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Demand for Farm Labor in the Coastal Fruit and Salad Bowl States Relative to Midland States: Four Decades of Experience

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This paper provides an updated assessment of the changing demand for farm labor, including its components and relative use, as reflected in the capital-labor ratios for California and Florida, which are major coastal producers of fresh fruits and vegetables, and of Iowa and Texas, which are two major midland agricultural states. Iowa is known for the production of the field crops of corn and soybeans. Texas is a large state with diverse climates and agriculture, which produces wheat and cotton and significant fresh fruit and vegetables. In order to get a good overview of long-term trends, much of our analysis spans more than four decades; i.e., we take this long-term perspective so as to be able to see the "forest" and not be obscured by all of the "trees" that are in noise data. In particular, this paper spans fifteen additional years of data on selected states relative to the data in my paper of one year ago (Huffman 2006)—extending the data forward over 2000 to 2004, which is the most recent data available from the USDA-ERS, and also extending backwards by an additional decade, 1960-1969. Our ability to summarize and analyze trends in US farm labor by state have depended heavily upon data collected by the USDA, but the USDA has withdrawn its funding for its data on self-employed and unpaid family labor by state. Without this information, we will be missing one of the important components of the total farm labor and farm input picture.

In this paper, I first present an overview of some important labor-saving technologies available to horticultural crop producers. Next I turn to a summary of some of the key input, output

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and TFP trends for US agriculture, and finally I provide new information on labor and capital use for CA and FL and for IA and TX. The USDA's estimate of total hired farm workers peaked in 2002, immediately following 9/11, and since then has decreased significantly for the U.S. as a whole and for California. The real wage for farm workers rose until 2003 and then backed off a little. Wages of US hired farm workers rose relative to those of US manufacturing over 1987 to 2000, but backed off a little over 2000-2005. Hence, the decline in hired farm worker numbers seems to reflect a small decline in the real wage let in the period. The share of US crop workers who were born in Mexico has been rising, at least since the 1980s, and now comprises about 80 percent. The share of crop workers who are undocumented has also risen since the Immigration Reform and Control Act (IRCA 1986). The demand for farm labor is affected not only by the local geoclimate that affects crop-choice and prices of various inputs and outputs, but also by technical change that has been steadily progressing, but more slowly in fresh fruits and vegetables that in other crops.

Changing Technology of Crop Production

Agriculture is largely production by biological processes that are affected by their environment—climate, weather, soil, air quality and technology. Plant growth and development are very sensitive to day length and available soil moisture, 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, where mechanization occurs, it must be largely through the use of powered 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 packing/processing facilities, where stationary power can be used (Huffman 2002, Huffman 2005, Huffman and Evenson

2006). The technology of crop production is focused on two key periods in the production cycle: planting through pre-harvest activities and harvesting activities.

Pre-harvest technology

Following are some of the significant advances over the past three decades in planting and pre-harvest technology. In vegetable and fruit production, major technical advances have been associated with drip irrigation, fertigation, plastic mulch and new plant varieties. Irrigation is an important supplement to natural precipitation for all crop production in California and Florida, some of the crop production in Texas and very little in Iowa. Although flood, moving rig, or center pivot irrigation systems center-pivot irrigation have been used for irrigating horticultural crops, the are being replaced by drip irrigation, which is a water- and labor-saving ways irrigate plants. Hoses with regularly spaced drip holes are laid permanently (or temporarily) at the center of beds. When the water is turned on, the drip system delivers water at the root base of the growing plants. This dramatically reduces water percolation out of the root zone or from evaporation, as in flood, moving rig, or center pivot irrigation systems. Also, it dramatically 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 growing plants, especially in fresh vegetable production. With this method of application, a farmer usually starts the growing season by applying dry fertilizer before planting vegetables and then supplements during the later 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 to produce vegetables, tomatoes, and strawberries in California, Florida and Texas. This plastic mulch is placed on raised or rounded seedbeds. Long clear (or sometimes black) sheets of plastic are laid over the entire bed, pierced only where the young seedlings or plants are planted. Plastic mulch reduces weed growth, promotes desired plant growth, especially in hot-season plants like tomatoes, and blocks micro-organisms from moving from the soil to the growing plants. It reduces the need for hand weeding, herbicides, fungicides, and other plant protection measures. Plastic also raises the soil temperature, reduces water evaporation and increases the total photosynthetic activity in most plants.

Since 1999, controlled-environment tomatoes have been grown hydroponically in green houses. These plants obtain all of their nutrients from a liquid solution surrounding the roots of growing plants. The hand labor in the hothouse is somewhat different from that for traditional open-air staked tomatoes and can approach full-time year-round work. These tomatoes have been attractive to consumers because of their greater uniformity than open-air tomatoes and, it is claimed, improved taste. Many of these tomatoes are being marketed “on-vine” in clusters to convey an appearance of freshness to consumers. US production of hydroponic tomatoes is now replacing the traditional Netherlands, Canada and Israel sources.

No-till farming and new herbicide tolerant crop varieties have greatly reduced the demand for labor and some other inputs in major field crop production in 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-70s and was speeded along 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, for large horsepower 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.

Herbicide tolerant field crop varieties were developed and first marketed in the mid-90s for soybeans, cotton, corn and canola. With this technology, a farmer purchases a herbicide tolerant crop variety, for example a RoundUp Ready (RR) tolerant soybean variety. The farmer then plants this soybean variety with minimal seedbed preparation. As the soybeans and weeds start growing, the fields are a mass of green, which is atypical of soybean fields under traditional production methods. After the soybeans have reached several inches of growth, the farmer sprays the whole field with the herbicide RoundUp. All of the non-herbicide tolerant plants are killed over the next few weeks leaving the soybean field clean from weeds. This technology has been especially successful with soybean growers because the soybean plant is not tolerant to long-term weed competition and, furthermore, the effectiveness of the technology is not particularly sensitive to the exact timing of the application of RoundUp. Hence, if a farmer faces an unexpected stretch of rainfall, he will still be able to apply RoundUp, and it will be effective in controlling the weeds in his soybean fields. Hence, RR technology has eliminated the need for hand-weeding of soybean fields and increased the range of chemical weed control from grasses under conventional herbicide use to all weeds under RR technology. Insect resistant cotton has virtually eliminated chemical control of the bud-boll worm complex, thereby dramatically reducing the demand for labor to apply up to 10+ applications of traditional chemical insecticides per growing season in the Delta States (Huffman and Evenson 2006).

Harvesting technology

Harvesting the produce from ripe crops, especially fruits and vegetables, has historically been labor intensive. Harvesting ranges from stoop-labor for vegetables such as strawberries, lettuce, asparagus, broccoli and tomatoes to standing on ladders to pick fruits such as citrus (oranges, grapefruits, lemons, limes), apples, peaches, cherries, pears and avocadoes. Labor-saving mechanization for these crops can be classified as labor aids (e.g., back-saving devices), labor-saving machines (e.g., tree shakers), and automation (e.g., electronic eyes that replace human eyes for selecting and harvesting crops) (see Martin 2006).

The most dramatic labor saving mechanization in US fruit and vegetable production continues to be the tomato harvester for harvesting tomatoes for processing (Schmitz and Seckler 1970). It was developed in the early 1960s by the University of California and spread rapidly in the processed tomato industry of California after the end of the Bracero program in 1964. Before the harvester, workers hand-picked ripe tomatoes, placing them into boxes weighing about 50 pound when full. Theses boxes were then carried to the ends of rows where they were dumped into specially designed trucks. In their place, the mechanical tomato harvester operates much like a conventional small-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 undertake hazardous hand-sorting getting rid of chunks of dirt and green tomatoes so as to have a truck load of high quality 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.

Over time, processed tomato varieties have been bred for a pear or cylindrical 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 easily harvested mechanically.

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 material on rolling conveyor belts and use air pressure to blow green tomatoes and chunks of dirt off the belts. The remaining ripe tomatoes are then 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, also eliminating the green tomatoes and dirt from loads of ripe tomatoes. The net result of the new processed tomato harvesting technology was that harvesting labor costs declined from 50 percent to 15 percent of the cost of producing processed tomatoes.

Mechanical harvesters have also 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 of the nuts or fruit fall off, either onto 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 trees from ladders.

Shake-and-catch machines harvest most tree nuts, and are used to harvest some tree fruits for processing, such as cling peaches for canning and Florida oranges for juice. Other fruit crops whose harvest has been largely mechanized are mid- and low-end wine grapes, and prunes (dried plums). In each case, machines were improved as they were introduced, and then diffused rapidly as processors changed their machinery to deal with machine-harvested crops.

In some commodities, mechanical aids rather than harvesting machines are making jobs easier and workers more productive. Lettuce, celery and broccoli are generally hand-harvested and placed on a slow-moving conveyor belt by workers who follow behind the machine. This eliminates the need for carrying heavy loads of vegetables to trucks, and makes the work accessible to women and older workers and less likely to cause back injuries. A similar conveyor belt harvesting system has been introduced and is spreading through strawberry harvesting. Again this worker-aid has eliminated the need to carry heavy flats of berries to pickup stations. Many leafy vegetables, such as spinach, are cut by band-blade machines, and a machine can harvest fresh-market asparagus, which eliminates stoop labor.

The major problems involved in spreading tree shakers to crops such as apples, avocados and peaches and pears are the lack of uniform ripening and excessive damage to the harvested fruit and sometimes to harvested trees. Some trees must be sprayed with a chemical to loosen their fruit so that they can be shaken off without damaging the trees. However, most fresh fruit packers and processors are not set up to handle crops that include significant damaged fruit. Moreover, mechanical harvesting is easier when trees are short, and these needs have been accommodated in new harvesting by planning dwarf trees at high density.

Overview of the Performance of US Agriculture

US agriculture has experienced steady output and productivity (TFP) growth over the 20th century; TFP growth was at 2 percent per year over 1970-1990, but has slowed to approximately 1 percent per year since 1990 (Huffman et al. 2007). A world grain shortage occurred in the early 1970s that doubled world grain prices for a few years. High grain prices, in turn, reduced the profitability of livestock production. Once farms discontinued livestock production, they were reluctant to re-introduce it. Growth in farm output over the 1970s was 2.24 percent per year and for the whole period, 1970-2002, averaged 1.79 percent per year (figure 1).[2] Over the 1970s and 1980s, crop output grew faster than livestock output, but this differential reversed in the 1990s, when factory style production methods were rapidly adopted in poultry, swine, and beef growing and fattening (Huffman and Evenson 2001; Huffman and Evenson 2006, p. 247-258).

Farm inputs consist of inputs under the control of farmers: capital (services of durable equipment and land), labor (hired and self-employed, including unpaid family labor), and materials

[2] These data on aggregate US agriculture were prepared under the leadership of Eldon Ball and are available at the USDA, ERS website.

