus Industry

	Citrus Production	Packinghouse	Total
		$ million	
Direct Effect	2,262.7	1,126.7	3,389.4
Indirect Effect	1,006.9	256.6	1,263.5
Induced Effect	1,285.2	1,178.8	2,464.0
Total Effect	4,554.8	2,562.2	7,116.9

Source: Calculated by author.

Impact of a Reduction in California Citrus Production

Increased cost of meeting regulations, increased cost of Asian citrus psyllid (ACP) control, and the possible spread of HLB from backyard citrus trees to commercial groves will reduce the profitability of California citrus and likely lead to decreased acreage and production. The multipliers reported here can be used to determine the impact of reduced production on California's economy. Quantification of the impacts of increased cost of regulations and ACP control will be taken up in another report. Here I report the economic impacts of a 20% reduction in California citrus production to illustrate how a change in production will impact California's economy. The economic variables that I use to measure the impact are value of output, employment, employment income, and value added. There are no published estimates of citrus employment data that I am aware of so I make my own estimates and show the assumptions I had to use in the estimation.

A 20% reduction in production could come about either from reduced yield, reduced acreage, or a combination of the two. To facilitate calculation of the impact on employment, I assume that reduced production would come about from a 20% decrease in citrus bearing acreage. UC Extension budgets estimate that is takes approximately 23 hours of labor per acre per year to grow oranges and 20 hours per acre to grow lemons. Harvest costs (picking and hauling to packinghouse) for the two crops are estimated to be $926/acre for oranges and $2,699 per acre for lemons. These harvest costs are based on a per acre yield of 24.5 bins (900 pounds per bin) for oranges and 47.5 bins per acre for lemons. Average yields in 2016-17 in California were 28.8 bins per acre for oranges, 38.8 bins per are for lemons, 37.4 bins per acre for grapefruit, and 37.3 bins per acre for mandarins[9]. Adjusting the UC Extension harvest costs to reflect actual yields in 2016-17 increases orange harvest costs to $1,095 per acre and lowers lemon harvest costs to $2,205 per acre. Lacking data on harvest costs for grapefruit I set per-acre grapefruit harvest costs equal to oranges. Grapefruit have higher yields than oranges but are larger. The only available UC Extension budget for mandarins was a 2011 budget with mandarin harvest costs of $2,385 per acre with a yield of 26.6 bins, which suggests that mandarin harvest

[9] Mandarins are not picked into 900 pound field bins but I express yield in bins to facilitate comparison with orange, lemon, and grapefruit yields.

costs exceed lemon harvest costs. To be conservative, and to reflect the lack of current estimates, I set mandarin harvest costs equal to lemon harvest costs.

The reason why I need to estimate harvest costs is to determine how many hours it takes to pick and haul fruit to the packinghouse. Table 6 shows the calculations and my estimate of the number of hours per acre for each citrus fruit type.

Table 6. Data and Assumptions Used to Calculate Total Hours to Produce California Citrus

	Production Labor	Pick and Haul Cost		Labor Cost	Harvest Hours	Total Hours
	hours/acre	$/acre	% Labor	$/hour	hours/acre	hours/acre
Oranges	23	1,095	90%	15	66	89
Lemons	20	2,205	90%	15	132	152
Grapefruit	20	1,095	90%	15	66	86
Mandarins	25	2,205	90%	15	132	157

Source: See text for calculations of pick and haul cost. Wage rate is total wage rate including taxes. Harvest hours calculated by multiplying pick and haul cost by %Labor and dividing the result by the wage rate.

The total number of hours to grow, harvest and haul California citrus is found by multiplying the Table 6 results by the number of acres for each type of fruit. Dividing the result by the number of hours of work per year (2,087 in an average year) gives the number of full time equivalent jobs involved in producing California citrus and delivering it to the packinghouse. The results are shown in Table 7. My method of estimating employment in producing, picking and hauling fruit results in 14,702 full time equivalent jobs. The number of people actually employed by the citrus industry is larger than this number to the extent that some of the jobs are not full time, which is the case for most harvest labor, for example. The next step is to determine the number of jobs in the packinghouse industry.

