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## FARM EXPORTS AND FARM LABOR

### Would a raise for fruit and vegetable workers diminish the competitiveness of U.S. agriculture?

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A quarter of the fresh fruit produced in the United States and almost a tenth of the fresh vegetables are exported. These exports—largely enabled by technology and transportation revolutions allowing fruits and vegetables to be consumed far from their place of production<sup>1</sup>—are a significant and growing force in the U.S. economy. In 2008, U.S. agricultural exports of \$115 billion exceeded agricultural imports of \$80 billion, generating a \$35 billion farm trade surplus. Between 1989 and 2009, the value of U.S. agricultural exports rose 2.5 times, while exports of high-value agricultural products, including fruits and vegetables, more than tripled.

However, over the same 20-year period, average hourly earnings for U.S. farmworkers only increased \$1.52, from \$8.55 to \$10.07 (in 2009 dollars). The workers who are helping to produce these labor-intensive commodities are not seeing much benefit from rising exports.

How would the competitiveness of U.S. fruit and vegetable exports be impacted if farmworker wages rose? And how would this affect the pocketbooks of U.S. consumers? By examining the links between U.S. farmworker wages and fruit and vegetable exports, this briefing paper answers these questions. Specifically, the paper finds:

- A 40% increase in farmworker earnings would lift a typical seasonal farmworker’s earnings from about \$10,000 a year to \$14,000 a year, above the poverty line for an individual.<sup>2</sup>

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- A 40% increase in farmworker earnings would *at the most* raise U.S. household spending about \$16 a year, roughly the price of two matinee movie tickets. U.S. consumers, who spent less than \$430 per household on fresh fruits and vegetables in 2009, would need to spend less than \$446 to accommodate the tiny share of retail prices going to farm labor.<sup>3</sup> (This \$16 estimate assumes that rising wages would not change production or consumption, which likely *would* change, as follows.)
- If farm labor costs rose, farm operators could and likely would make changes that increase worker productivity, including providing workers with productivity increasing harvesting aids, hastening the adoption of productivity-increasing growing and harvesting techniques, providing labor aids that reduce the physical demands of farm work and thus expand the potential workforce, and speeding the mechanization already underway in harvesting of commodities such as oranges and raisin grapes as well as in pre-harvesting activities such as pruning. (Producer responses would of course vary by commodity, producer size, and location.)
- If higher wages prompt changes by farm operators to boost worker productivity, wage increases might expand, rather than reduce, U.S. fruit and vegetable production.
- The impact of any price changes from increased wages (i.e., production cost increases not offset by corresponding increases in productivity but passed along to consumers) would be small because the major export markets for U.S. fresh fruits and vegetables—Canada and Mexico—have few lower cost alternative sources. (Rising U.S. farm wages may have relatively few short-term impacts on certain high-value exports to Asian markets, but these exports could be threatened in the long run by the lower-cost, high-quality production in places such as China even at current wages.)

In short, increasing farmworker wages to raise farmworkers out of poverty poses little threat to consumer pocketbooks or U.S. exports.

## U.S. fruit and vegetable production and trade today

There are several ways to define the U.S. fruit and vegetable industry. The most common definition of labor-intensive agricultural commodities combines the three major categories of fruits (specifically, fruits, berries, and nuts), worth \$19 billion in the 2007 Census of Agriculture; vegetables (specifically, vegetables, potatoes, and melons), worth \$15 billion; and horticultural specialties such as greenhouse and nursery crops, worth \$17 billion. Total fruit, vegetable, and horticultural (FVH) sales in 2007 were \$51 billion, 35% of the value of all U.S. crops. Field crops such as corn, wheat, and soybeans composed much of the balance.

Dependence on hired workers varies within the FVH sector. Most fresh fruits and berries are harvested by hand, while most nuts are harvested by machine. The mechanization in fruits that are processed varies—most grapes used for wine are harvested by machine, but most oranges processed into juice are picked by hand (see the appendix for more details). Potatoes account for an eighth of the value of vegetables and melons, and they are harvested mechanically, while most lettuce and all fresh-market tomatoes are hand-harvested. Greenhouse, nursery, and floriculture production may be the most labor-intensive subsector of U.S. agriculture; since most nursery plants, flowers, and mushrooms involve hand labor, mechanization has proven difficult. However, with trade in these commodities sometimes restricted to avoid the spread of pests and diseases, opportunities to export and exposure to imports is uneven in this sector.

U.S. employment of hired FVH farmworkers has been relatively stable because expanding production of labor-intensive commodities such as cherries and strawberries has offset declining production of labor-intensive asparagus and similar commodities. In some cases, work previously performed by nonfarm workers in packing sheds has moved into the fields, as with packing broccoli and melons. Hard-to-mechanize greenhouse and nursery crop production has expanded with population and housing growth.

The U.S. population increased about 20% between 1991 and 2006. By comparison, **Table 1** shows that U.S.

TABLE 1

## U.S. fresh fruit and vegetable production and trade

	Measurements	Average		Percent change
		1990-92	2005-07	
<b>Acreage</b>				
<i>All fruit (fresh and processed)</i>	1,000 bearing acres	2,839.6	2,972.0	5%
<i>All vegetables (fresh and processed)**</i>	1,000 acres	3,356.2	3,193.6	-5
<b>Total production</b>				
<i>Fresh fruit*</i>	Million pounds	19,540.7	20,930.1	7%
<i>Fresh vegetables</i>	Million pounds	35,334.6	47,964.0	36
<b>Per capita consumption</b>				
<i>Fresh fruit*</i>	Pounds	67.7	75.5	12%
<i>Fresh vegetables**</i>	Pounds	141.6	178.8	26
<b>Imports</b>				
<i>Fresh fruit</i>	Million pounds	2,133.4	6,651.3	212%
<i>Fresh vegetables</i>	Million pounds	3,873.5	10,205.3	163
<b>Exports</b>				
<i>Fresh fruit</i>	Million pounds	4,428.8	5,240.2	18%
<i>Fresh vegetables</i>	Million pounds	2,948.6	4,011.2	36
<b>Import share of consumption</b>				
<i>Fresh fruit*</i>	Percent	12%	30%	140%
<i>Fresh vegetables</i>	Percent	11	19	76
<b>Export share of production</b>				
<i>Fresh fruit*</i>	Percent	23%	25%	10%
<i>Fresh vegetables</i>	Percent	8	8	0

\* Excludes bananas.

\*\* Excludes potatoes, sweet potatoes, dry peas, dry beans, and lentils. Includes melons.

SOURCE: USDA, Economic Research Service, Fruit and Tree Nuts Situation and Outlook Yearbook, Vegetable and Melons Situation and Outlook Yearbook.

fresh fruit production increased just 7% during this period, while U.S. fresh vegetable production increased 36%. Land devoted to fruit production increased 5%, while land devoted to vegetable production fell 5%. Increased vegetable production from fewer acres reflected higher yields, some made possible by producing two or more crops a year on some farmland.