(farm-origin materials and purchased energy, agricultural chemicals, and services, including contract labor).[3] At the US level, input growth was slightly negative over the whole period (figure 1). It was positive over the decade of the 1970s, at 0.8 percent per year, but negative over the decade of the 1980s, at -1.63 percent per year. Over 1990-2002 there was little change in the farm input index.

Figure 2 permits a deeper penetration into the farm input index by showing how its three major components performed. Farm labor declined rapidly over 1970-1986, at -2.86 percent per year. However, during the post-IRCA (1986) period, the farm labor index had only a slight negative trend (-0.5 percent per year), which was a dramatically different rate than during 1970-1986.

Farm capital service input grew during the 1970s at 0.9 percent per year, but with the deregulation of interest rates in the late 1970s and a switch from negative to positive real borrowing interest rates, farm capital input declined over the decade of the 1990s by -0.7 percent per year.[4] The decline continued over the remainder of the period, but at a slower rate (figure 2).

Farm materials input grew very rapidly over the decade of the 1970s, at 2.4 percent per year. With the farm crisis of the 1980s, the farm materials input then declined at -1.0 percent per year. The decade of the 1990s brought a return to rapid positive growth of the materials input, at 1.5 percent per year. The materials input index was the only one of the three major farm input groups that ended 2002 at a higher value than when it started in 1970 (figure 2). Hence, there was a major shift from farm-origin to purchased inputs.

Figure 3 provides added perspective on farm labor input and purchased services, including contract labor and other purchased services, that have a large labor share. US hired farm labor

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[3] The USDA continues to ignore recommendations to combine contract farm labor with "hired" and self-employed labor.

[4] Recall that nominal interest rates were de-regulated in 1979 and interest rates shot up abruptly over 1979-83 (US President 1986, p. 256). Real interest rates (the nominal interest rates less the rate of inflation) also show up over this period (US President, p. 256). With a positive and higher real interest rate, the cost of capital services rose.

increased over 1970-1975 by 1.5 percent per year and then had a negative trend over 1975-1986, at -1.45 percent per year. After the IRCA (1986), the amount of hired labor was untrended through 2002. The self-employed category, including unpaid family labor, trended downward for the whole period. However, it had a strong negative trend over 1970-1986, at -3.2 percent and, thereafter, only a slight decline to 2002.

Farm purchased services grew rapidly during the 1970s, at 2.6 percent per year (figure 4). Over the decade of the 1980s there was no trend in farm purchased services. However, over the 1990s, the trend rate of growth was positive again, at 2.6 percent per year. Hence, farm purchased services have become an input of growing importance to US agriculture for more than three decades. One component of these services is labor obtained through farm labor contracts (Martin and Taylor 1995).

Figure 4 shows that the ratio of capital services-to-farm labor in US agriculture grew steadily over 1970-1986, at 2.6 percent per year. But thereafter, this ratio remained unchanged. In contrast, the farm materials-to-labor ratio has a positive trend over the whole period, growing at an average of 2.5 percent per year.

Multifactor (MFP) and labor productivity (LP) in US agriculture have been growing steadily over the 1970-2002 period, at 2.01 percent per year (Huffman and Evenson 2006). This is a fantastically high rate, given that MFP need not change at all when growth in output is due to growth in inputs under the control of farmers. Labor productivity, which is a single factor or partial productivity measure, has been growing even faster than MFP. For the whole period, labor productivity grew at a very high 3.46 percent per year.

In 1950, when there were about 10 million farm workers, 20 percent were hired workers; in 1970, when there were 4.5 million farm workers, 26 percent were hired; and in 2000, when the number of farm workers was only 3 million, one-third were hired workers.[5] Thus, the share of all farm workers that is hired has been rising over the past five decades, and the share would be even larger if all of the contract farm labor were included. This change could be interpreted as a shift away from family farming in the US.

Although a key objective of the IRCA (1986) was to reduce the use of unauthorized workers in the US (see Martin et al. 1995), the share of farm workers who are unauthorized (of illegal status) reported by the NAWS has risen, generally, over time (Mehta et al. 2000). About eight percent of these workers were unauthorized in 1989, 44 percent in 1993, 52 percent in 1998, 55 percent in 1999-2000, but a slightly lower 53 percent in 2001-2002 (USDL 2005, p. ix).

Consistent with the rising share of unauthorized farm workers, Spanish has become the native language of a growing share of US crop workers, e.g., 80+ percent in 1998 and 2001-2002 (Mehta et al. 2000; USDL 2005, p. 17). US farm workers who were educated outside of the US had a median of only 6 years of schooling in 1997-98, versus 11 years for those who completed their schooling in the US. However, since the early 1990s, the amount of schooling completed by farm workers born outside the US has been rising (USDL 2005, p. 18). Mexican workers have relatively easy access to the US and have been quite effective in using ethnic migration networks to substitute for English language facility and education, which is normally associated with geographic mobility. Immigrant farm workers and their families have spread across rural communities of the US during the past 15 years (Huffman 2003). Although drawing upon ethnic capital aids early entry to the US, tight ethnic ties over the long term retards assimilation (Borjas 1999; Borjas 2007).

A growing share of farm crop workers are hired and supervised by a farm labor contractor

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[5] These numbers are based on the USDA Quarterly Agricultural Workers Survey, which seems to under-count contract workers that the USDL National Agricultural Workers Survey focuses upon.

(FLC) rather than a grower/farmer. Although FLCs have existed at least since the early 1960s, their intermediary services have grown since the IRCA. Under the IRCA (and subsequent legislation), employers could be fined for knowingly hiring undocumented workers. FLCs are frequently Hispanics who have few assets, and this seems to make them a less frequent target of the INS/ICE than growers (Martin and Taylor 1995). The number of FLCs in the West and Southeastern US has increased by about 50 percent since 1989, and the number of contract workers has doubled. In 1997-1998, 20 percent of farm crop workers were hired by FLCs (Mehta et al. 2000).

In 1997-1998, 20 percent of crop workers were paid a piece rate and 77 percent were paid hourly; and in 2001-2002 (Mehta et al. 2000), a lower 16 percent were paid a piece rate and a higher 79 percent were paid hourly (USDL 2005, p. 37). Not surprisingly, a larger share of contract labor is paid a piece rate than other hired crop workers. Also, a piece rate is used most frequently in fruit and nut harvesting tasks.

Over 1989-2003, the nominal wage rate for all hired farm labor (USDA-QFLS data) rose by 50 percent, and this translated into a 21.7 percent increase in the real wage after deducting for the increase in the implicit price deflator for personal consumption expenditures from the GNP accounts.[6] (See tables 1 and 2.) However, the real wage declined a little over 2002 to 2005 for all hired farm workers (table 2). Furthermore, it is useful to compare the lot of US hired farm workers with those of another major group of US workers. I choose manufacturing workers because the data have been collected over the long term and they are a recognizable group. Although undocumented non-agricultural workers are more likely to be employed in low skilled service occupations and construction, the manufacturing wage represents a broad spectrum and a fairly large number of workers, and is collected and reported regularly. In 1989, the wage rate for US hired farm workers was roughly one-half the hourly wage of labor in US manufacturing (table 2). Over 1989-2000, all hired farm workers gained relative to US manufacturing workers by about 10 percent, but crop workers covered by NAWS lost relative to workers in manufacturing by about 6 percent. However, over 2000-2004, wages of all hired farm labor and hired crop labor, relative to the wage for US manufacturing workers, was unchanged.

Over 1989-2000, the improvement in the hired farm labor wage was 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 non-crop workers over 1989 to 2002, who most likely are fluent in English and have more education, and thus, face a better nonfarm labor market.[7] Immigrant flows to the farm labor market, especially, near the US-Mexican border may have been disrupted by the anti-terrorist actions in the US after 2001. We do see a major deviation from a positive rate of growth of hired farm workers before 9/11 to a negative one for the whole use and a large decline for California (table 2). The adjustment in immigrant numbers, however, has at most a small effect on real wage rates of hired farm workers. Hence, there are unresolved puzzles about adjustments during the 2002-2005.

Farm Labor and Capital Demand in CA and FL, and in IA and TX

California and Florida lay on the southwestern and southeastern boundaries of the US, and are centers of labor intensive crop production, being major producers of fresh fruits and vegetables. In contrast, Iowa, which is located in the middle of the US, is heavily into field crop production of corn and soybeans, and Texas is located in the middle, but on the southern border with Mexico. Texas is a

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[6] Over 1989-2002, the prices paid by farmers for other production expense rose 22 percent.

[7] However, the rise in the real wage rate for hired farm workers since 1989 is unusual relative to the 1980s (Huffman 1995).

large diverse state producing fresh fruit and vegetables in the far South, but also producing cattle, cotton and wheat elsewhere. Agricultural crops are heavily irrigated in California and Florida, but rain fed in Iowa. In Texas, fruits and vegetables are irrigated. In order to provide a good overall perspective, and not to have my judgment colored by year-to-year fluctuation that may be largely noise, I focus on the long period 1960-2004.[8] See Ball et al. (2002) for details on the construction of indexes for inputs.

Total labor (hired, self-employed and unpaid family) use in California and Florida agriculture remained relatively unchanged over 1960 to 2004, but in Iowa and Texas there was a noticeable negative trend (see Figures 5, 6, 7 and 8). The net decline over the whole period in Iowa and Texas was about 90 percent. The decline in Texas farm labor occurred over 1960 to 1975 and thereafter was largely unchanged. In California and Florida, the quantity of farm hired labor is significantly larger than that of self-employed and unpaid family labor, and the divergence grew over the whole period for California, but grew for Florida only over 1960 to 1996 and then the difference closed. In Iowa and Texas, the quantity of hired farm labor is small relative to self-employed and unpaid family labor. As confirmation of these trends, Figures 9, 10, 11, and 12, show the trend in ln share of hired farm labor in total farm labor over the study period. This share is steadily rising for California agriculture and slightly rising for Florida. In Iowa, the ln share is constant over 1960-1972 and 1978-2000, but rose in 1972-1979 when the world food shortage occurred and real US and world grain prices shot up to near record levels. However, over 2000-2004, the Iowa share of hired labor declined to the level of the 1960-72 period. The share of hired in total farm labor for Texas is most similar to

[8] The Administrators of ERS have decided to discontinue research efforts on the state productivity accounts after 2004. This means that state aggregate data on outputs and inputs will no longer be available on an annual basis. This certainly limits future comparisons and analyses of US agriculture at the state level.

Iowa; it had a negative trend over 1960 to 1972, rose abruptly during the world food shortage era, and has slowly declined thereafter.

The pattern for capital services over the study period is very similar in all four states. Farm capital services (rental on autos, trucks, tractors, and other farm machinery) rose slowly over 1960 to 1970, then more rapidly to 1982 (being about 60 percent larger in 1982 than 1960) and thereafter rose very slowly over the remainder of the period (Figures 9, 10, 11 and 12). Note here that we have excluded land services from the capital service measure; it changes slowly over time.

