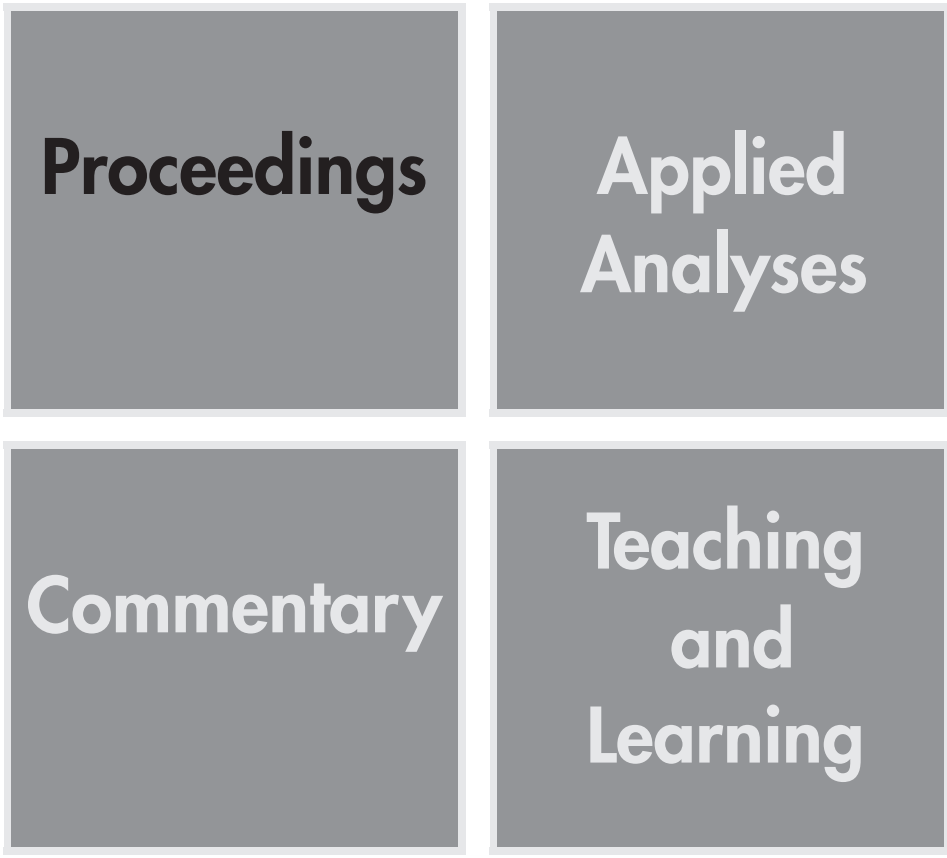

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*Trends, Adjustments, and Demographics, and Income of Agricultural Workers**

Wallace E. Huffman

This paper examines changes in the structure of U.S. agriculture with emphasis on farm productivity, technology, labor, and other major input use. The composition of farm labor, which comprises self-employed and unpaid family, hired, and contract labor, has changed over the past two decades. Some U.S. agricultural production is more easily mechanized, e.g., field crops like corn and soybeans. In contrast, fresh fruit and vegetable harvesting remains very labor intensive with relatively low-skilled workers. For the United States and all regions, immigration legislation passed in 1986, as well as later changes, has meant hired and contract labor have become increasingly synonymous with immigrant workers (Huffman 2003). Important public policy issues are associated with the changing structure of agriculture, including shifts in the composition of farm labor, which affect the well-being of long-term residents and new immigrants (Borjas).

In most of U.S. agriculture, the adoption of increasingly mechanized technique; the use of new chemical inputs, such as herbicides, insecticides and fertilizers; the availability of genetically improved crop varieties and animals; and countless other technical and organizational improvements have dramatically changed agricultural practices. The new biotechnology era started in the mid-1990s with herbicide-tolerant and insect-resistant crops that changed greatly the nature of U.S. field crop production. The widespread diffusion of new information technologies has accentuated the changing structure of agriculture (Huffman 2001).

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The private sector has long been an important source of mechanical, chemical, and biological innovations, and it has been a major factor in shaping the structure of U.S. agriculture (Huffman and Evenson 2005). Mechanical, chemical, and biotech innovations have allowed development of production techniques that economize on labor.