The United States exports about 25% of its fresh fruit production and 8% of its fresh vegetable production. The higher value of fruit compared with vegetables helps to

justify the transportation costs involved in trade. The two leading destinations for U.S.-produced fruits and vegetables are Canada and Mexico (Japan is third). As **Table 2** shows, the leading exported fruits are apples, grapes, and oranges, and the leading exported vegetables include lettuce, tomatoes, and carrots. Total fresh fruit exports were about \$3 billion in 2009, and total fresh vegetable exports about \$1.5 billion (note that the sub-totals in the table are smaller because only the leading export commodities are included there). The top five fruit

TABLE 2

## Major fresh fruits and vegetable exports, 2009

Fresh fruits	Value (\$ millions)
<i>Apples</i>	5753
<i>Grapes</i>	588
<i>Oranges</i>	345
<i>Strawberries</i>	325
<i>Cherries</i>	286
<i>Grapefruit</i>	185
<i>Pears</i>	153
<i>Peaches</i>	137
<i>Lemons</i>	110
<b>Subtotal</b>	<b>\$2,882</b>
<b>Fresh vegetables</b>	
<i>Lettuce &amp; cabbage</i>	431
<i>Tomatoes</i>	179
<i>Carrots</i>	127
<i>Onions</i>	126
<i>Potatoes</i>	125
<i>Broccoli</i>	119
<b>Subtotal</b>	<b>\$1,107</b>

**NOTE:** Includes only fresh fruits and vegetables with export values over \$100 million in 2009.

**SOURCE:** USDA, ERS. Fruits: <http://www.ers.usda.gov/Briefing/FruitandTreeNuts/trade.htm>.  
Vegetables: [www.ers.usda.gov/Briefing/Vegetables/trade.htm#Export](http://www.ers.usda.gov/Briefing/Vegetables/trade.htm#Export)

exports accounted for 80% of the total, and the top five vegetable exports accounted for 90% of the total.

Tree nuts such as almonds, pistachios, and walnuts (grouped with fruits in most FVH data but not included in the table) are the most valuable FVH exports. The value of almond exports, almost \$2 billion a year recently, exceeds the value of vegetable exports, while the value of walnut exports, almost \$700 million, exceeds the value of fresh grape exports. The production of tree nuts is not labor intensive.

On the import side, **Table 3** shows that fresh fruit and vegetable imports have been rising faster than exports. There are several reasons for rising imports, including a year-round U.S. demand that prompts imports of fruits and vegetables when they are not produced in the United States. With the exception of well-known cases such as

Mexican tomatoes arriving during the winter months when Florida is also reducing tomatoes, it is relatively rare for imports to arrive in the United States during peak periods of U.S. production of the same commodities.

### U.S. farmworkers and labor costs

Historically, most U.S. farm work was performed by farm operators and their unpaid family members. During the 1990s, when U.S. Department of Agriculture's Farm Labor Survey asked farm operators how many unpaid family members worked on their farms, it found there were an average of 1.3 million hired workers among the 3.5 million persons employed on U.S. farms, suggesting that hired workers were one-third of average farm employment. If farm employers and unpaid family members worked the same number of hours as hired workers, then

TABLE 3

## Fresh fruits and vegetables, import shares of U.S. consumption, 2007

Commodity	Import share of consumption 2007	Commodity	Import share of consumption 2007
Mangoes	100%	Apricots	22%
Limes	100	Watermelon	21
Bananas	100	Raspberries	14
Papayas	94	Onions	14
Green onions*	91	Snap beans	11
Pineapples	90	Broccoli	11
Asparagus	78	Peaches and nectarines	10
Kiwifruit	78	Carrots	10
Avocados	64	Cherries	9
Grapes	57	Strawberries	8
Cucumbers	52	Oranges	8
Squash	51	Apples	7
Blueberries	43	Lemons	7
Tomatoes	41	Cauliflower	6
Cantaloupe	35	Grapefruit	5
Honeydew	33	Cabbage	5
Radishes	29	Spinach	4
Tangerines	27	Head lettuce	3
Pears	23	Sweet corn	2
Plums	22	Leaf/romaine lettuce	2

\* Green onion data from USDA, Agricultural Marketing Service.

**SOURCE:** USDA, Economic Research Service, Fruit and Tree Nuts Yearbook and Vegetables and Melons Yearbook; USDA, Agricultural Marketing Service, Fresh Fruit and Vegetable Shipments.

one-third of the work on U.S. farms was performed by hired workers.

### **Farm employers, by size of farm, geography, and commodity**

Less than a quarter of all U.S. farms, 482,000 of 2.2 million in 2007, hire workers, and only 36,000 of these had farm labor expenditures of \$100,000 or more (fewer than 10,000 had annual payrolls of more than \$250,000). These large farm employers accounted for 75% of total farm labor expenditures, and on these farms, hired workers do most of the farm work.

In 2007, five states accounted for 43% of the \$22 billion in hired farm labor expenditures: California (\$5

billion), Florida (\$1.2 billion), Texas (\$1.2 billion), Washington (\$1.2 billion), and Oregon (\$815 million).<sup>4</sup> U.S. farmers reported hiring 2.6 million workers directly<sup>5</sup> (the same worker reported by two farmers is counted twice), and the same five states accounted for 41% of direct-hire workers: California (448,000), Florida (115,000), Texas (155,000), Washington (240,000), and Oregon (106,000).

Farmers spent an additional \$4.5 billion on contract labor, that is, workers brought to farms by farm labor contractors and custom harvesters. Farmers do not report to the Census of Agriculture how many workers were brought to their farms by contractors and other intermediaries. However, if total farm labor expenses of \$26.4

TABLE 4

### Fruit-vegetable-horticultural farms, labor expenses and workers hired, United States, 2007

	All farms with labor expenses	Vegetables & melons	Fruits & nuts	Greenhouse, nursery	Three sectors	Share of all	Dairy
<b>Direct hire farms (number)</b>	482,186	13,642	36,293	23,615	73,550	15%	30,994
<i>Labor expenses (\$000)</i>	\$21,877,661	\$2,201,929	\$3,514,033	\$4,698,926	\$10,414,888	48%	2,837,455
<i>Distribution</i>	100%	10%	16%	21%	48%	48%	13%
<i>more than \$250,000</i>	14,627	1,721	2,574	3,147	7,442	51%	2,676
<b>Contract farms (number)</b>	182,701	5,265	30,075	7,638	42,978	24%	5,313
<i>Labor expenses (\$000)</i>	\$4,514,166	\$883,842	\$1,977,432	\$306,091	\$3,167,365	70%	123,747
<i>Distribution</i>	100%	20%	44%	7%	70%	70%	3%
<i>more than \$50,000</i>	11,261	1,399	4,847	802	7,048	63%	543
<b>Direct hires farms (number)</b>	482,186	13,642	36,293	23,615	73,550	15%	41,965
<b>Workers hired</b>	2,636,509	255,940	613,889	351,064	1,220,893	46%	207,307
<i>more than 150 days</i>	911,439	84,987	148,705	180,850	414,542	45%	115,003
<i>fewer than 150 days</i>	1,725,070	170,953	465,184	170,214	806,351	47%	92,304
<i>fewer than 150 days (share)</i>	65%	67%	76%	48%	66%		45%

SOURCE: Census of Agriculture 2007, U.S., Table 62.

billion are divided by the average earnings of U.S. hired workers in 2007, \$10.21 an hour, then the number of full-time equivalent (2,000 hours) jobs on U.S. farms was 1.2 million.