A major driving force for the capital-labor ratios is the wage-to-capital rental ratios, which are also presented in Figures 9, 10, 11 and 12. In California and Florida, the wage for farm labor relative to the rental rate on farm capital services (quality adjusted) rose over 1960 to 1976 by about 60 percent, declined forty percentage points in the mid-80s in California and by 20 percent in Florida, and then trended upward slowly in both of these states thereafter. In Iowa and Texas, the wage-to-capital rental ratio rose over 1960 to 1972 by about 70 percentage points, but then declined over 1972 to 1984 by about 60 percent. From 1984 to 2002, the trend for the ratio was slowly upward to 2002, and then, seemingly more rapidly upward over 2002-2004. Clearly, the wage-capital rental ratio was higher in all four states in 2004 than it was in 1960. Given the dramatic positive effect that IRCA 1986 had to increase labor availability in agriculture starting in the late 1980s, we can easily speculate that the rate of increase of the wage-capital rental ratio would have been larger with a tighter US-Mexican border. Regarding the 9/11/01 attack, I believe we don’t have enough data yet to make a judgment about its impact on this ratio.

The evidence for the pattern of the capital service-to-total farm labor ratio is presented in Figures 13, 14, 15, and 16. It shows the same general pattern across all four states. The capital service-to-labor ratio rose slowly from 1960 to 1972, then more rapidly to 1980, and flattened out to

2004. The increase over 1960-1980 was about 130 percent. However, in Florida, the rate of growth of the capital-service to labor ratio was slower over 1960 to 1970 than in the other states, and it seems to turn down after 1995 relative to the flat pattern over the remaining years in other states. One conclusion that can be drawn from these results is that the wage-to-capital rental ratio seems not to have been the dominant force behind the change in the capital service-to-labor ratio over 1960 to 2004. This leaves technical change and farm output prices as other likely forces.

Conclusions

US agriculture has benefited from technical change in both pre-harvest and harvesting activities. Technical innovations in crops occurred in both the public and private sector, but over time became more concentrated in the private sector. US agriculture has an amazing record of output growth during the past four decades, but without input growth. Total factor productivity grew at approximately 2 percent per year from 1960 to 1990 and at about one-half that rate thereafter. The exact reason for this slow-down is not known, but may be related to the much slower growth of public agricultural research expenditures starting in the late 80s. In fact, the USDA's index of farm labor fell steadily over 1970-1986, and then flattened out. The level of use of farm purchased services, which includes contract labor, was flat during much of the 1970s and early 1980s, but started growing steadily in 1987. This might be coincident with the passage of IRCA 1986, but I expect there is a causal relationship.

The real wage for hired crop workers rose over 1987 to 2002, and over 1987 to 2000 their wages improved a little relative to workers in US manufacturing. However, over 2002-2005, the real wage of hired farm workers declined a little. Relative to US manufacturing workers, the wage of hired farm workers improved over 1987 to 2000, but then leveled off. NAWS crop workers lost a little relative to manufacturing workers over this period. Anti-terrorist border control activity may have disrupted the farm labor market after 9/11/01. However, the average wage for farm workers over the post-IRCA period, including post 9-11 does not indicate dramatic changes—either positive or negative—in the number of farm workers. However, we do not have information on the counterfactual, so we cannot say that immigrant workers had no effect on real wages of US farm workers.

Farm labor in California and Florida has become increasingly dominated by hired farm labor, while in Iowa and Texas, self-employed and unpaid family labor has been the growing component over the past 45 years. The wage-to-capital service rental has had a generally positive trend over time, which was briefly reversed in the mid-80s. The capital service-to-labor ratio rose in all four states to 1982, and thereafter flattened out. We would expect that a dramatic reduction in immigrant farm workers due to a new tough immigration policy would cause the wage rate for hired and contract farm workers to rise more rapidly than in the past, and the capital service-to-labor ratio also to increase with a lag. Although some harvesting activities have not effectively experienced technical change that lessens the burden of hard field work, a rapidly rising real farm wage rate would cause growers and inventors to search for new ways to economize on farm labor.

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Figure 1. Indexes of Total Farm Output, Total Farm Input, and Multifactor Productivity: U.S. Agriculture, 1970-2002 (1970=1.00)

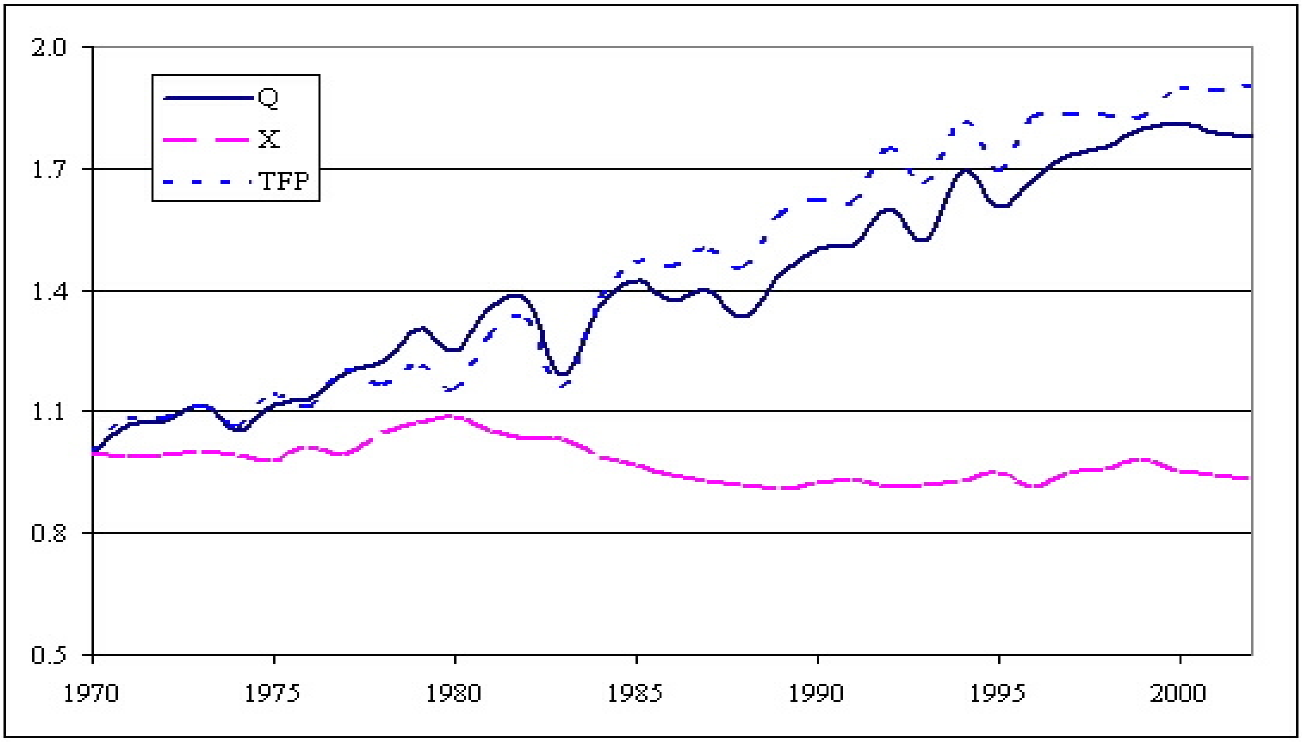

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Figure 2. Indexes of Total Farm Input, Capital Input (including Land), Labor Input, and Materials Input: U.S. Agriculture, 1970-2002 (1970=1.00)

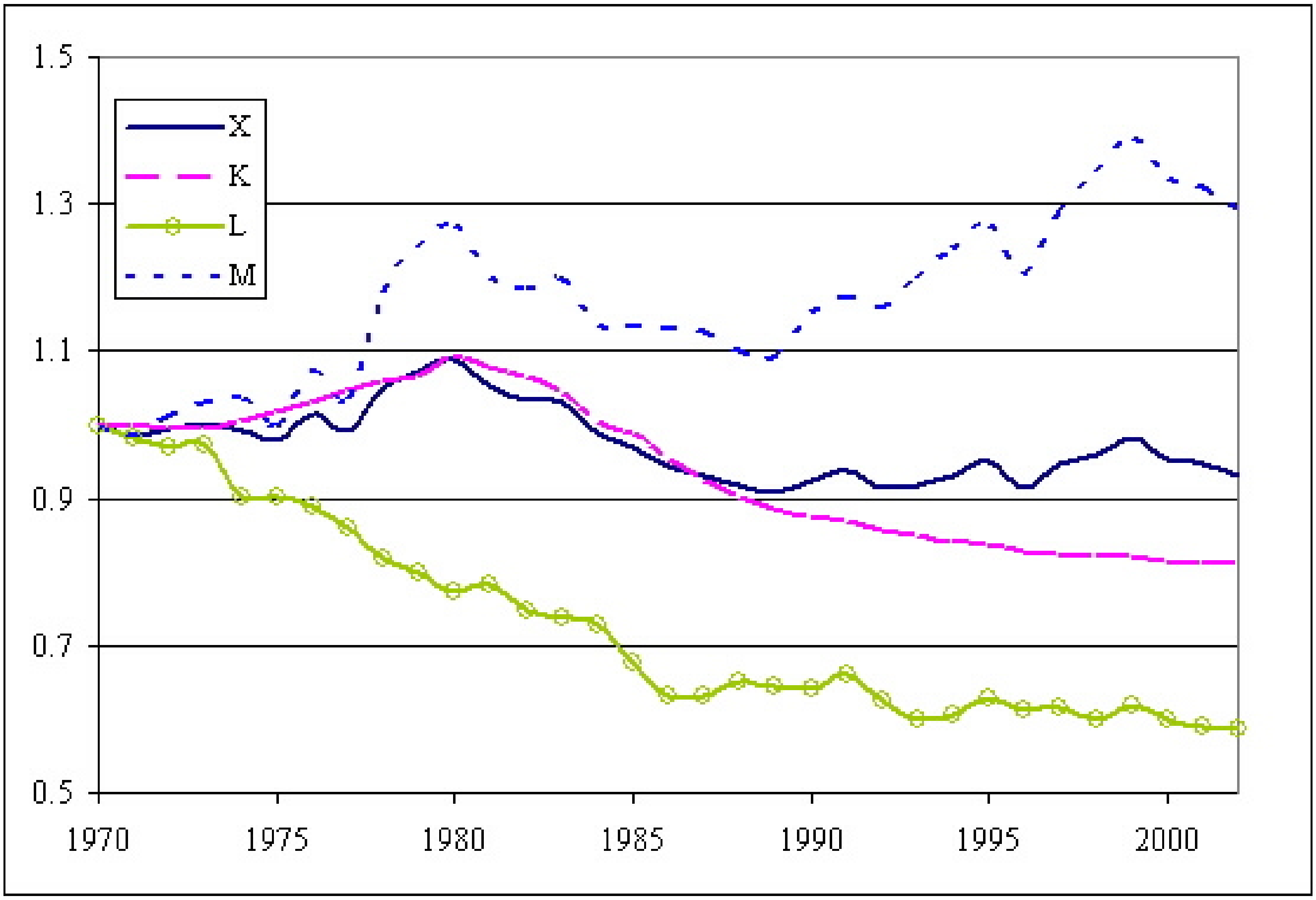

Figure 3. Indexes of All Labor, Self-Employed (Including Unpaid) and Hired Labor, and Purchased Services (includes Contract Labor): U.S. Agriculture, 1970-2002 (1970=1.00)