Agricultural Production and Changing Technology

Agriculture is production by biological processes. Plant growth and development are very sensitive to day length, and crop production is land surface area intensive. For non-greenhouse plants, day length and temperature trigger plant stages. Although the completion of any phase of crop production can sometimes be accelerated by using new technology, the timing from planting to harvest is largely unaffected. Furthermore, because crop farming uses large amounts of land surface area, mechanization must consist primarily of mobile power or machines that move through the fields (e.g., tractor-drawn planters, self-propelled combines). Packing and processing operations can be completed in the field or in facilities where stationary power can be used (Mines).

Historically, milk production has been relatively labor intensive, with year round, twice or three times per day feeding and milking. Mechanized milking, automated milk production and feeding records, automated feed distribution based on performance, and automated cleaning of dairy barns has reduced the labor intensity of dairying. Although totally automated milking systems that use electronic sensors, robotic milkers, and video cameras exist, they have not been popular among U.S. producers. Farmers who have large dairy herds have recently discovered that immigrant farm workers are more cost effective than totally automated milking systems.

In vegetable and fruit production, major technical advances have been made in drip irrigation, fertigation, plastic mulch, and new varieties. Irrigation is an important supplement to natural precipitation in most cropland west of the Mississippi and on the sandy soils of Florida and other southern states. Drip irrigation is a water- and labor-saving way to irrigate plants. Hoses with regularly spaced drip holes are laid at the center of beds. When the water is turned on, the drip system delivers water to the root base of the plants, dramatically reducing water percolation (or evaporation) out of the root zone, moving of irrigation rigs, or center pivot irrigation systems. Also, it significantly reduces the amount of labor used relative to irrigation with portable surface pipes.

Fertigation uses the same drip irrigation system to deliver liquid fertilizer efficiently to the roots of plants. A farmer usually applies dry fertilizer before planting vegetables and then supplements during the growing season with fertigation. A positive externality of fertigation is reduced water pollution from leaching and runoff of agricultural chemicals.

Plastic mulch is frequently used with raised and rounded seedbeds in the production of vegetables, tomatoes, and strawberries. Long clear sheets of plastic are laid over the entire bed and pierced only where the young seedlings or plants are planted. Plastic mulch reduces weeds, promotes growth, especially in hot-season plants like tomatoes, and blocks micro-organisms from moving from the soil to plants. The result is less need for hand weeding, herbicides,

fungicides, and other plant protection measures. Plastic raises the soil temperature, reduces water evaporation, and increases the total photosynthetic activity in most plants.

No-till farming has greatly reduced the demand for labor and some other inputs in major field crop production of the Midwest and South. In dry-land farming, the gradual change from intensive seedbed preparation and cultivation to no-till farming started with the relatively high fuel prices of the mid-1970s and was further encouraged by the soil conservation requirement of the Food, Agriculture, Conservation and Trade Act of 1990. The net impact of less tillage and fewer field operations has been reduced demand for labor, large horse-power tractors, mould board plows, heavy disks, and fuel. These savings are partially offset by increased demand for chemical herbicides, herbicide-tolerant plants, and specialized no-till equipment.

Mechanical harvesters also have been developed and widely adopted in some areas for soft fruit (e.g., cherries, peaches, plums), and hard fruit (e.g., apples) for processing, and for nuts. These harvesters have one motorized part that grips the tree and shakes it hard enough to make virtually all the nuts or fruit fall off either on to the ground (nuts) or onto a sloping canvas (fruit). Conveyors can be used to move fruit into boxes. After harvesting, the gripping part of the machine releases and moves to the next tree. These machines greatly reduce the labor needed for harvesting and eliminate the hazardous work of harvesting fruit or nut trees from ladders.

Tomato Production: A Case in Point

Tomatoes are one of the largest U.S. fruit and vegetable crops and the technology has been changing over the past three decades (Huffman 2002). Fresh tomato production is concentrated in Florida and processed tomato production in California. Fresh market tomatoes are hand picked and processed tomatoes are mechanically harvested.

Medium-sized fresh market tomato varieties have been developed that are firm when purchased by the consumer, and generally flavorful. To reduce disease and insect pest problems, these tomato plants are tied to individual wooden stakes or to lines strung between stakes, which is a labor-intensive operation.