FVH commodities accounted for a third of U.S. crop sales, while FVH farms accounted for one-half of direct-hire labor expenses and 70% of contract labor expenses. Over 73,500 FVH farms hired farmworkers in 2007, but fewer than 7,500 had labor expenditures of \$250,000 or more. The Census of Agriculture does not release the share of total labor expenditures accounted for by these large farm employers, but it is likely that they pay two-thirds or more of farm wages. Similarly, the roughly 7,000 FVH farms that spent \$50,000 or more on contract labor likely accounted for two-thirds or more of total contract labor expenses.

**Table 4** highlights several features of farm labor expenditures. First, most FVH employers were fruit and nut farms, but almost half of the 7,442 FVH farms with \$250,000 or more in labor expenditures were greenhouse

and nursery operations. Second, greenhouse and nursery operations accounted for a fifth of total farm labor expenditures, which was almost as much as fruit and vegetable farms combined. Third, dairy farms, the major employer in the livestock sector of farmworkers, accounted for 13% of total farm labor expenses, and the roughly 2,700 largest dairies (each with labor expenditures of \$250,000 or more) likely accounted for two-thirds or more of dairy labor expenses.

Some 65% of the 2.6 million workers hired by U.S. farms in 2007 were employed fewer than 150 days on the farms that reported them, a common definition of seasonal worker. FVH farms had about the same share of total, year-round, and seasonal hires as their share of farm labor expenses, 45-47% versus 48%. Fruit farms reported the most seasonal hires, about 465,000, and greenhouses and nurseries reported about the same number of seasonal workers as vegetable and melon farms, about 170,000. While fruit and vegetable farms might be expected to hire more seasonal than year-round workers, it is surprising that

almost half of the workers hired by greenhouses, nurseries, and dairies were employed for less than 150 days by the operator reporting them.

### ***Immigrant farmworkers***

Most U.S. farm employers are older white males, while most U.S. hired workers are younger Hispanic immigrants. The U.S. Department of Labor's National Agricultural Worker Survey (NAWS), which surveys workers employed on U.S. crop farms, reported that almost three-fourths of crop workers were born in Mexico and a quarter were born in the United States. Over half of the workers interviewed between 2005 and 2007 were unauthorized (Carroll, Saltz, and Gabbard 2009).<sup>6</sup> The unauthorized share of workers was highest in the Western states, more than 60%, and lowest in the Midwest, less than 30%.

The NAWS interviews over 2,000 crop workers<sup>7</sup> each year. Despite the stable 50% share of crop workers who are unauthorized, several trends point to improving conditions for farmworkers. First, the share of workers hired directly by farmers, rather than via farm labor contractors, rose from 75% in the late 1990s to more than 85% between 2005 and 2007; directly hired workers tend to earn higher wages and are more likely to receive work-related benefits. Second, a rising share of crop workers—75% of those interviewed between 2005 and 2007—had only one farm employer, and the average weeks of farm work have been rising since the late 1990s (Carroll and Saltz 2008). Third, after a few years of modest increases, average hourly earnings in 2007 reached \$9.35 an hour in the USDA's employer survey and \$8.65 an hour in the NAWS.

About three-fourths of the workers interviewed between 2005 and 2007 for the NAWS worked in fruit and nut crops (33%), vegetables (24%), and greenhouse and nursery crops (21%). Crop workers earned an average \$8 an hour in 2006, half of the almost \$17 average hourly earnings<sup>8</sup> of U.S. production workers<sup>9</sup> (Carroll and Saltz 2008). Because crop workers work two-thirds as many hours as full-time workers ( $2/3 \times 2080 = 1387.4$ ), their annual earnings of \$11,100 averaged one-third of the almost \$35,000 average of nonfarm production workers. In addition, most crop workers reported no employment-related benefits, such as health insurance or pensions, from farm employers.

Most hired workers stay in the seasonal farm workforce a decade or less, and the NAWS found that 15% of crop workers were newcomers (i.e., in the U.S. farm workforce for less than a year) between 2005 and 2007. Relatively low wages and seasonal jobs reduce the appeal of working on crop farms. Those attracted to this work are generally workers whose alternative U.S. job options are limited by lack of English-language skills, education, and other factors.

This last point deserves elaboration. Farm employers often say that seasonal farm jobs require skills that most U.S. workers do not have, and so employers presumably have an incentive to recruit and retain skilled farmworkers. However, it is more common for farmers to call labor contractors and other intermediaries and request a crew of workers than for employers to have formal recruitment systems and measures of on-the-job performance.<sup>10</sup>

Furthermore, many of the foreign workers employed on U.S. farms do not have experience in their country of origin with the commodity in which they are employed in the United States. For example, Jamaica, Mexico, and Thailand are not major producers of tree fruits such as apples, a commodity that employs workers from these countries in the United States, and Mexico and Central American countries are not major producers of oranges, raisin grapes, and many of the other U.S. commodities that employ workers from these countries. The major skill of immigrant farmworkers may be their willingness to work at the wages and conditions presented to them rather than experience with the commodity from their countries of origin.

An analysis of California unemployment insurance (UI) data suggests very high turnover among farmworkers in that state (Khan et al. 2004). California requires employers who pay \$100 or more in quarterly wages to obtain a UI reporting number and pay UI taxes,<sup>11</sup> and those with agricultural Standard Industrial Classification or North American Industry Classification System codes reported 1.1 million unique Social Security numbers (SSNs) in 2001,<sup>12</sup> a year in which average employment on the state's farms was about 400,000.

There were about a million unique SSNs or farmworkers in 1991, 1996, and 2001, and they had an average 1.7 million jobs each year, but there is little continuity

from year to year. Only 25% of the SSNs were reported by farm employers in all three years, and only 40% of the SSNs reported by agricultural employers in 1996 were also reported by agricultural employers in 2001.

## **Adjusting to higher wages: case studies**

What would happen to fruit and vegetable production and exports if farmworker wages and labor costs rose? Farm operators could adjust to rising labor costs in several ways. First, they could increase the productivity of current workers by picking fields less often or providing workers with productivity-increasing harvesting aids, such as from-the-field conveyor belts that reduce the time required to carry harvested commodities. Taking this idea a step further, operators could introduce labor aids to raise productivity and encourage farmworkers to remain in the farm workforce longer; making farm work less physically demanding may also induce new workers into the farm workforce. An example of a productivity-increasing labor aid is a lightweight ladder for climbing trees; alternatively, farm operators could switch to dwarf trees and eliminate the need for ladders altogether.

Second, farmers could mechanize activities to reduce the need for hand-harvest workers. Mechanization has been the dominant response to higher labor costs throughout U.S. history, and helps to explain how the United States went from 95% of the population living on farms in the first Census of Population in 1790 to less than 2% today. Mechanization can focus on pre-harvest activities, as when chemicals or precision planters reduce the need for hand-weeding and hand-thinning of crops; harvesting; and post-harvest handling, as when harvested crops are placed in 1,000-pound bulk bins and moved with forklifts rather than in 50- or 60-pound lugs that are carried manually.