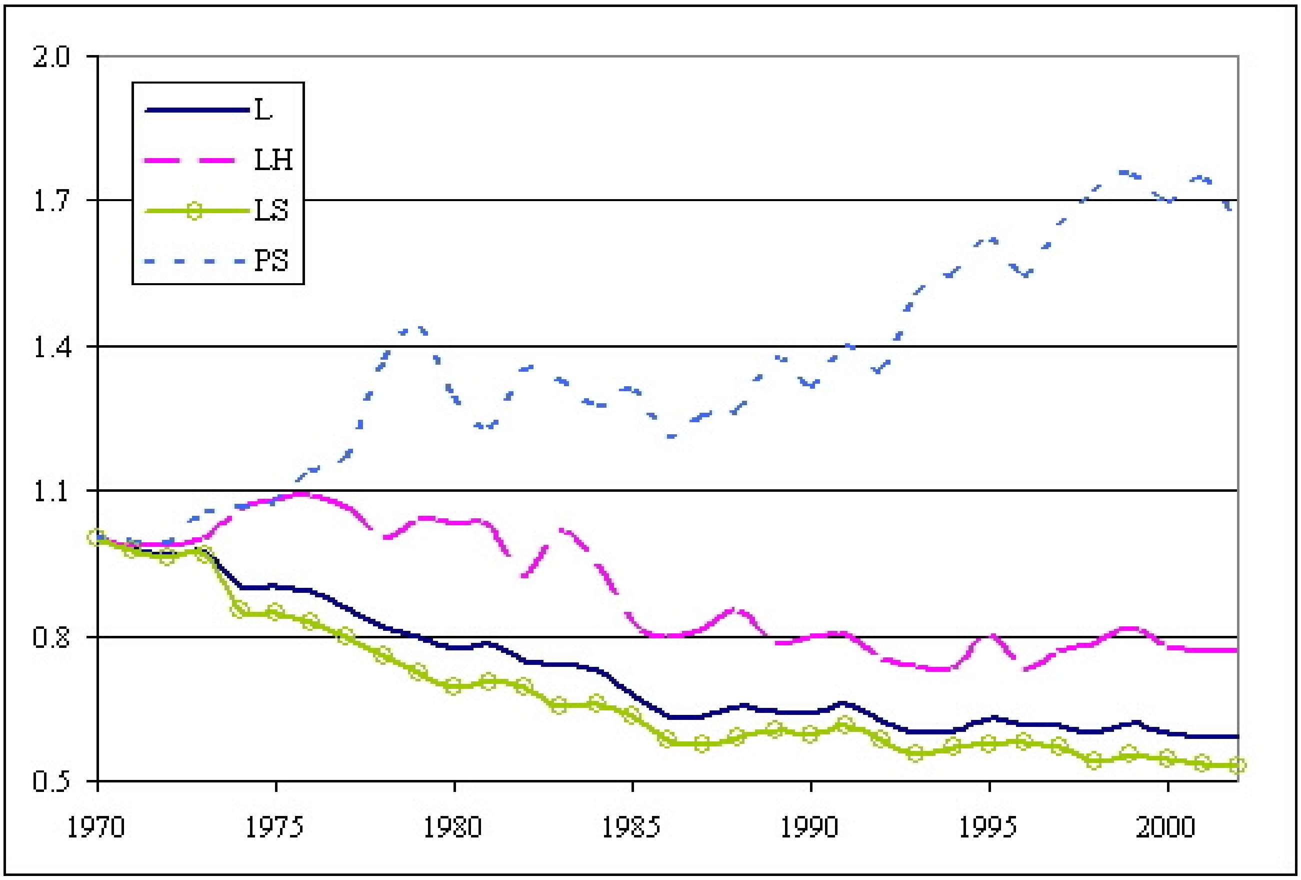

Figure 4. Multifactor Productivity, Labor Productivity, Capital-to-Labor Ratio and Materials-to-Labor Ratio: U.S. Agriculture, 1970-2002 (1970=1.00)

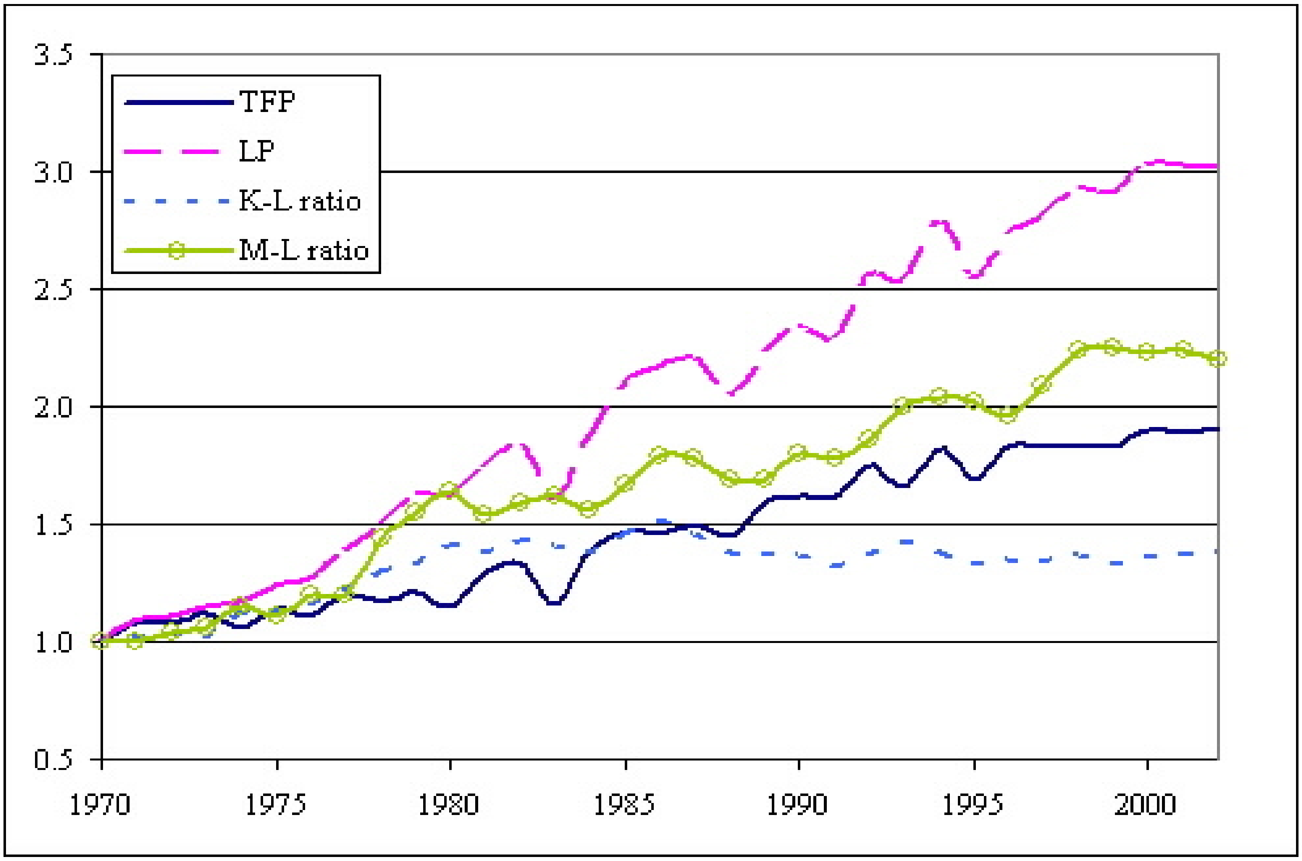

Figure 5. Hired Farm Labor, Self-Employed and Unpaid Family and Total Farm Labor, California: 1960-2004

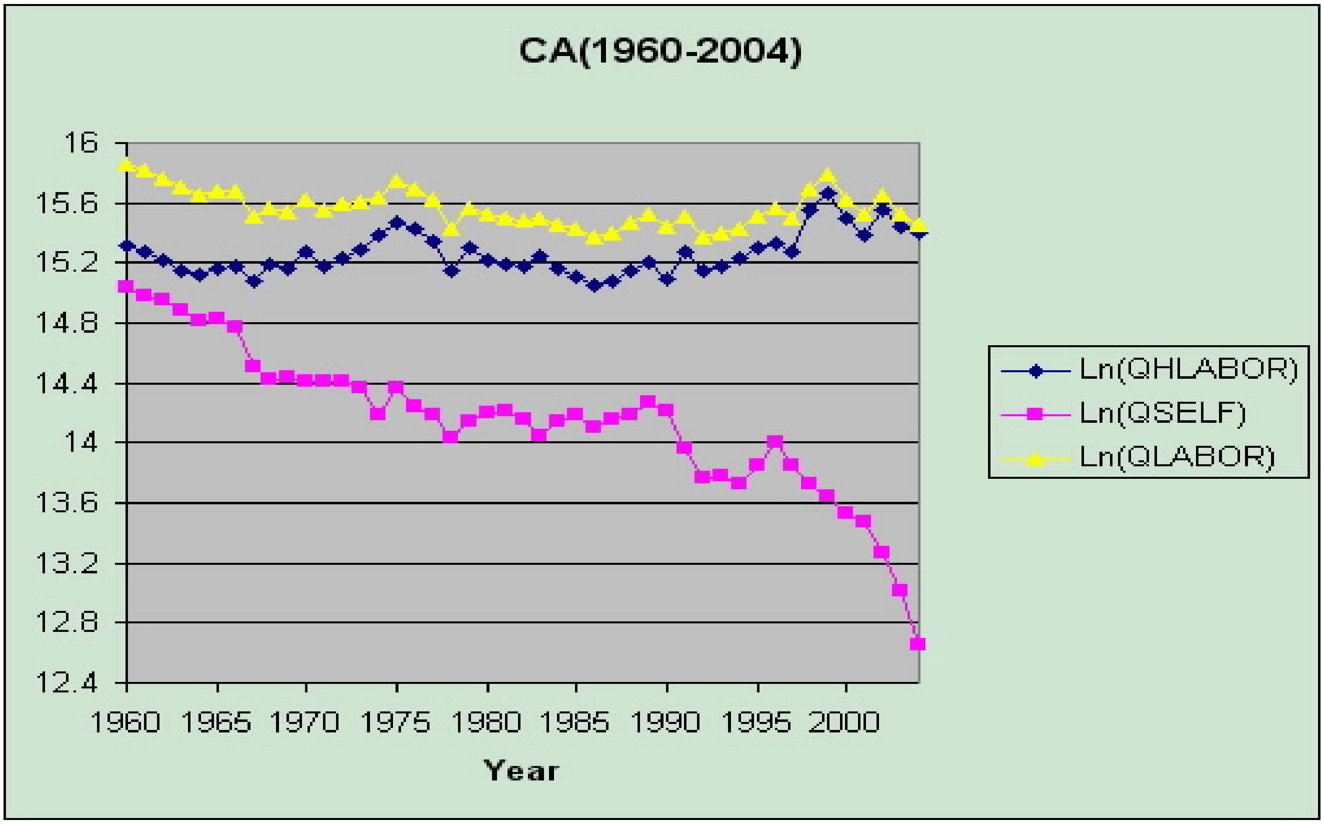

Figure 6. Hired Farm Labor, Self-Employed and Unpaid Family and Total Farm Labor, Florida: 1960-2004