Controlled-environment tomatoes (greenhouse- and hydroponically grown) that are harvested vine ripe have experienced rapid growth since 1999. These tomatoes have been largely imported from the Netherlands, Canada, and Israel, but U.S. producers are entering the growing market. The tomatoes have greater uniformity than the open-air varieties, and it is claimed, improved taste. Many are being marketed "on-vine" in clusters to convey the appearance of freshness to consumers. The hand labor in the hothouse is somewhat different from that for traditional open-air staked tomatoes and can approach year-round work.

In contrast, processed tomatoes have been bred for a pear or cylinder shape, high-solids content, uniformity in ripening date, and generally tough skins. With these attributes, they are less susceptible to pests while growing near the ground and can be harvested mechanically (Schmitz and Seckler). The mechanical tomato harvester was developed and adopted widely by California processed tomato growers in the late 1960s. It operates much like a grain

combine, cutting the plants off near ground level and pulling them into a separator, where the tomatoes are shaken off the vines and sorted by gravity through a screen onto rolling conveyor belts. Until the early 1990s, four to six workers were needed to ride on the machines and to undertake hazardous hand sorting of chunks of dirt and green tomatoes from the ripe tomatoes. During this era, payments to growers were frequently docked for excessive dirt and green tomatoes that accompanied ripe tomatoes delivered to processing plants.

During the early 1990s, electronic sorters were developed and attached to mechanical tomato harvesters. These electric-eye sorters were a major technical advance. They sense the color of materials on rolling conveyor belts and use air pressure to blow green tomatoes and chunks of dirt off the belts. The remaining ripe tomatoes are elevated into wagons or trucks. The electronic sorters have reduced the amount of hazardous hand sorting and the number of workers riding on the tomato-harvesting machines. The sorters also have improved the quality of the product delivered to processors by largely eliminating green tomatoes and dirt from loads of ripe tomatoes.

The Changing Structure of Agriculture

Since 1950, U.S. agriculture has had steady output growth at 2% per annum compound. The index of inputs under the control of farmers has hardly changed, although the composition has shifted dramatically. Hence, farm productivity has risen steadily (U.S. Department of Agriculture).

Farm output composition has shifted slightly toward crops relative to livestock, but since 1990, livestock output has grown faster that crop output (figure 1). From 1950 to 1970, the indexes of crop and livestock output each grew at about 1.8% per year. A world grain shortage occurred in the early 1970s and it

Figure 1. Indexes of total farm output, all livestock and livestock products, and all crops: U.S. agriculture, 1950–1999 (1950 = 100)

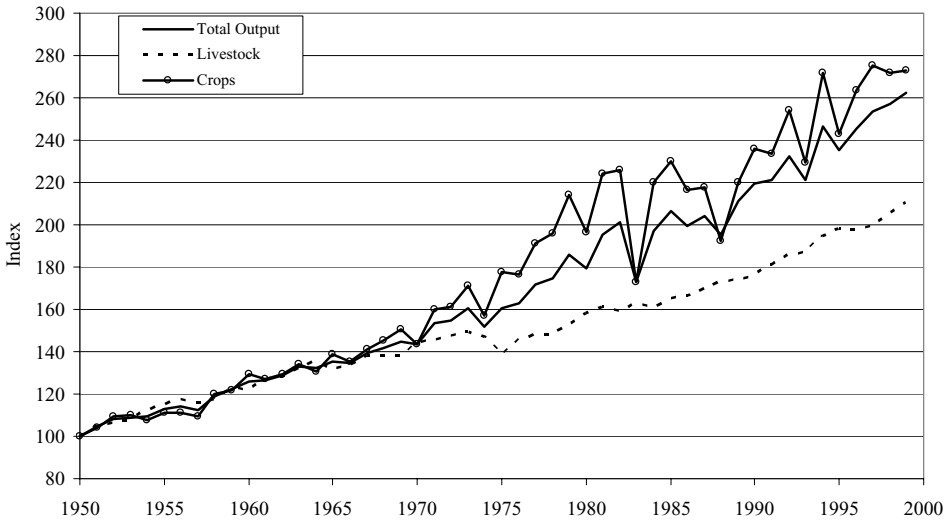
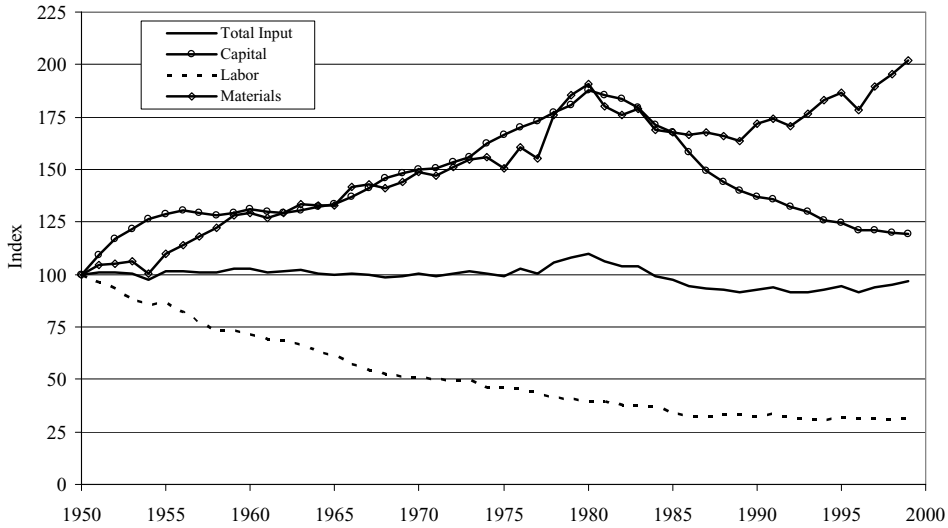