### **Higher wages in apple production**

The state of Washington produces 55-60% of U.S. apples. Washington apple growers aim to sell their crop as fresh apples to consumers, and generally do, since the price of apples sold for processing is much lower. China, the world's largest apple producer, accounts for a quarter of the world's apple exports and the United States a sixth of global exports. However, China does not export fresh

apples to the United States, only processed apple products such as apple juice.

The United States exports almost a quarter of its apple production and is a net exporter of fresh apples. One reason for rising fresh-apple exports is newer varieties preferred by consumers. For example, between 1990 and 2010, the Red and Golden Delicious varieties fell from more than 80% of the apples produced in the Western states to less than 40%, while the Gala and Fuji varieties more than doubled, from less than 10% to almost 25%. Diversifying varieties has lengthened the apple harvesting season, which now runs from mid-August to late October, up to four weeks longer than in the past.

If labor costs rose, Washington's fresh apple industry would likely make several changes that increase worker productivity. Most newly planted apples are semi-dwarf or dwarf and planted in rows with trellises to support the weight of the fruit. Newly planted varieties often require more careful pruning, which occurs during the winter months when unemployment rates are typically high for seasonal farmworkers.

Apples growing on dwarf trees are much easier for pickers to locate, and so the use of dwarf trees increases worker productivity. Fewer ladders would reduce falls, improving worker safety, and enlarge the pool of apple pickers beyond the young men who are best suited to climb ladders.

Most apples are picked for piece rate wages that range from \$15 to \$25 per 1,000-pound bin, and most pickers earn more (up to 25% more) than Washington's minimum wage, which was \$8.55 in 2010. Older and lower-value varieties such as Red and Golden Delicious are often picked only once or twice, while newer and higher-value varieties are picked more often, increasing hours per acre. If piece rates and hourly earnings rose, the shift from traditional to newer apple varieties would likely accelerate, which would make labor more productive because most new plantings use dwarf rootstocks.

Harvest mechanization is less likely than increased use of mechanical aids. Apples bruise easily, and this limits the use of the shake-and-catch harvesting machines widely used to harvest tree nuts. Apples are also relatively heavy, so bins full of them could tip the hydraulic platforms on which workers might stand for picking. However, hydraulic

platforms can be used to prune trees, limiting the need to move and climb ladders.

Washington is also the major producer of sweet cherries, whose production has more than doubled in the past two decades. Cherries are an unusual commodity because grower prices have remained high despite sharply rising production. As a result, growers have been willing to pay high piece rate wages for harvesting cherries, and many harvest workers earn \$13 to \$15 an hour. Washington's demand for harvest labor has a saddle shape; it peaks in June-July for the harvest of cherries and again in September-October for apples. Thinning apples and picking pears in August are lower-wage jobs, which is one reason why some Washington apple growers have turned to foreign "guest" workers so they can employ "loyal" workers, that is, workers who remain available for both higher- and lower-wage jobs.

### **Higher wages in orange production**

Almost all Florida-produced oranges, the official state fruit, are turned into juice, while two-thirds of California-produced oranges are sold fresh to consumers. U.S. production of oranges for juice has been declining since the late 1990s due to the urbanization of farmland, freeze and hurricane damage, and two diseases, citrus canker and citrus greening. Imports of frozen concentrated orange juice from Brazil, the world's largest orange juice producer and exporter, have been rising despite a tariff of 7.85 cents a liter. About 30% of U.S. orange juice is imported, mostly from Brazil. Tropicana, owned by PepsiCo, and Minute Maid, owned by Coca-Cola, account for two-thirds of U.S. retail orange juice sales.

Florida's orange groves are often owned by corporations or have absentee owners who rely on a variety of intermediaries to produce oranges. For example, a farm management company may care for the ripening fruit, and a contractor may harvest it and haul it to a processor. Florida has more farm labor contractors than any other state, more than 2,500 in recent years, and they vary in their capabilities and adherence to labor and immigration laws. Some provide only harvest workers, while others buy the orange crop on the tree and profit from the difference between what they receive from the processor and what they paid for the on-tree crop.

Florida's layered labor market has contributed to 14 slavery and involuntary servitude cases involving farm labor contractors between 1996 and 2006.<sup>13</sup> However, owners and operators of orange groves are rarely punished; they claim ignorance of the contractor's activities and assert that a farmer hiring a contractor to harvest oranges is analogous to a homeowner hiring a painter to paint a house. Orange grower Jim Griffiths said: "I wouldn't have the slightest idea who any of them [workers] were or where they are from. Theoretically, you can be fined or penalized for that [hiring unauthorized workers]. But it doesn't matter to me because I don't ever see them or know anything about them.... That's the responsibility of the guy [contractor] hiring them to determine whether they're legal or not. The liability goes back to him."<sup>14</sup>

An acre of oranges yields 300 to 400 ninety-pound boxes of fruit worth \$5 to \$6 or \$0.05 to \$0.06 a pound.<sup>15</sup> Harvesters receive \$0.75 to \$0.80 for each box picked and dumped into 900-pound field bins, less than a cent a pound. Orange harvesting involves climbing ladders, picking oranges, dropping them into a picking sack that weighs 60 to 70 pounds when full, and emptying the sacks into the bins, after which a "goat truck," often a school bus with the sides and roof cut off to resemble a flatbed truck, takes the bins to a trailer that hauls the fruit to a juice concentrate plant.<sup>16</sup>

Florida orange production is moving from the center to the southwest of the state. Newer plantings with smaller trees planted closer together are better suited to mechanical harvesting, which involves continuous-canopy harvest machines that have fingers that reach into trees, pull ripe fruit off the branches, and drop it into a catching frame or to the ground to be picked up. The machines are expensive, and usable only in orange groves that have been designed and pruned for mechanical harvesting, but they reduce harvesting costs by up to 50% compared to hand-harvesting.

Less than 10% of Florida's oranges are mechanically harvested. Mechanization would be sped up by rising wages, improvements in the machines and farming practices, or reduced tariffs that currently protect the Florida growers from cheaper Brazilian imports. The key short-term issue involves the request to approve a chemical loosening agent to facilitate mechanical harvesting of Valencia oranges,

whose trees hold both mature fruit and next year's crop. If too much force is applied to harvest the mature fruit, then the next year's crop is damaged, and an abscission chemical would loosen only the mature fruit.

### **Higher wages in lettuce production**

California (75%) and Arizona (25%) produce virtually all U.S. lettuce; Arizona production is limited to the winter months. U.S. lettuce production increased more than 20% between 1990-92 and 2005-07, but there has been a shift in the type of lettuce preferred by consumers over the past quarter century. Leaf (13%) and romaine (27%) lettuces are increasing their share of the market, while the share of iceberg or head lettuce has declined, though it is still 60% of U.S. lettuce production. More than 60% of U.S. lettuce is sold in bags, and a rising share is produced under contract for the companies that dominate the bagged salad market, Dole and Fresh Express.

A handful of large producers dominate the production of lettuce, which occurs in Salinas most months of the year and in the California-Arizona desert during the winter months. Large lettuce producers have a history of innovation, from developing vacuum tubes that cool heads of lettuce quickly to packaging lettuce in refrigerated bags.