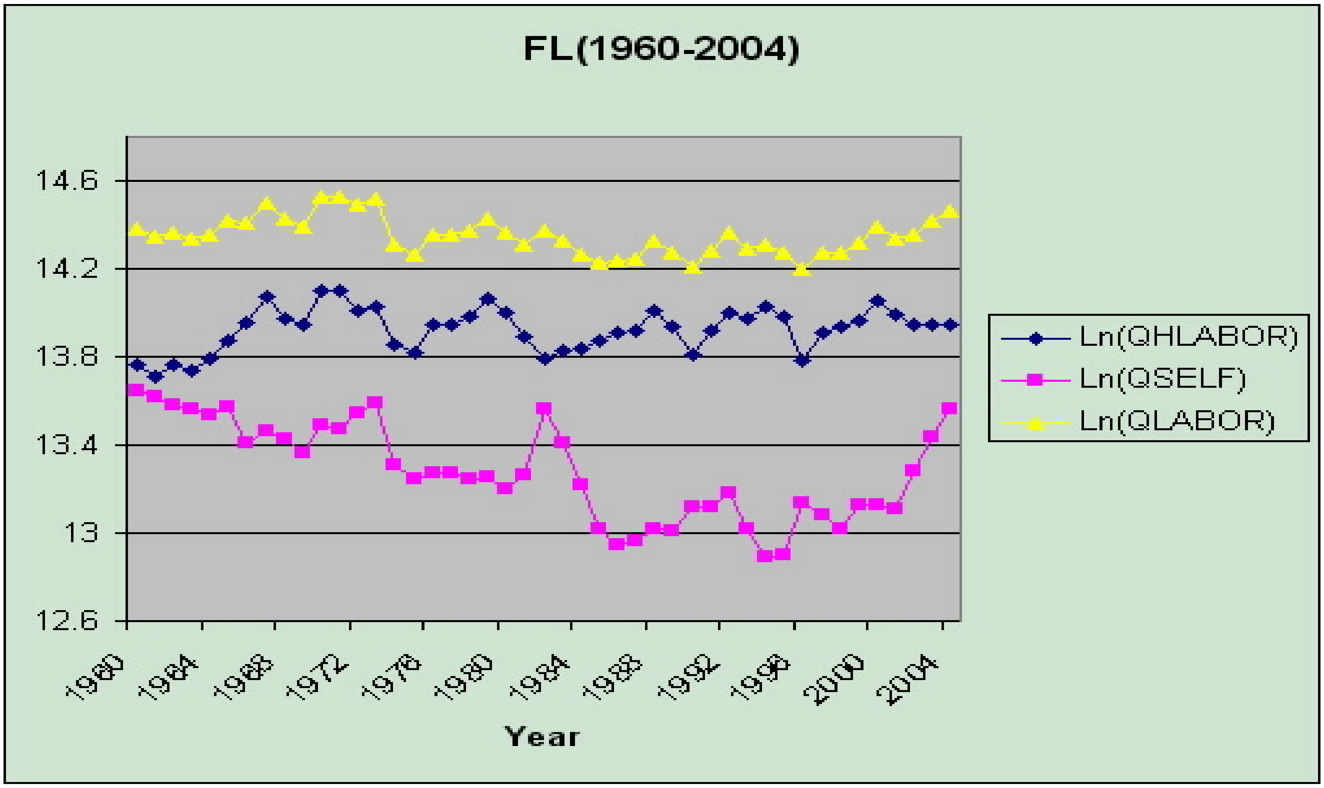

Figure 7. Hired Farm Labor, Self-Employed and Unpaid Family and Total Farm Labor, Iowa: 1960-2004

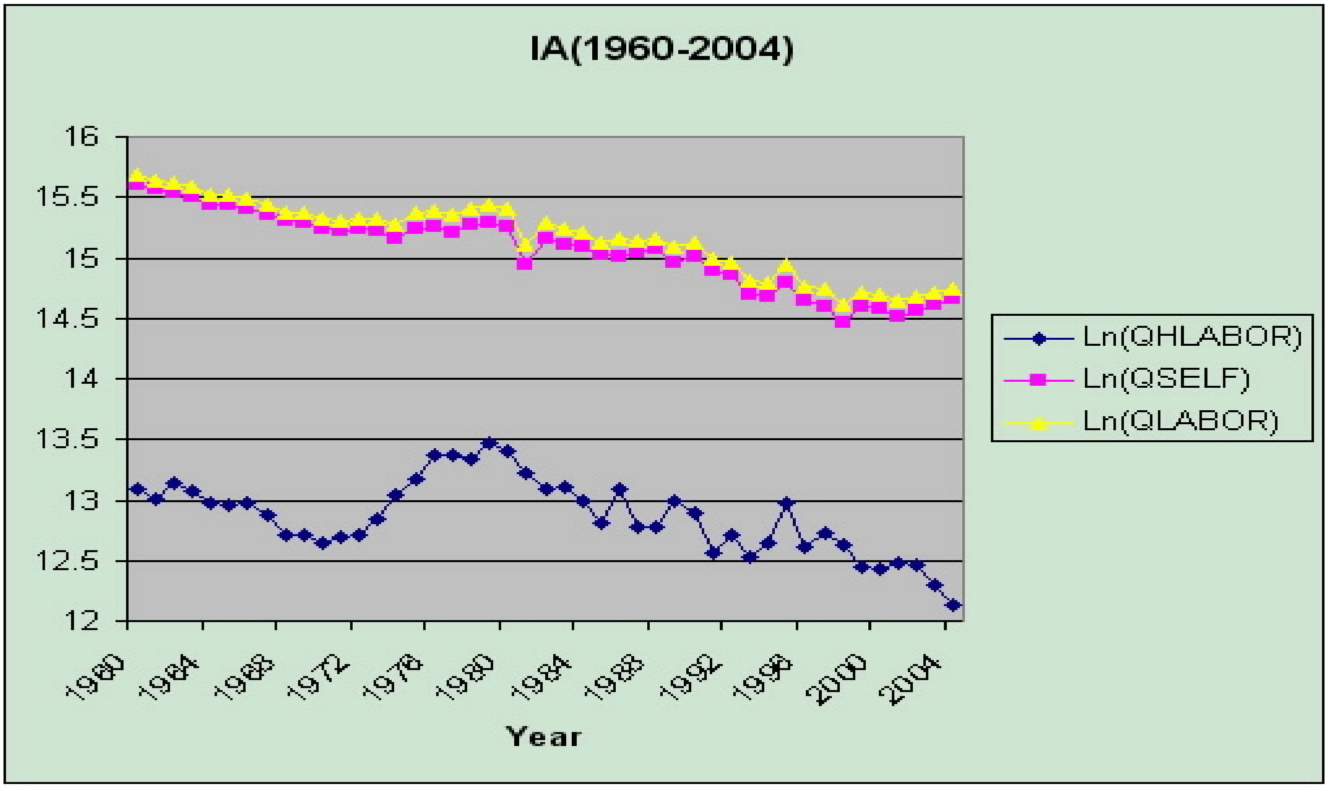

Figure 8. Hired Farm Labor, Self-Employed and Unpaid Family and Total Farm Labor, Texas: 1960-2004

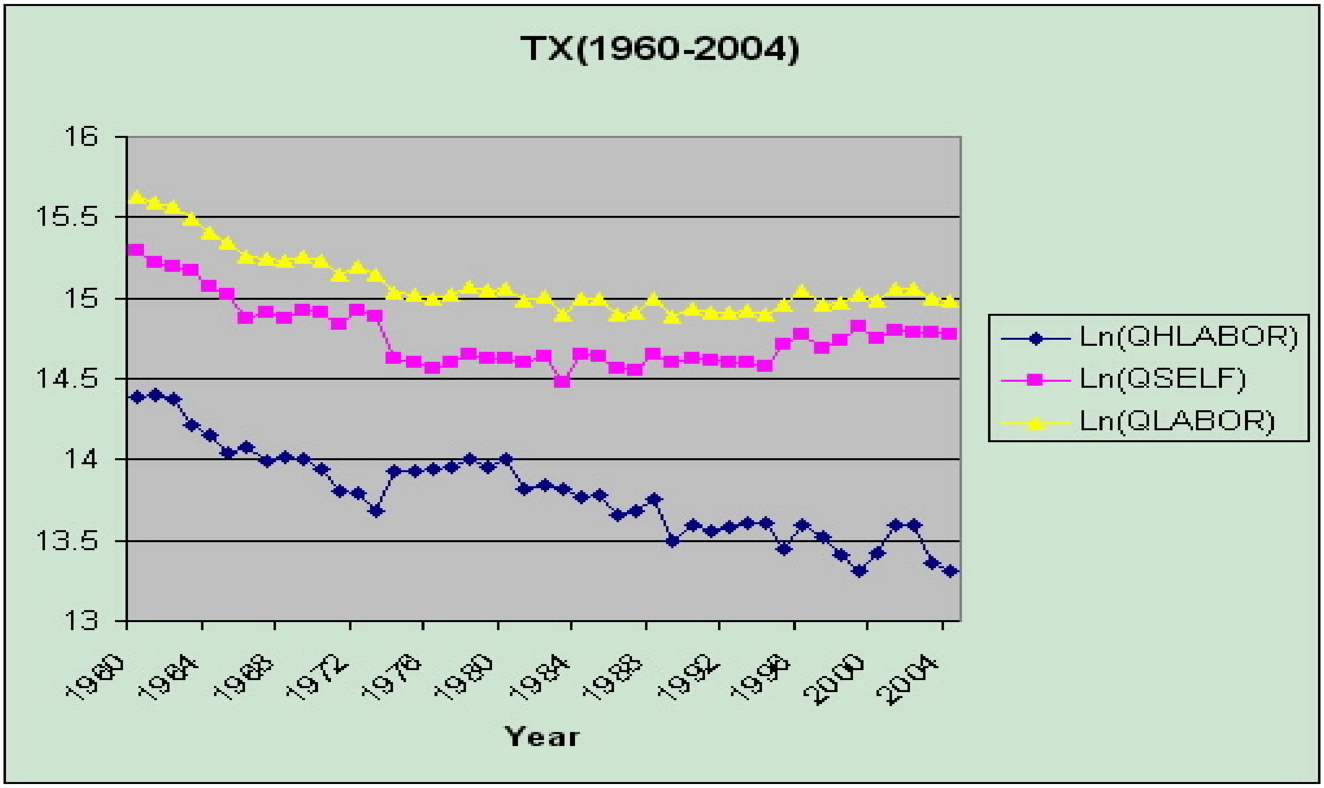

Figure 9. Farm Capital Services (excluding Land), Share of Hired Labor in Total Farm Labor, and Price of Labor Relative to Capital, California: 1960-2004