Table 7. Estimation of Citrus Jobs Producing, Picking, and Hauling to Packinghouse

	Hours Per Acre	Bearing Acres	Total Annual Hours	FTE Jobs
Oranges	89	155,000	13,745,940	6,586
Lemons	152	47,000	7,157,889	3,430
Grapefruit	86	9,500	813,993	390
Mandarins	157	57,000	8,965,845	4,296
Total	114	268,500	30,683,667	14,702

Source: Calculated by author. Total hours per acre is the acreage-weighted average for each citrus type.

There is no published data showing employment in citrus packing houses. In lieu of a survey of all California packinghouses I base my estimate in this report on published data from the Hodges et al study of the Florida citrus industry. Hodges et al estimate that the fresh fruit packinghouse operations employed 831 people in 2012-13. NASS reports that 6,031 80-pound boxes of fresh oranges were packed in that year.[10] Assuming that California packinghouses have the same ratio of jobs per thousand boxes packed as assumed by Hodges et al, then this ratio—137.7 jobs per thousand boxes packed—can be used to estimate the number of citrus packinghouse jobs in California. According to NASS, California packinghouses packed 77,980 80-pound boxes of citrus in 2016-17. Applying the Florida ratio to the California pack results in 10,744 citrus packinghouse jobs in California.

This estimate does not imply that there are 10,744 full time equivalent jobs in California citrus packinghouses however, because the Florida report does not differentiate between part-time and full-time jobs. Due to the seasonal nature of citrus production, most jobs in the

[10] Citrus Fruits 2013 Summary. NASS, United States Dept. of Agriculture. September 2013.

packinghouse industry are likely less than full time. If 2/3rds of the jobs are half time and 1/3 of the jobs are full time then this translates into 8,301 full time equivalent jobs. Adding 6,972 jobs in the packinghouse industry to the 14,702 jobs in the citrus industry that are needed to produce the fruit and get it to the packinghouse results in a total of 21,674 full time equivalent citrus industry jobs in California. If the average wage in the citrus industry is $10 per hour then this amounts to total income of $452 million in wage income.

As with employment data there are no published data on value-added of California citrus. USDA publishes value added estimates by broad crop category. In 2016 California agriculture sold about $49 billion worth of product and generated about $25 billion in value added, which means that value-added equaled about 50% of total crop sales. If we apply this ratio to the citrus industry then from Table 4, $3.4 billion in sales generated about $1.7 billion in value added. An examination of the UC Cost of Production estimates for oranges and lemons suggests that after subtracting labor costs taxes, including the portion of custom costs accounted for by labor that this 50% value added ratio is reasonable. A report put together by Dr. Timothy Richards in 2008 used a value-added to value of output ratio for California citrus of 57%, but he did explicitly document where he obtained this ratio. Presumably that estimate was provided by IMPLAN. My estimate of $1.7 billion is the direct contribution that the citrus industry made to California's GDP.

I am now in a position to determine the impact of a 20% reduction in citrus acreage caused by either increased cost of regulations or increased costs of ACP control. My calculations are reported in Table 8. A 20% reduction in citrus acreage would decrease the value of California citrus production by $678 million. After adding in the indirect and induced impacts of this reduction, the total value of goods produced in California would amount to $1.114 billion.

Employment in the citrus industry would decrease by 4,335 jobs. Total California employment would decrease by 7,350 jobs after accounting for the indirect and induce impacts. Associated employment income would be reduced by $127 million. State GDP would decrease by about $500 million after the indirect and induced impacts are added to the direct impacts.

Table 8. Annual Economic Impact of a 20% Reduction in California Citrus Acreage

	Output Value $ million	Employment jobs	Employment Income $ million	Value Added $ million
Direct	678	4,335	90	339
Indirect	253	1,649	19	96
Induced	184	1,367	18	66
Total	1,114	7,350	127	501

Source: Calculated by author using IMPLAN multipliers.