Most head lettuce is harvested by crews of about 40 workers who walk behind slow-moving conveyor belts, cut heads of lettuce, and place them on the belt, where they are conveyed to packers who wrap them with film and pack them into cartons. Most fields are picked twice. Most growers are reluctant to adopt a once-over mechanical harvester because heads of lettuce do not ripen uniformly, so they could lose a quarter of the crop with a once-over harvester. Baby-leaf lettuces are usually harvested by \$250,000 machines that have a band saw to cut up to seven tons an hour, replacing 140 hand workers.

Lettuce has been called green gold because of its profitability, and unions were quick to target large and profitable lettuce growers in the 1970s. Most of the large growers had union contracts with the United Farm Workers or Teamsters that offered entry-level wages twice the minimum wage as well as work-related benefits (including health insurance and pensions) that were rare for seasonal farmworkers. However, rising illegal migration in the

1980s reduced the number of union contracts, and today most lettuce is produced by nonunion workers.

There were reports of labor shortages in the Yuma-area lettuce industry in 2005-06. Large growers operate in this region about four months a year, and they have traditionally relied on green-card commuters, Mexicans with U.S. immigrant visas who elect to live in Mexico and commute daily to U.S. jobs. Green cards were readily available for Mexicans living in the border-area who had U.S. job offers in the 1960s and 1970s. As the number of green-card commuters shrank, younger workers with false documents sometimes joined border-area crews. However, stepped-up border-area enforcement, plus low wages in the border area, encourage younger workers to migrate to the interior of the United States, where they are not subject to daily Border Patrol inspections. The shrinking and aging green-card commuter workforce, plus the availability of low-cost housing in the Yuma area, has encouraged some lettuce firms to hire H-2A workers, legal guest workers who must be provided with housing while they work seasonally in the United States.<sup>17</sup> The fact that some of these H-2A workers live in Mexico instead of in Yuma-area housing explains why there are more H-2A admissions in Arizona in Department of Homeland Security data than in any other state.

The United States exports about 10% of the lettuce it produces, and 85% of U.S. lettuce exports go to Canada. The United States is a net importer of lettuce from Mexico, but imports account for less than 2% of U.S. lettuce consumption. The major reason why some United States growers produce lettuce in Mexico is because they need a backup source of supply in the event that disease or weather, especially in Arizona during the winter months, interrupts production and triggers penalty clauses in their contracts to provide bagged salads. Lettuce growers operating in Mexico acknowledge that wages are lower there, but production costs are similar because of the need to pay transportation costs to the United States.

### **Higher wages in tomato production**

There are three major types of tomatoes grown in the United States. Mature-green tomatoes are picked "green" and ripened with ethylene, a gas that turns them red and yields the hard "slicing tomato" desired by U.S. fast-food

chains. Vine-ripened tomatoes picked when red are preferred by many consumers. Processing tomatoes are grown primarily in California, picked red by a once-over harvesting machine, and turned into catsup and other tomato products. Almost 40% of U.S. tomatoes are imported, primarily vine-ripe tomatoes from Canada and Mexico.

Florida produced almost 60% of U.S.-grown mature-green tomatoes in 2007, primarily during the winter months, and California almost 30%, primarily during the summer months.<sup>18</sup> Mature-green tomatoes are hand-picked into 32- to 35-pound buckets. In Florida, where tomato production is concentrated among 16 growers in the Bradenton-Palmetto region south of Tampa and around Immokalee, pickers receive \$0.40 to \$0.45 a bucket, a piece rate of 1.5 cents a pound which has not changed significantly in two decades. Most Florida growers extend their season by growing tomatoes in Georgia, South Carolina, North Carolina, Tennessee, and Virginia, and rely on labor contractors to supply crews who move north with the harvest.

The Coalition of Immokalee Workers organized boycotts of fast food chains, the major buyers of mature-green tomatoes, until they agreed to raise the price they paid for Florida mature-green tomatoes by a cent a pound and pass the extra penny on to pickers. Taco Bell (2005), McDonald's (2007), Burger King (2008), and Subway (2008) signed agreements with the CIW. However, the extra payments made by these tomato buyers accumulated in trust accounts until November 2010, when the Florida Tomato Growers Exchange allowed its member-growers to distribute the extra money paid by buyers of tomatoes to workers.

The United States is a net importer of tomatoes from Canada and Mexico; the United States exports mature-green tomatoes and imports vine-ripe tomatoes. Canada's greenhouse-grown vine-ripe tomatoes, many grown around Leamington, Ontario with the help of Mexican workers admitted under the Seasonal Agricultural Workers Program, are exported to the Eastern and Midwestern states (Cook and Calvin 2005).

There are several possible responses to an increase in wages for tomato pickers. First, there could be renewed interest in mechanization, especially if tomato varieties that did not have to be staked and were amenable to once-over harvesting were developed. Second, since most mature-

green tomatoes are used in the food-service industry, higher wages could lead to higher prices and reduced usage of slicing tomatoes. Third, imports of mature green tomatoes from Mexico and other countries might rise.

## **Adjusting to higher wages in trade: likely scenarios**

The United States is a net exporter of some fruits and vegetables, such as fresh apples and lettuce, and a net importer of others, such as orange juice and fresh tomatoes (Calvin and Cook 2001). Because fresh fruits and vegetables are mostly water,<sup>19</sup> high transportation costs mean that the major U.S. export markets for fresh fruits and vegetables are neighboring Canada and Mexico. The effects of rising farm wages on fruit and vegetable exports are likely to be minimized by the fact that other suppliers of these commodities to Canada and Mexico face higher transportation costs than the United States. Furthermore, increases in U.S. productivity in producing these commodities could limit price increases.

Fruit and vegetable exports can be broken down into three types, and for each the impact of rising U.S. farm wages is likely to be modest:

1. *Exports facing limited competition.* U.S. exports of fresh apples and lettuce to Canada and Mexico are likely to face little competition from local production or other exporters if rising U.S. farm wages raise production costs. The major effect on U.S. exports of these commodities is likely to be some reduction in consumer demand as a result of higher prices. The exact amount of the drop in demand depends on the price elasticity, which is low for most fruits and vegetables.
2. *Season- and transportation-dependent exports.* The United States exports high-value fresh fruits and vegetables such as cherries and lettuce to Japan and Hong Kong when there is limited local production. Rising farm wages, even if passed on to consumers, may have limited short-term impacts on fruit and vegetable exports to these distant markets, where the major threat to U.S. exports comes from lower-cost and high-quality production that is closer to these markets, such as Chinese production for Japan.

3. *Storable exports competing with low-cost production abroad.* Fresh apples can be stored up to a year and raisins and frozen or canned fruits and vegetables can be stored several years. The long-run competitiveness of storable U.S. fruit and vegetable exports depends on increasing yields and productivity in the United States to compete with lower-cost production elsewhere. Currently, the federal government subsidizes research to improve yields and curb diseases in specialty crops and, after a several decade hiatus, has recently resumed limited support for labor-saving mechanization research. However, the major federal assistance to U.S. fruit and vegetable exports are subsidies to commodity groups to promote their commodities abroad.