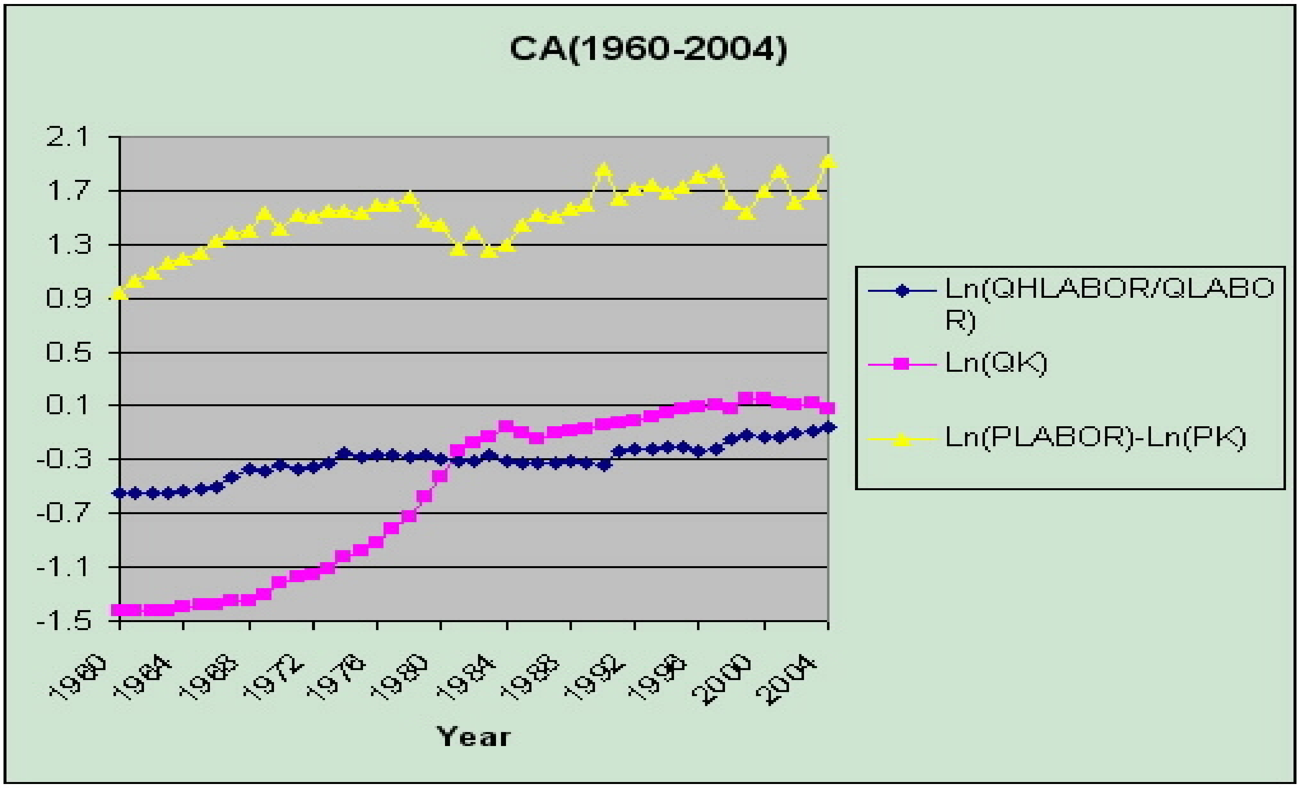

Figure 10. Farm Capital Services (excluding Land), Share of Hired Labor in Total Farm Labor, and Price of Labor Relative to Capital, Florida: 1960-2004

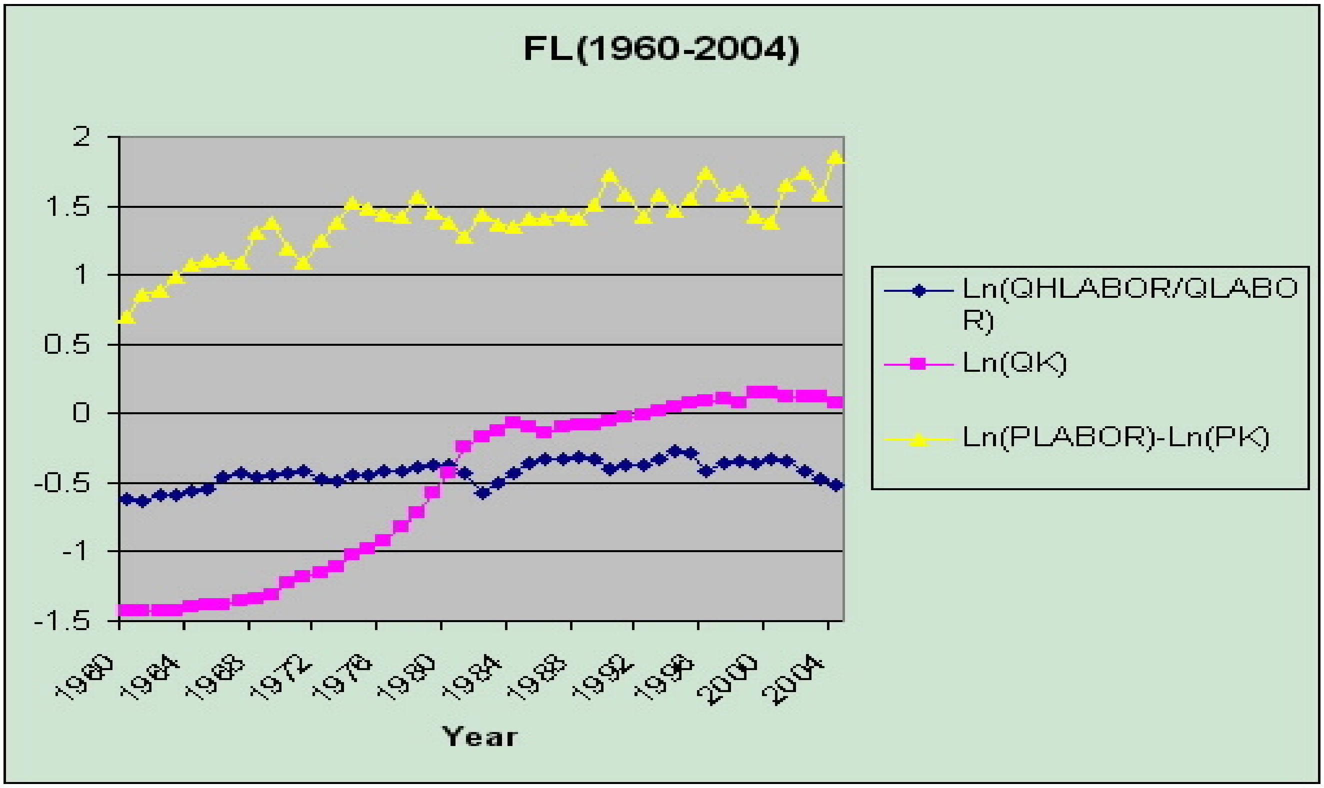

Figure 11. Farm Capital Services (excluding Land), Share of Hired Labor in Total Farm Labor, and Price of Labor Relative to Capital, Iowa: 1960-2004

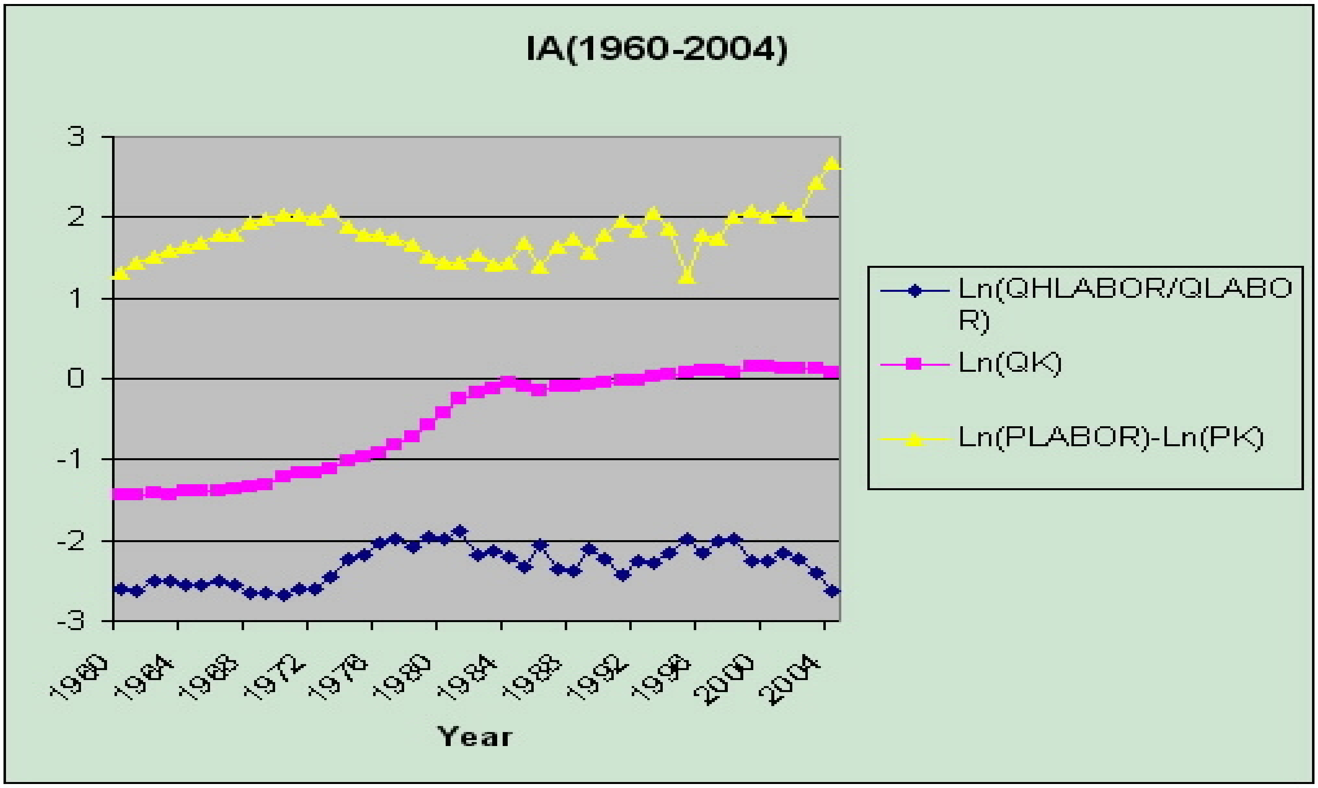

Figure 12. Farm Capital Services (excluding Land), Share of Hired Labor in Total Farm Labor, and Price of Labor Relative to Capital, Texas: 1960-2004