Figure 2. Indexes of total farm input, all capital, all labor, and materials: U.S. agriculture, 1950–1999 (1950 = 100)



doubled world grain prices for a few years. High grain prices in turn reduced the profitability of livestock production. Hence, during the 1970s (and 1980) crop output grew faster than livestock—2.5 versus 1.0% per annum. Total farm output grew at a slightly faster rate of 2.1%.

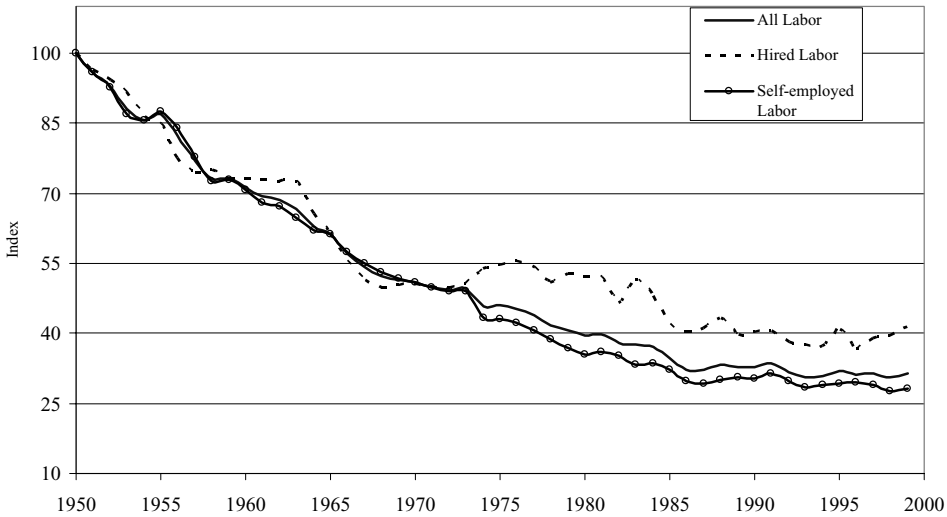
The 1990s brought major reorganization of the U.S. swine industry—consolidation and specialization into factory-type units. At the same time, the highly specialized and integrated poultry industry expanded (Huffman and Evenson 2005). Hence, between 1990 and 1999, livestock output growth regained its lead over crop output—1.96 versus 1.63%.

The index of inputs under the control of farmers was unchanged from 1950 to 1970 (figure 2). It grew at roughly 1% per year during the 1970s, then reversed course, falling 1.7% per year during the 1980s. The input index was roughly unchanged during the 1990s. Hence, little significant net change occurred in the input index over the past half century.