Similarly, fruit and vegetable imports can be categorized in three ways, and again the impact of rising U.S. farm wages would be small:

1. *Imports that compete directly with U.S. commodities.* Relatively few fruits and vegetables are imported during times of peak U.S. production; instead, most fulfill off-season demand. There is often some spill-over between imports and U.S. production as production winds down abroad and picks up in the United States, as when Mexican table grape imports in May-June compete with early U.S. production. However, imports are minimal during the July-September peak period of U.S. table grape production.
2. *Imports that meet off-season demand.* U.S. consumers increasingly purchase fresh fruits and vegetables year round, allowing producers in Chile, Mexico, and other countries to supply commodities when there is little or no U.S. production. Because imports are measured on an annual basis, they can rise year-after-year without threatening U.S. farmers and farmworkers if they fill off-season demand in the United States.
3. *Imports of commodities that the U.S. does not produce.* The U.S. produces very few bananas and other tropical fruits, and these accounted for just over 10% of the 270 pounds of fruit consumed by the average

American in 2009. Noncompetitive imports affect U.S. farmers and farmworkers only indirectly, as more banana imports may reduce demand for apples, unless overall fruit consumption rises.

## **Next steps for foreign workers**

Farm employers and worker advocates in December 2000 agreed on an immigration reform plan known as AgJOBS that would allow currently unauthorized farmworkers and their families to become legal immigrants and would make it easier for farm employers to recruit and employ H-2A workers. In the decade since the AgJOBS proposal was negotiated, U.S. fruit and vegetable production has expanded, the share of unauthorized farmworkers has been stable at about 50%, and more farmers, notably vegetable growers operating during the winter months in Arizona and fruit growers in Washington, have turned to the H-2A program to obtain workers.

The changes in the U.S. fruit and vegetable industry since AgJOBS was negotiated suggest three possible next steps:

1. *Examination of the obstacles to productivity-increasing and labor-saving changes in the major crops employing farmworkers.* For example, Environmental Protection Agency approval of abscission chemicals to loosen ripe oranges could accelerate mechanical harvesting of Florida oranges that are processed into juice, as could falling costs for the experimental technology-dependent scout-and-harvest mechanization systems that use scout machines to locate ripe fruit and transmit the information to other machines for harvesting.

Commodities with expanding acreage are likely to mechanize faster, since most new plantings of perennials are designed for the use of machines and mechanical aids in pre-harvest and harvest activities. The federal government plays key direct and indirect roles in shaping the level of production, methods of production, and exports, so its programs, subsidies, and regulations warrant careful examination to determine how rising wages are likely to affect U.S. farmworkers and trade patterns.

2. *A focus on the commodities and areas with growing dependence on H-2A workers.* Even without the employer-friendly changes to the H-2A program included in AgJOBS, the number of H-2A workers has been expanding. Many are in the United States for 10 months or more, meaning that H-2A workers may fill 10% of the roughly one million farm jobs in the United States lasting more than 150 days in U.S. agriculture (there were 911,000 more-than-150-day jobs on U.S. farms in the 2007 Census of Agriculture).

What are the implications of the expanding H-2A program for the legalization envisioned in AgJOBS? Are Arizona vegetable and Washington fruit farmers relying on H-2A workers to be their core labor forces and turning to farm labor contractors who may employ unauthorized workers to supplement these core labor forces? Many of the farm employers who have turned to H-2A workers in recent years stress the importance of “loyal” workers, noting that some U.S. workers left the farm for construction and other nonfarm jobs between 2005 and 2007. With the Department of Labor routinely certifying the employment of H-2A workers for 10 months, what was once a “seasonal workers for seasonal jobs” program is becoming a program to fill what in agriculture are considered almost year-round jobs.

3. *Examination of the horticultural end of the FVH spectrum, i.e., greenhouses and nurseries, as well as dairies that employ large numbers of farmworkers.* Greenhouses and nurseries are major farm employers; they hired twice as many more-than-150-day workers as vegetable farmers in 2007 and the same number of less-than-150-day workers as vegetable farmers. Greenhouses and nurseries face uneven competition from imports—there are many flower imports, but few plant imports (except from Canada). Many U.S. nurseries are located in fast-growing urban areas where workers have a better chance of finding non-farm employment in the off-season.

The dairy industry had higher farm labor expenditures than vegetable and melon farms in 2007, and would be allowed to hire H-2A workers if AgJOBS

were enacted. Dairies are very dependent on government policies, from protectionist trade policies to subsidy programs that prop up milk prices, and dairy is likely to loom larger in farm labor debates as fruit and vegetable producers mechanize.

## Conclusion

Most U.S. farm exports are field crops such as corn and wheat, but a rising share consists of high-value commodities, including fresh fruits and vegetables. Labor costs are 20-40% of the *variable* production costs incurred to produce apples and other tree fruits as well as lettuce and other vegetables. If farm labor costs rise, employers would respond by trying to raise productivity via increased investments in productivity-increasing techniques for use by hand-pickers (lighter ladders, conveyor belts) and labor-saving technologies (harvest machines). They may also make management changes, such as repicking fields less often or recruiting and retaining the best workers.

Producer responses to rising wages are likely to vary by commodity, size of employer, and area. Large farms produce most U.S. fruits and vegetables, and they are more likely than smaller growers to develop and adopt new technologies and to make changes to their labor-management systems. Rising wages, for example, may encourage some producers who now rely on labor contractors and other intermediaries to hire such workers directly.

Efforts to mechanize pre-harvest, harvest, and post-harvest tasks are ongoing. However, implementing mechanization often requires changes in farming practices, such as planting smaller trees and pruning them to facilitate the use of machines, making machines cost-effective compared with hand harvesters, and changing handling and selling practices to accommodate machine-picked fruits and vegetables. Government can play an important role in accelerating mechanization through research subsidies and regulatory changes, and by encouraging cooperation between farm operators and packers and processors.

U.S. production and exports of fruits and vegetables are rising, but hired farmworkers are sharing little of the increased revenues from the trend of increasingly affluent

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and health-conscious consumers buying more produce. Between 1989 and 2009, average hourly earnings for U.S. farmworkers increased only \$1.52, from \$8.55 to \$10.07 (in 2009 dollars). If farm wages rose, there is little threat to consumer pocketbooks because of the tiny share of the retail price that goes to farm labor. And if higher wages prompt changes in farm management practices that increase worker productivity, then a wage increase might even serve to expand rather than reduce U.S. production of fruit-vegetable-horticulture commodities.

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## Appendix: Status of mechanization in fruits and vegetables

Most U.S. fruits and vegetables are harvested mechanically (see **Table A1**). About 75% of U.S. vegetable and melon acreage was machine-harvested in 2000, as was 55% of U.S. fruit production (Sarig et al. 2000). The harvesting of vegetables is easier to mechanize because most are annuals, so the harvest machine can destroy the plant. The harvesting of commodities that are processed often occurs before the harvesting of the same commodity for the fresh market.