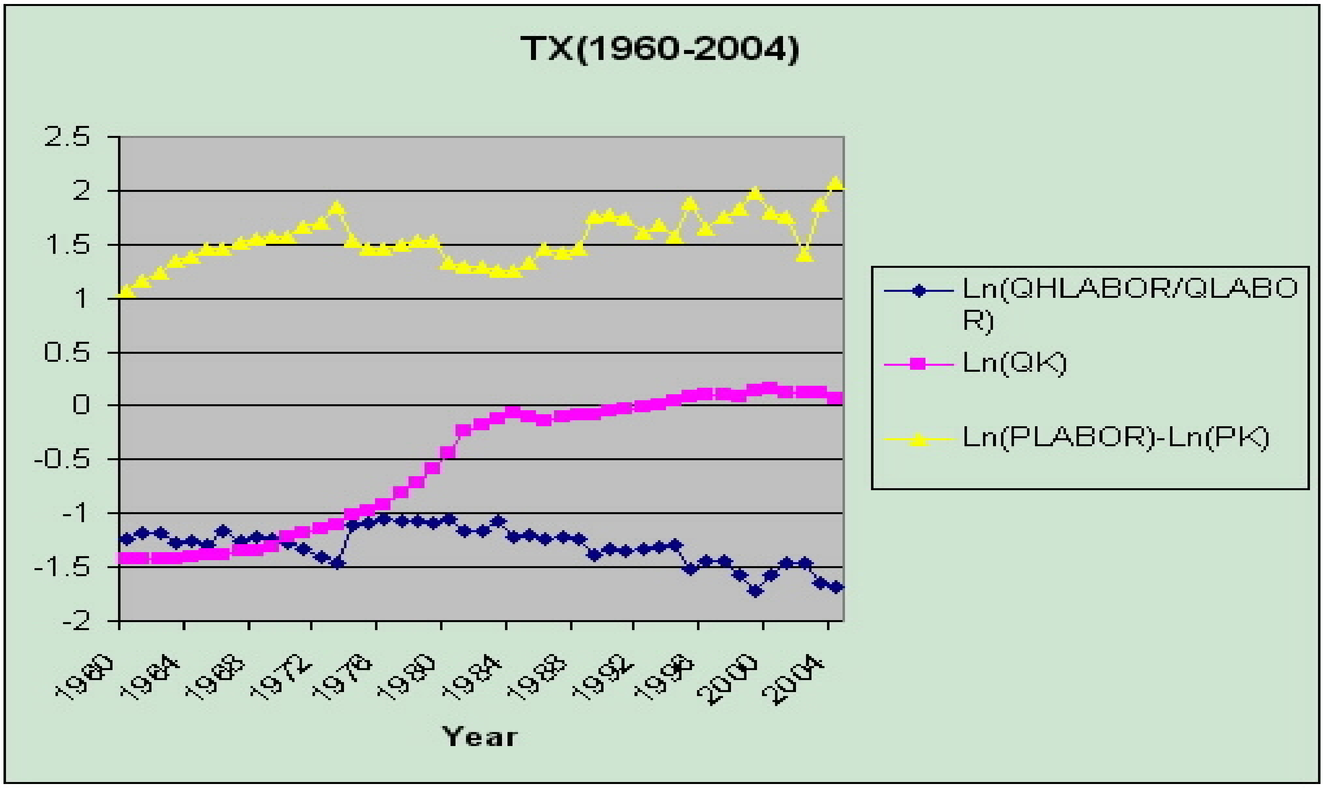

Figure 13. Farm Capital Service (excluding Land) to Farm Labor Ratio, California: 1960-2004

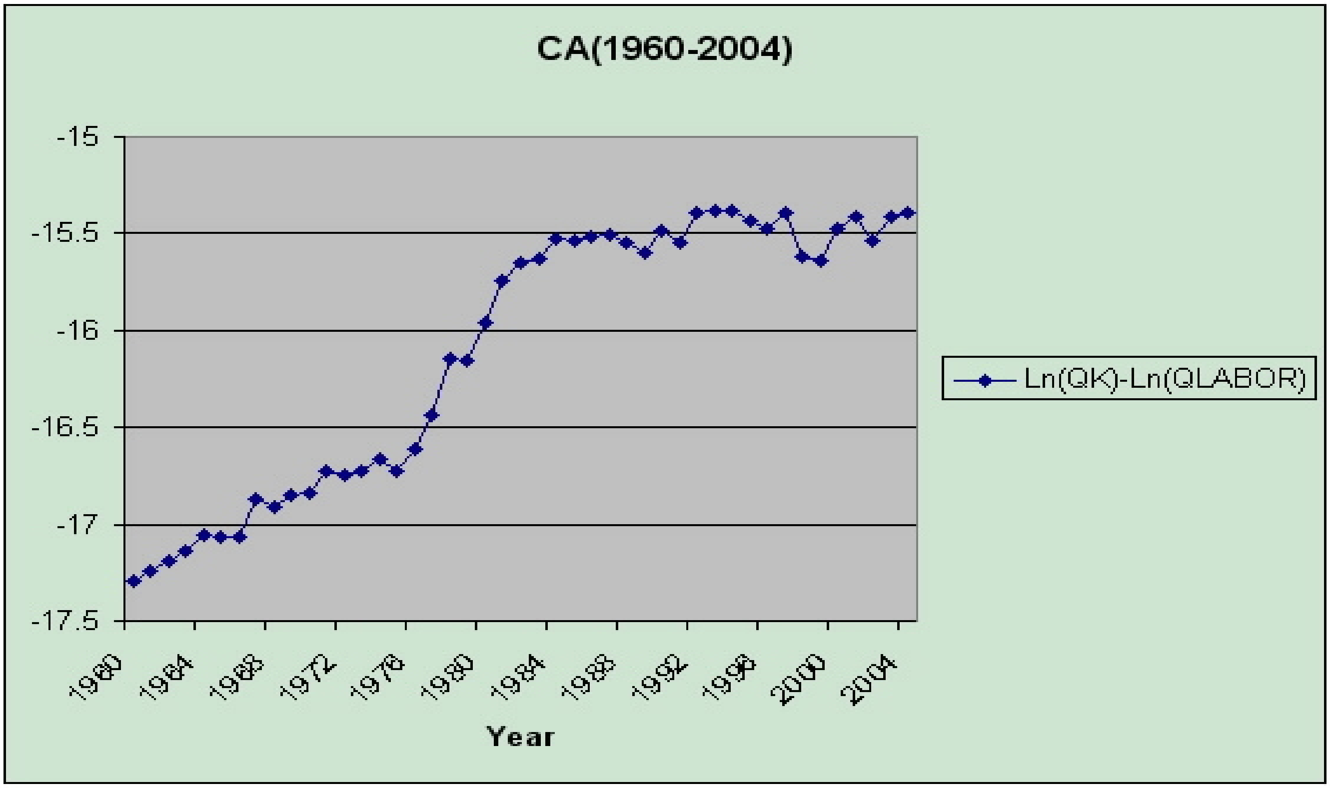

Figure 14. Farm Capital Service (excluding Land) to Farm Labor Ratio, Florida: 1960-2004

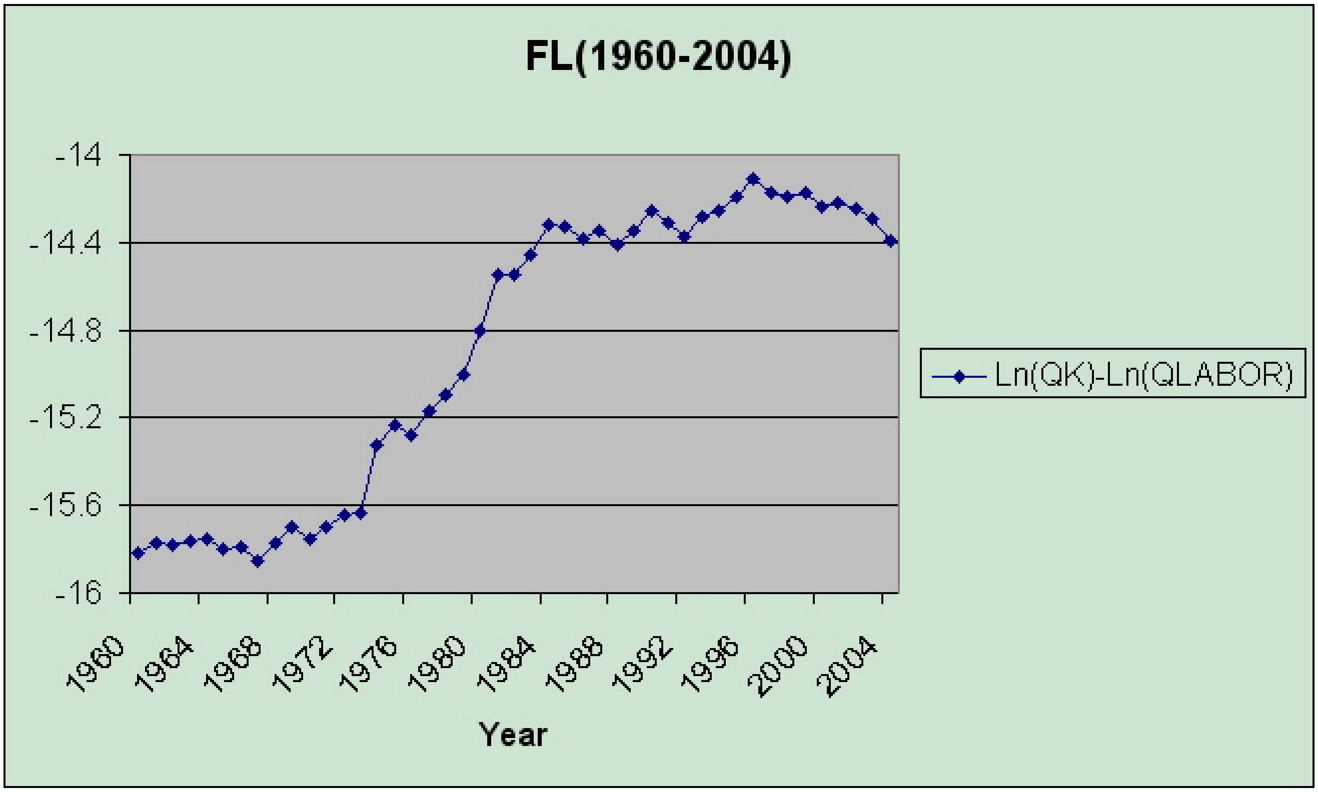

Figure 15. Farm Capital Service (excluding Land) to Farm Labor Ratio, Iowa: 1960-2004