The farm labor input (self-employed, unpaid, and hired) has steadily declined since 1950, falling at 3.1% per annum over 1950–1980 and then 1.5% between 1980 and 1999 (figure 2). Starting in 1950, the rental rate of farm machinery relative to farm wage fell steadily until 1990 (Huffman and Evenson 2001). Major advances in farm machinery invention and mechanization occurred during 1950 to 1980. The size and versatility of farm tractors increased considerably. Farm capital and materials rose steadily at approximately 2.1% per annum each. Hence, this 30-year period was one of rapidly rising capital-to-labor ratio in the farm sector—at 5.5% per annum, while the materials-to-capital ratio was unchanged.

No-till and reduced tillage farming dramatically reduced demand for the large horsepower tractors used during the 1970s for plowing and heavy disking.

Figure 3. Indexes of all labor, self-employed including unpaid and hired labor: U.S. agriculture, 1950–1999 (1950 = 100)

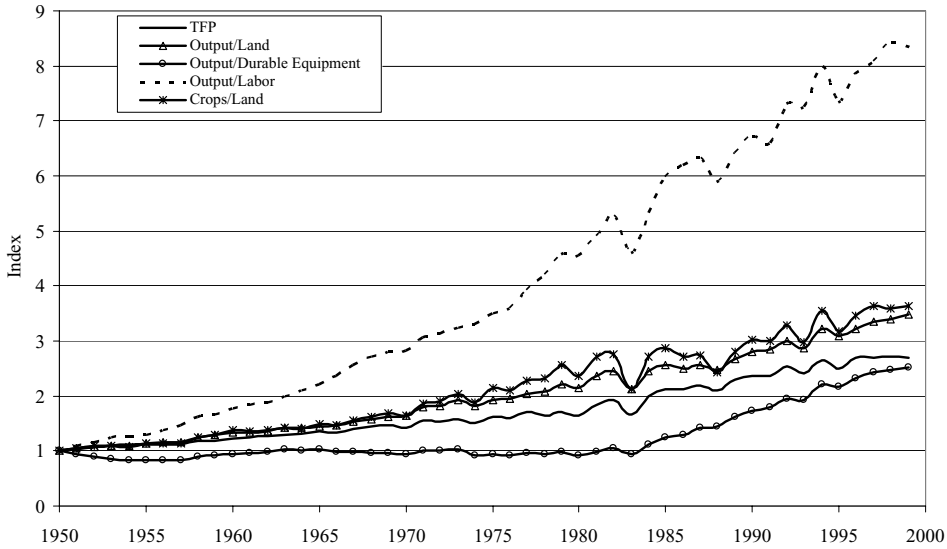


Over 1980–1999, farm capital input declined 2.4% per annum (figure 2). Farm materials fell 1.7% per annum from 1980 to 1989, but then reversed course and started growing again. Hence, over 1980–1990, the farm capital-to-labor and materials-to-labor ratios rose very slowly and the materials-to-capital ratio remained roughly unchanged. Over 1990–1999, the capital-to-labor ratio actually declined 1% per year. The materials-to-capital ratio rose roughly 4% per annum and the materials-to-labor ratio increased 3.4% per year.

The USDA does not include labor obtained through a farm labor contractor as part of its farm labor measure, and instead, this type of labor is included with farm materials.[1] Figure 3 illustrates the long-term adjustment in farm labor. From 1950 to 1970, self-employed and hired farm labor each declined 3.4% per annum. Over 1970–1986, self-employed (including unpaid) farm labor continued to decline at 3.4% annually. In contrast, hired labor grew from 1970 to 1977, remained relatively steady over 1977–1983, and then declined over 1983–1986. The 1986 Immigration and Control Act (IRCA) increased the number and reduced the risks of employing immigrant farm workers (Martin et al.). Since 1986, the number of self-employed and hired labor has been relatively unchanged.

Several aggregate farm productivity indicators exist. Output divided by the quantity of one input results in a "partial productivity index." Figure 4 displays four of these measures. First, total farm output or crop output divided by farmland showed a similar positive trend over 1950–1999, rising at 2.6% per annum. Total farm output per unit of durable equipment was roughly unchanged over 1950–1983, and then rose steadily at 6.4% per annum. Total farm output per unit of farm labor grew rapidly over time—4.3% per year. As a result, farm labor productivity grew dramatically over the past 50 years and was a major factor behind the ability of the farm sector to release labor to other sectors of the economy while farm output continued to grow (Johnson).