Mechanizing the harvest of a fruit or vegetable is more akin to a process than an event, reflecting the fact that new plant varieties may have to be developed to facilitate machine harvesting, farming methods may have to change, and packing and processing systems may have to be adapted to deal with the machine-harvested commodities. Some vegetables that grow below ground, such as potatoes, are harvested mechanically by machines that scoop up the commodity, sift it from the soil, and

**TABLE A 1**

### Harvest mechanization in U.S. fruit and vegetable crops

Commodity	Typical type of harvest		Commodity	Typical type of harvest	
	Fresh	Processed		Fresh	Processed
<b>Deciduous tree fruits</b>			<b>Below-ground vegetables</b>		
<i>Apple</i>	Hand	Hand (a)	<i>Beets</i>	Hand	Machine
<i>Apricots</i>	Hand	Hand (a)	<i>Carrots</i>	Machine (k)	Machine
<i>Avocados</i>	Hand	NA (b)	<i>Garlic</i>	Hand	Machine
<i>Cherries, sweet</i>	Hand	Hand (a)	<i>Green onions</i>	Hand	Hand
<i>Cherries, tart</i>	NA	Machine	<i>Leeks</i>	Hand	Machine
<i>Dates</i>	Hand	Hand	<i>Onions</i>	Hand/machine (e)	Machine
<i>Figs</i>	Hand	(c)	<i>Parsnips</i>	Hand/machine	Machine
<i>Kiwi</i>	Hand	NA	<i>Potatoes</i>	Machine	Machine
<i>Nectarines</i>	Hand	Hand (a)	<i>Sweet potatoes</i>	Machine	Machine
<i>Olives</i>	NA	Hand/machine	<i>Radishes</i>	Hand/machine (h)	NA
<i>Peaches, freestone</i>	Hand	Hand (a)	<i>Turnips/rutabagas</i>	Hand	Machine
<i>Peaches, clingstone for canning</i>	NA	Hand/machine	<b>Above-ground vegetables</b>		
<i>Pears</i>	Hand	Hand (a)	<i>Artichokes</i>	Hand	NA (b)
<i>Plums</i>	Hand	Hand (a)	<i>Asparagus</i>	Hand	Hand
<i>Prunes</i>	Hand	Machine	<i>Broccoli</i>	Hand	Hand/machine
<b>Grapes</b>			<i>Brussels sprouts</i>	Hand	Hand
<i>Wine/juice (grapes)</i>	NA	Machine (i)	<i>Cabbage</i>	Hand	Machine
<i>Raisins</i>	NA	Hand/machine	<i>Cauliflower</i>	Hand	Hand
<i>Table grapes</i>	Hand	NA	<i>Celery</i>	Hand	Machine
<b>Berries</b>			<i>Corn, sweet</i>	Hand/machine	Machine
<i>Blueberries, cultivated</i>	Hand	Hand/machine (l)	<i>Cucumbers</i>	Hand	Hand/machine
<i>Blueberries, wild</i>	Hand	Machine	<i>Eggplant</i>	Hand	Hand
<i>Cranberries</i>	Machine	Machine	<i>Herbs</i>	Hand	Machine
<i>Raspberries/blackberries</i>	Hand	Hand/machine (l)	<i>Lettuce</i>	Hand/machine (j)	NA
<i>Strawberries</i>	Hand	Hand	<i>Lima beans</i>		Machine
			<i>Mushrooms</i>	Hand	Hand (a)

cont. on page 16

**TABLE A1 (CONT.)**

**Harvest mechanization in U.S. fruit and vegetable crops**

Commodity	Typical type of harvest		Commodity	Typical type of harvest	
	Fresh	Processed		Fresh	Processed
<b>Citrus fruit</b>			<b>Above-ground vegetables</b>		
<i>Grapefruit</i>	Hand	Hand (a)	<i>Okra</i>	Hand	Hand
<i>Lemons/limes</i>	Hand	Hand (a)	<i>Peas</i>	Hand	Machine
<i>Oranges</i>	Hand	Hand/machine	<i>Peppers, chili</i>	Hand	Hand/machine (f)
<i>Tangerines</i>	Hand	Hand (a)	<i>Peppers, sweet</i>	Hand	Hand
<b>Melons</b>			<i>Potatoes</i>	Machine	Machine
<i>Cantaloupe, honeydew</i>	Hand	(a)	<i>Snap beans</i>	Hand/machine (g)	Machine
<i>Watermelon</i>	Hand	(a)	<i>Spinach</i>	Hand/machine (m)	Machine
<b>Tree nuts</b>			<i>Squash and pumpkins</i>	Hand	Machine
<i>Almonds</i>	NA	Machine	<i>Squash, summer</i>	Hand	Hand
<i>Hazelnuts</i>	NA	(d)	<i>Sweet potatoes</i>	Hand/machine	Machine
<i>Macadamias</i>	NA	(d)	<i>Tomatoes</i>	Hand	Machine
<i>Pecans</i>	NA	Machine			
<i>Pistachios</i>	NA	Machine			
<i>Walnuts</i>	NA	Machine			

NA = not applicable.

- a. These commodities are hand-harvested and destined to be sold fresh, but some are diverted to processing if they cannot be sold fresh.
- b. California avocados and artichokes are harvested for the fresh market, while processed avocados and artichokes are imported.
- c. Dried figs dry on the tree and fall naturally to the ground for collection.
- d. Most nuts that grow on trees are harvested with machines that grasp the trunk or limb and shake them to the ground or into a catching frame.  
Hazel nuts and macadamia nuts do not ripen uniformly. These nuts dry, fall to the ground, and are collected by machine.
- e. Nonpungent onions with a high water content are often hand-harvested, while pungent onions with less water are more often machine-harvested.
- f. Green chili peppers for canning are hand-harvested, while red chili peppers used to make ground paprika are machine-harvested.
- g. Snap beans are hand- and machine-harvested in Florida; hand-harvested beans usually have a higher grower price.
- h. Radishes sold in bags without tops are machine-harvested, but radishes sold in bunches with tops are hand-harvested.
- i. Up to 10% of wine grapes, mostly those destined for ultra-premium wines costing more than \$14 a bottle, are hand-harvested.
- j. Baby lettuces are often harvested with a saw-band machine.
- k. Bunched carrots with tops are hand-harvested.
- l. Berries destined for the fresh market are often hand-harvested, while those that are frozen, etc. are machine-harvested.
- m. Bunched spinach is hand-harvested; bagged spinach is machine-harvested.

**SOURCE:** Adapted from Calvin and Martin (2010); Sarig et al. (2000).

convey it to a truck or wagon. Most vegetables that grow above the ground, including lettuce and fresh-market tomatoes, are hand-harvested.

Some fruits and nuts that grow on trees are harvested by machines that grasp the trunk or limbs and shake the commodity to the ground or into a catching frame. The key to mechanizing the harvest of tree crops is to develop shake machines that have sufficient force to dislodge the fruit or nut crop without damaging the tree and thus reducing yields in future years. Fruits that are processed are more amenable to being shaken off trees than fruits that are sold fresh, so as a result tart cherries are more

likely to be harvested mechanically than sweet cherries. In some cases, abscission or loosening chemicals are applied to the ripe fruit to make them easier to dislodge by shaking. Florida oranges that are processed into juice are likely to be harvested mechanically if abscission chemicals are approved to loosen the fruit from the stems (Roka 2009).