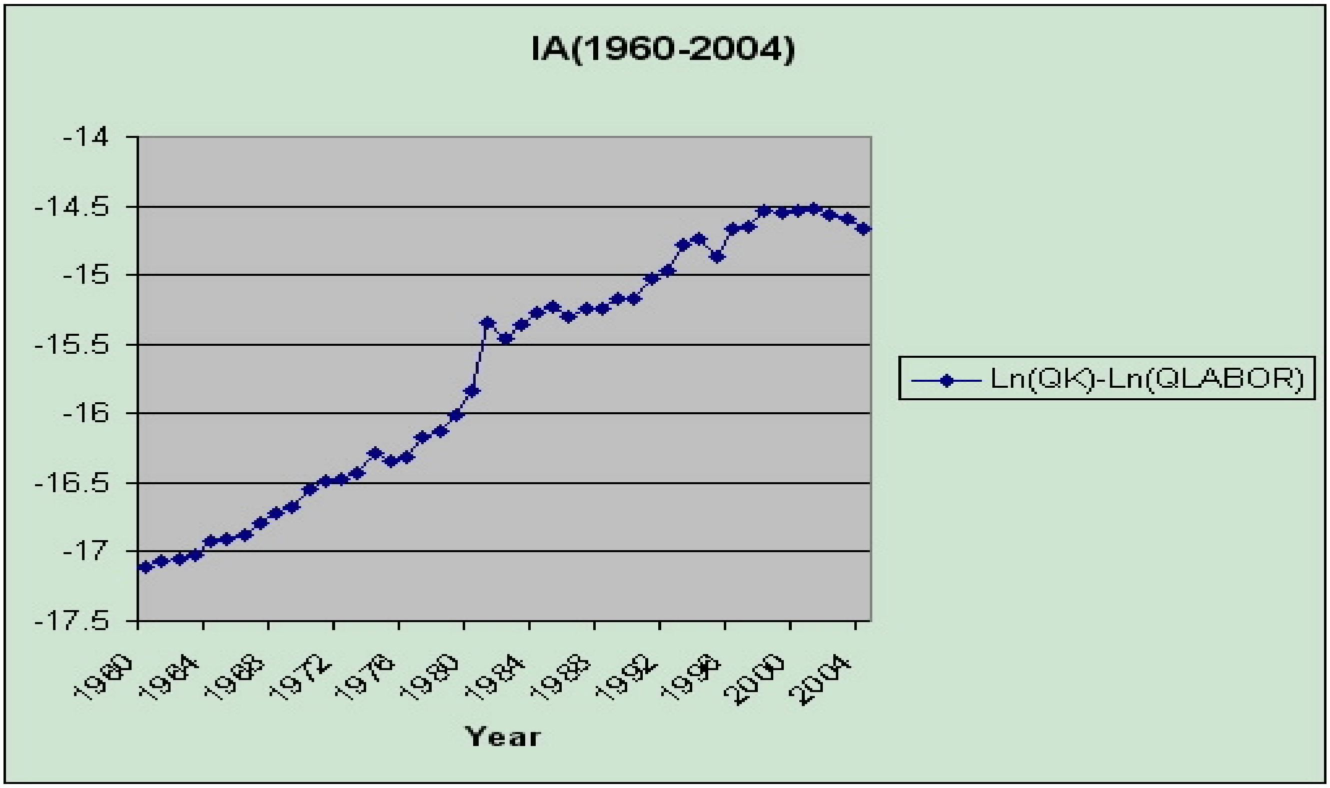

Figure 16. Farm Capital Service (excluding Land) to Farm Labor Ratio, Texas: 1960-2004

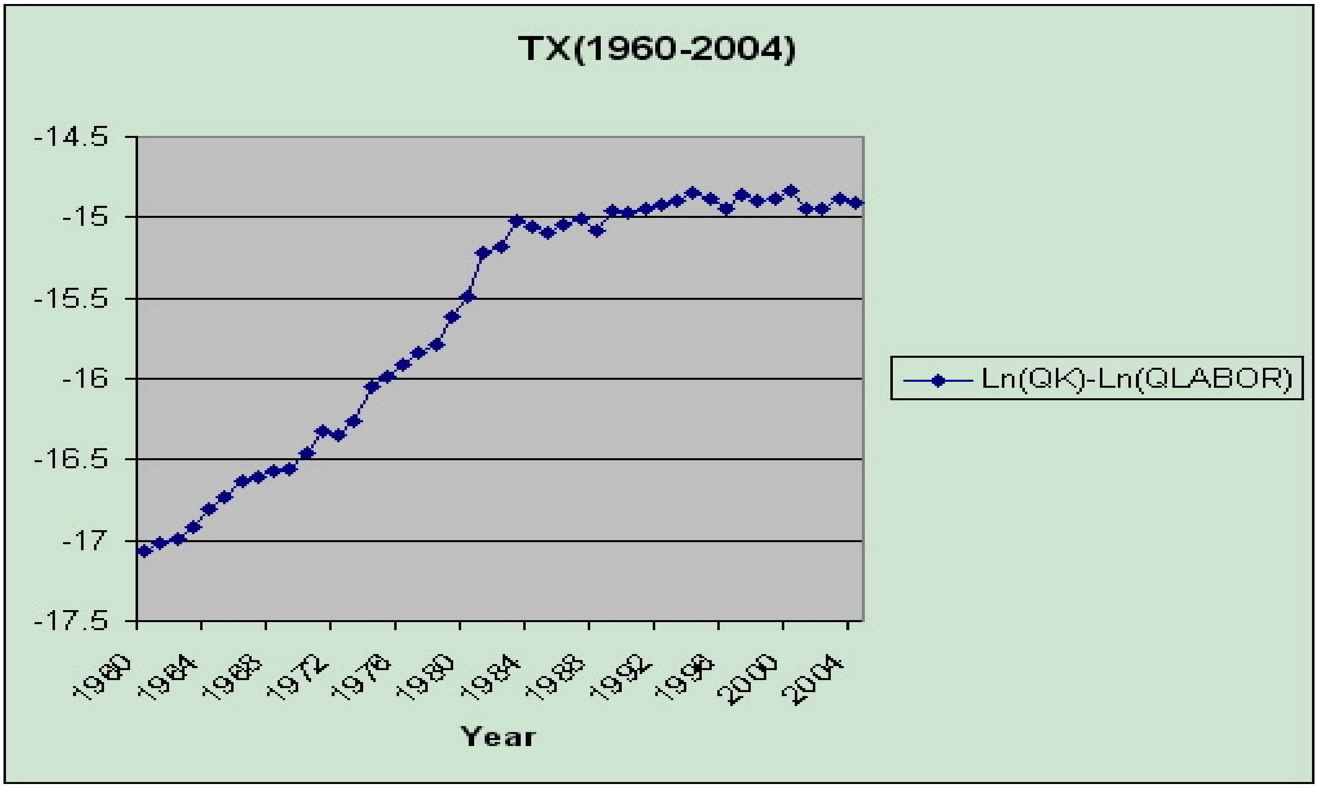

Table 1. Hired Farm Labor for the US. and Selected States: Number of Workers and Hourly Wage, 1993-2005

Year	USDA – Hired Farm Labor												USDL-NAWS
	Number on All Farms[a/]				Wage-Workers on All Farms ($/h)[b/]				Wage-Crop ($/h)[c/]				Wage-Crop ($/h)[d/]
	US	CA	FL	Cornbelt[e]	US	CA	FL	Cornbelt II	US	CA	FL	Cornbelt II	US
2005	779.5	178.0	45.0	27.0	9.50	9.76	9.46	10.16	8.69	8.81	8.50	9.00	7.77
2004	825.2	210.5	52.2	23.2	9.23	9.33	9.04	9.45	8.45	8.41	7.97	8.79	7.77
2003	836.0	227.5	54.2	23.2	9.08	9.25	9.14	9.75	8.31	8.34	8.18	8.88	7.47
2002	885.7	245.2	53.2	26.5	8.81	9.14	8.69	9.26	8.12	8.34	7.71	8.44	7.30
2001	873.3	209.0	54.3	26.3	8.44	8.67	8.54	8.63	7.78	7.89	7.66	7.99	7.11
2000	890.3	237.8	56.5	25.8	8.10	8.21	8.49	8.12	7.50	7.48	7.68	7.51	7.00
1999	929.0	277.3	53.0	24.0	7.77	7.88	8.21	8.07	7.19	7.18	7.26	7.50	6.54
1998	879.5	246.0	50.0	28.5	7.47	7.71	7.91	7.61	6.97	7.13	7.11	7.14	6.40
1997	876.5	188.8	50.3	33.5	7.35	7.32	7.47	7.10	6.66	6.79	6.76	7.02	5.81
|													
1993	803.0				6.25	6.56	6.62	6.14	5.90	5.96	6.02	5.71	5.46

[a/] Number of hired farm workers on all farms: Data taken from the USDA's Quarterly Farm Labor Survey
[b/] Average wage for hired farm labor on all farms: Data taken from the USDA's Quarterly Farm Labor Survey
[c/] Average wage rate for hired crop workers: Data taken from the USDA's Quarterly Farm Labor Survey
[d/] Average wage rate for hired crop workers: Data taken from the USDL's National Agricultural Worker's Survey
[e/] Cornbelt II includes Iowa and Missouri

Table 2. Nominal and Real Hourly Wage Rages for US Hired Farm Workers and Manufacturing Workers, 1993-2005

Year	Nominal Wage				Real Wage (Deflator in 2000 = 1.00)[d]				IPD-PCS
	Farm				Farm				
	Crops[a]		All[b]	Mfg[c]	Crops		All	Mfg	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2005	8.69	7.77	9.50	16.56	7.73	6.91	8.45	14.73	112.4
2004	8.45	7.77	9.23	16.14	7.75	7.12	8.46	14.79	109.1
2003	8.31	7.47	9.08	15.74	7.82	7.05	8.54	14.81	106.3
2002	8.12	7.30	8.81	15.29	7.82	7.03	8.47	14.72	103.9
2001	7.78	7.11	8.44	14.76	7.60	6.94	8.24	14.41	102.4
2000	7.50	7.00	8.10	14.32	7.50	7.00	8.10	14.32	100.0
1999	7.19	6.54	7.77	13.85	7.34	6.68	7.94	14.15	97.9
1998	6.97	6.40	7.47	13.45	7.22	6.63	7.74	13.94	96.5
1997	6.66	5.81	7.35	13.14	6.98	6.17	7.70	13.17	95.4
1993	5.90	5.46	6.25	11.70	6.67	6.18	7.07	13.24	88.4

[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 in the Economic Report of the President-2007, Table 47.
[d] Real wage is obtained by deflating the nominal wage by the implicit price deflator for personal consumption expenditures, which is in column (9), after dividing by 100.