Figure 4. Aggregate productivity measures for U.S. agriculture: TFP, total output/land, total output/durable equipment, total output/all labor, all crops/land, 1950–1999 (1950 = 100)



Total factor productivity (TFP)—the ratio of the farm output index to the index of farm inputs under the control of farmers—rose 2.0% per annum over 1950–1999. No other sector of the U.S. economy can match this growth over a period as long as a half century (Jorgenson and Stiroh).

Farm Workers: Type, Number, Wage Rates, and Attributes

In 1950, when there were about 10 million farm workers; 20% were hired workers. In 2000, when the number of farm workers fell to about 3 million, one-third were hired workers. Three sources of data exist on farm workers, and provide different perspectives. The Quarterly Farm Labor Survey (QFLS) is conducted by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS). It is a survey of about 14,500 establishments (farm/ranch/nursery/greenhouse) using farm labor in all states except Alaska. The survey provides quarterly and annual estimates of the number of hired farm workers, percentage of workers who are migrants, average weekly hours worked, and average wage rates for hired workers for 16 separate states and 15 regions. Hourly wages are provided by type of work (field, livestock, supervisor, and other) and method of pay (hourly, piece rate, salary, other). The data include bookkeepers, secretaries, and mechanics who are generally not considered to be hired farm labor, as well as persons involved in the operation of a "farm," but who pay themselves a regular salary, such as corporate partners. Hence, the QFLS provides information on a very broad class of farm workers. Also, the sample size and methods provide accurate estimates down to the state level.

The U.S. Department of Labor conducts the National Agricultural Workers Survey (NAWS), which also is an employer-based survey but with a somewhat

different objective than the QFLS. Each year the survey is conducted in three cycles of 10–13 weeks each and provides the most detailed data on the social and economic characteristics of farm workers employed by growers/farmers and farm labor contractors working in crop production.[2] The NAWS collects data from personal interviews with about 3,600 randomly selected farm workers in crops. NAWS provides detailed information on the demographic and employment characteristics of workers, including legal status, literacy and education, nationality/ethnicity, earnings (hourly, piece rate, salary), and job characteristics. NAWS also collects information on migrant farm workers defined as those who have traveled 75 miles or more from home looking for work or have moved from job to job during the year. The NAWS has a rather narrow definition of farm workers but is designed to provide extensive detail on hard-to-find crop workers. Its sample size and methods provide good national and regional estimates but not state estimates.

The Current Population Survey (CPS) is conducted monthly by the U.S. Bureau of Census. The CPS is a probability sample of the U.S. civilian noninstitutional population containing a sample of about 47,000 households. While the CPS has employment and demographic information for the entire U.S. workforce, it is not specifically designed to collect information on agricultural workers, especially those that are hard to find because of their migratory lifestyles. Hence, the CPS is likely to undercount the number of farm workers and the sample is too small to provide reliable state estimates.

Although a key objective of the IRCA was to reduce the use of unauthorized workers in the United States (Martin et al.), the share reported by the NAWS has risen steadily (Mehta et al.). In 1989, about 8% of hired farm workers were unauthorized, compared with 44% in 1993. It was a little lower for two years and then rose to 52% in 1998.

A growing share of farm crop workers are hired and supervised by farm labor contractors (FLC) rather than growers/farmers. Although FLCs have existed at least since the early 1960s, their intermediary services have grown since IRCA. Under IRCA, employers could be fined for knowingly hiring undocumented workers. FLCs are often themselves immigrants with few assets, which makes them a less frequent target of the INS than growers (Martin and Taylor). The number of FLCs in the West and Southeastern United States has increased by about 50% since 1989, and the number of contract workers has doubled. In 1997–1898, 20% of farm crop workers were hired by FLCs (Mehta et al.).

Although 20% of crop workers were paid a piece rate in 1997–1998, 77% were paid hourly. A piece rate is used most frequently in fruit and vegetable harvesting (36%). A small share of workers are paid a combination of piece and hourly rates (Runyan).