Mechanical harvesting is generally motivated by efforts to save labor costs. The process of developing new plant varieties and machines to harvest fruits and vegetables is often lengthy, and can be sped up or slowed down by government, which can be involved in the process in many stages, from research to grading the commodity.

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The poster child for successful government intervention to mechanize a harvest is the processing tomato industry, whose harvest in California was mechanized in less than a decade after the Bracero program, which had allowed the seasonal importation of contract workers from Mexico, was terminated in 1964.

Tomato harvest mechanization combined the efforts of plant scientists, who developed a uniformly ripening tomato plant, with those of engineers, who created a machine that cut tomato plants, shook off the tomatoes, and conveyed the fruit past sorters before dumping it into large tubs for transport to processing facilities. Government research funds subsidized the university scientists and engineers who developed the plants and machines, and the new system played a key role in winning acceptance

of mechanically harvested tomatoes by overcoming the perennial price–quality struggle between growers and processors. Growers are paid by weight, and they are penalized by processors if their deliveries contain excess material such as dirt clods and green tomatoes. Government-operated grading stations took random samples of tomatoes from their 12.5-ton containers prior to shipment, thereby reducing rejection rates and speeding mechanization.

In a few cases, harvesting by machine improves the quality of the commodity. For example, because grape-harvesting machines—more than 90% of California’s wine grapes are harvested mechanically—can operate as efficiently at night as during the day, they can take advantage of lower night-time temperatures that reduce the stress on harvested grapes.

## Endnotes

1. Historically, most fresh fruits and vegetables were consumed near their place of production, making them available only seasonally. But technology and transportation revolutions, supported by the availability of labor and water, allowed production for many more months in California to compete with seasonal production in New Jersey and other Eastern garden states in the 1950s, and interstate highways that lowered transportation costs contributed to California's current 40% share of U.S.-produced fresh fruits and vegetables. The United States is hardly alone in this agricultural revolution; the separation of production and consumption is spreading throughout the world, increasing the trade in fresh fruits and vegetables.
2. The poverty line for an individual was \$10,830 in 2009 and 2010 (<http://aspe.hhs.gov/poverty/10poverty.shtml>). For more on the relationship between farmworker wages and food costs, see "Immigrant Workers and Fresh Fruits and Vegetables" ([www.youtube.com/watch?v=BNbQ0xdLXqc](http://www.youtube.com/watch?v=BNbQ0xdLXqc)).
3. Of the less than \$430 spent per U.S. household on fresh fruits and vegetables in 2009, only about 10%, or roughly \$40, went to farm labor costs. Farmers themselves receive a relatively small share of the retail and export price of fruits and vegetables, usually less than 30%, and farm labor costs are typically less than one-third of a farmer's production costs. So if farm labor costs rose 40% and neither production nor consumption changed, household spending would rise about \$16 a year.
4. Census of Agriculture 2007, State Table 7, pp. 336-44.
5. About 35% or 910,000 of these 2.6 million workers hired were employed 150 days or more on the responding farm.
6. The share of U.S.-born crop workers varies by region. Between 2005 and 2007, 24% of workers interviewed by the NAWS were born in the United States. The highest share of U.S.-born workers, 48%, was in the Midwest (some were follow-the-crop migrants based in southern Texas), followed by 36% in the East (some were follow-the-crop migrants based in Florida), and 6% in the Western states.
7. A "crop worker" is defined by the NAWS as someone who performs "seasonal agricultural services...in the vast majority of nursery products, cash grains, and field crops, as well as in all fruits and vegetables," and "also includes persons who work in the production of silage and other animal fodder" but does not include "poultry, livestock and fishery workers, secretaries, mechanics, or H-2A foreign temporary workers." Introduction, National Agricultural Workers Survey, DOL website, <http://www.doleta.gov/agworker/report9/introduction.cfm>
8. Average Hourly Earnings of Production Workers in Manufacturing Industries by State, U.S. Census Bureau, [www.census.gov/compendia/statab/2011/tables/11s1013.xls](http://www.census.gov/compendia/statab/2011/tables/11s1013.xls)
9. The definition of "production workers" includes those "engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, shipping (but not delivering), maintenance, repair, janitorial and guard services, product development, auxiliary production for plant's own use (e.g., power plant), recordkeeping, and other services closely associated with these production operations." Definitions, Annual Survey of Manufacturers, U.S. Census Bureau, <http://www.census.gov/manufacturing/asm/definitions/index.html>
10. There are no survey data that provide the share of farm employers with formal hiring and performance measurement systems. Their number is believed to be small. Fewer than 5% of farmworkers in California are employed on farms with union contracts, and the association for human resources professionals formed to deal with unionized workforces in the 1970s and 1980s, the Ag Personnel Management Association, has shrunk ([www.agpersonnel.org](http://www.agpersonnel.org)).
11. California farm employers have reported their employees and earnings to the California Employment Development Department each quarter since 1978, when unemployment insurance coverage was extended to almost all farm employers.
12. Some SSNs were excluded from the analysis, including the 602 of the total 1,067,948 that had 50 or more employers in 2001 (their 59,776 wage records or jobs were also excluded) and the 2,750 SSNs that had less than \$1 in earnings and jobs that paid more than \$75,000 in one quarter (their 62,571 wage records were excluded).
13. See "Modern-Day Slavery," *Palm Beach Post*, December 7-9, 2003 ([www.palmbeachpost.com/hp/content/moderndayslavery/index.html](http://www.palmbeachpost.com/hp/content/moderndayslavery/index.html)). Contractors are reported to have provided drugs and women to their workers in so-called \$21 clubs, where men are charged \$20 for sex and \$1 for a condom.
14. Quoted in Diane Lacey Allen, "Migrant Workers Find Jobs Easily in Polk County and Across Florida," *The Ledger*, May 22, 2005 ([www.theledger.com/apps/pbcs.dll/article?AID=/20050522/NEWS/505220407/1039](http://www.theledger.com/apps/pbcs.dll/article?AID=/20050522/NEWS/505220407/1039)).
15. Florida typically produces over 200 million 90-pound boxes of oranges a year. In 2006-07, production is expected to be less than 140 million boxes because of 2004-05 hurricane damage and citrus canker; growers received \$10 a box in 2007. However, production is expected to rebound toward 200 million boxes a year.
16. Some 1,800 "goat trucks" were registered in Florida in 2004, and they are allowed to operate within 150 miles of the registered address. Accidents involving goat trucks, which often lack windshields, have prompted calls to ban them from state roadways.
17. The H-2A program, created in 1952 and modified in 1986, allows U.S. farm employers anticipating too few U.S. farmworkers to request that the Department of Labor certify their need for temporary foreign workers ([www.foreignlaborcert.doleta.gov/h-2a.cfm](http://www.foreignlaborcert.doleta.gov/h-2a.cfm)).
18. Florida and California also produce plum, cherry, and grape tomatoes; they accounted for 25% of Florida's tomato production in 2007 and 17% of California's.
19. The water content of fresh fruits and vegetables is typically 85% or more. For example, the water content of apples is 84%, oranges 87%, lettuce 96%, and tomatoes 94%. See [www.ca.uky.edu/enri/pubs/enri129.pdf](http://www.ca.uky.edu/enri/pubs/enri129.pdf)

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