Over 1989 to 2002, the nominal wage rate for all hired farm labor (QFLS data) rose by 49.6%, which translated into a 21.7% increase in the real wage (table 1).[3] In 1989, the wage rate for the U.S. hired farm workers was roughly one-half the hourly wage of a U.S. manufacturing worker.[4] In 1989–2002, the wage of hired farm workers gained relative to U.S. manufacturing workers by about 10%. However, the wage of hired crop workers covered by NAWS lost relative to workers in manufacturing by about 6%.

Table 1. Nominal and real hourly wage rates for hired farm workers and manufacturing workers, 1989–2004

Year	Nominal Wage				Real Wage (2000 = 1.00)[d]				
	Farm				Farm				
	Crops[a]		All[b]	Mfg[c]	Crops		All	Mfg	IPD-PCS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1989	$5.12	$5.24	$5.36	$10.35	$6.51	$6.67	$6.82	$13.17	78.6
1990	5.23	5.23	5.52	10.78	6.41	6.41	6.76	13.21	81.6
1991	5.49	5.57	5.79	11.13	6.50	6.59	6.85	13.17	84.5
1992	5.69	5.33	6.06	11.40	6.59	6.17	7.01	13.19	86.4
1993	5.90	5.46	6.25	11.70	6.67	6.18	7.07	13.24	88.4
1994	6.02	5.54	6.39	12.04	6.67	6.14	7.08	13.33	90.3
1995	6.13	5.71	6.54	12.34	6.64	6.20	7.10	13.40	92.1
1996	6.34	5.67	6.78	12.75	6.75	6.06	7.22	13.58	93.9
1997	6.66	5.89	7.35	13.14	6.98	6.17	7.70	13.77	95.4
1998	6.97	6.40	7.47	13.45	7.22	6.63	7.74	13.94	96.5
1999	7.19	6.54	7.77	13.85	7.34	6.68	7.94	14.15	97.9
2000	7.50	7.00	8.10	14.32	7.50	7.00	8.10	14.32	100.0
2001	7.78	7.11	8.45	14.76	7.60	6.94	8.25	14.41	102.4
2002	8.11	7.30	8.80	15.29	7.81	7.03	8.47	14.72	103.9
2003	8.31		9.08		7.84		8.57		106.0
2004	8.45		9.22		7.82		8.53		108.1
%Δ89–02	46.0	33.2	49.6	39.0	18.2	5.3	21.7	11.1	27.9

[a]Crop workers: column (1) is from the USDA's Quarterly Farm Labor Survey and column (2) is from the National Agricultural Workers Survey (USDL).
[b]All hired farm workers: column (3) from the USDA's Quarterly Farm Labor Survey.
[c]Manufacturing wage: column (4) data are reported by the U.S. Department of Labor.
[d]Real wage is obtained by deflating the nominal wage by the implicit price deflator for personal consumption expenditures, which is in column (9).

Hence, the improvement in hired farm wages has been least for hired crop workers where unauthorized workers from Mexico have provided a steady supply of low-wage but relatively reliable workers. The rate of increase has been higher for noncrop workers who most likely are fluent in English and have more education, which means they face a better nonfarm labor market. However, the rise in the real wage rate for hired farm workers since 1989 is unusual relative to the 1980s (Huffman 1995).

Conclusion

U.S. agriculture has undergone an amazingly rapid and steady technical change over the post–World War II era, and this has continued through the 1990s. New immigration legislation in 1986 assured agriculture of a steady supply of immigrant farm workers, especially for hand harvesting of fruits and vegetables. The real wage rate for hired farm labor rose during the 1990s but

remained low, for example, relative to U.S. manufacturing workers. Very little increase occurred in the NAWS hired crop workers but larger gains occurred for other hired farm workers.

Acknowledgments

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Endnotes

[1]Contract farm labor makes up roughly one-fifth of crop hired labor.

[2]The population excludes H2A farm workers (which are foreign workers requiring a special U.S. Department of Labor permit), mechanics, and secretaries.

[3]From 1989 to 2002, the prices paid by farmers for other production expenses rose 22%.

[4]Although the share of the U.S. labor force employed in manufacturing (or goods producing) has fallen to one-half its level of 1960, this occupation continues to represent an important reference group for farm workers (Ehrenberg and Smith, p. 31).

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