THE MARKET FOR CITRUS HARVESTING LABOR*

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A number of aggregate agricultural labor market studies exist, typically concentrated on data at the national level [e.g. 1, 8, 12, 15]. The Florida agricultural labor market, however, differs substantially from that of the rest of the nation, excepting California. In Florida, a large portion of the labor force is employed as harvesting labor. This is not only highly seasonal work, but also among the least demanding of skill. Also, over the period 1953-57 to 1967-69, the total number of farm workers declined in 49 states and by 43 percent nationally. During this time, Florida, however, experienced a 53 percent increase in hired labor usage, more than offsetting a 38 percent decline in family labor [9].

Growers have been faced with rising piece rates for harvesting labor and a diminished comparative advantage relative to foreign producers. Workers and other observers (e.g. U.S. Department of Labor) was concerned about technological displacement through mechanization, as well as with detrimental wage and employment impact for domestic labor from a revitalized stream of off-shore labor imports.

The analysis reported here is restricted to citrus harvesting labor. This market has been selected for several reasons. First, more hired labor is employed in citrus picking than in any other agricultural activity in Florida. Secondly, the harvesting of citrus is characterized by a structureless labor market.[1] More precisely, no technical change has occurred to significantly affect labor usage through the potential substitution of capital for labor. Consequently, the operational assumption of historically constant labor productivity is tenable in analysis of citrus harvesting labor, while it might prove untenable in a study on picking labor in other fruits and vegetables. Third, due to increasing labor costs, the mechanical harvesting of citrus, including only two percent of the 1974-75 crop, represents an area of concern to the industry. In addition, it is fortunate that reliable wage and employment time series data are more readily available on citrus than on other commodities. In contrast, the usual time series wage data for farm labor [13] have a considerable downward bias with respect to harvesting labor, since piece rates, significantly higher than hourly rates, were not included in this series during the major portion of our period of analysis, 1960-1973.

MODEL OF HARVESTING LABOR

Operation of the citrus harvesting labor market is represented by equations (1-4).[2] Explicit recognition is made of the interrelation between domestic and foreign labor in the system. Wise has recently investigated the bracero program for three California crops with a similar system [16]. One difficulty with that system, however, is that it is non-linear in the variables and does not consistently handle the equilibrium "adding up" condition, namely that total labor usage is the sum of domestic and foreign labor.

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[1] Fisher depicted the conditions for an unstructured market in his analysis of California harvesting markets as free access to the labor market; impersonal relationships between employer and employee; job tasks requiring largely unskilled labor; financial remuneration based on the piece rate; and the absence of significant doses of capital used in the operation [3].

[2] A variant of this model is set forth in Walker [14].

Secondly, he relies solely on time as the determinant of wage rate.

Supply:

$$\text{DOMLAB} = \alpha_0 + \alpha_1 \text{WAGE} + \alpha_2 \text{NFWUN} + \alpha_3 \text{CIVLF} + \mu_1 \quad (1)$$

Demand:

$$\text{TOTLAB} = \beta_0 + \beta_1 \text{CROPSZ} + \beta_2 \text{FREEZE} + \mu_2 \quad (2)$$

Wage:

$$\text{WAGE} = \delta_0 + \delta_1 \text{NFWUN} + \delta_2 \text{RESTCT} + \mu_3 \quad (3)$$

Foreign labor (identity):

$$\text{FORLAB} = \text{TOTLAB} - \text{DOMLAB} \quad (4)$$

Equation (1) represents an aggregate labor supply equation for domestic labor with a specification as in Schuh and as adopted by others [8]. Quantity of domestic labor supplied is dependent on wage rate, alternative opportunities in the nonfarm sector and on the size of the civilian labor force. The wage rate (deflated by Consumer Price Index, CPI) is measured as an hourly rate determined from piece rates and average productivities in citrus picking. Alternative opportunities in the nonfarm sector are represented by the wage in Food and Kindred Industry deflated by the CPI, adjusted for the employment rate, i.e. $\text{NFWUN} = (\text{Wage}_{\text{F\&K IND.}} \div \text{CPI}) \times (1 - \text{unemployment rate})$. An alternative model specifies nonfarm wage and unemployment rates separately in an attempt to distinguish their independent effects. The civilian labor force represents the base from which harvesting labor is drawn. Expected signs are α_1, $\alpha_3 > 0$, $\alpha_2 < 0$.

Technology involved in citrus harvesting is such that there is essentially no possibility of substituting capital for labor at prevailing price ratios. Consequently, the harvesting operation is considered as production subject to fixed proportions. This implies that the quantity of labor demanded, equation (2), is invariant to the wage rate and depends only on the amount of fruit to be picked.[3] Rather than using an *ex post* measure of the volume of output, we prefer an *ex ante* measure, namely USDA October cropsize forecast measured in boxes [4]. The only significant case in which fruit remains unpicked results from severe freeze, rendering fruit useless. We thus include a dummy variable which takes on the value of one in years during which there was a damaging freeze and zero otherwise. The expected signs are $\beta_1 > 0$ and $\beta_2 < 0$.

Equations (3) and (4) bring the system into equilibrium. During the period under analysis, there were in excess of 600 foreign workers employed in citrus during the peak month, while there have been none since 1971. Approval for importation of labor under contract must be certified by the Department of Labor. It is contingent upon expected domestic wage and employment effects of imports. Reviewing the system thus far, there is a supply function for domestic labor assumed to be upward sloping with respect to wage and a total labor demand function, argued perfectly inelastic. We argue that the wage rate during periods of labor importation is determined through a bargaining process between petitioners and government.

To the extent that the domestic supply curve is upward sloping, the effect of labor importation is reduction of the wage rate and curtailment of domestic employment below what it would otherwise be. The wage determination process is represented by equation (3), defining the wage rate as a function of alternative employment opportunities (NFWUN)[4] and a dummy variable for the change in governmental attitude toward agricultural labor importation with the termination of the bracero program (RESTCT).[5] The remaining equation, (4), closes the system with the quantity of foreign labor filling the excess demand at the "prevailing" wage rate.[6]

Estimated parameters of the system will determine the effects of labor importation utilizing two implicit tests: (1) whether or not the domestic labor supply curve is in fact upward sloping and (2) the impact of the dummy variable in the wage equation representing the restriction on imported agricultural labor (RESTCT).[7]

[3] We reemphasize that this is assumed to hold for prevailing price ratios. Clearly, if wage rate were to increase sufficiently, a demand response would be expected. But over the analysis period, this was not the case. This characteristic distinguishes and simplifies our model considerably from Wise's formulation [16]. Since he deals with annual crops, a larger system is considered to account for joint determination of output with quantity of labor utilized in the production process.

[4] As in the supply equation, an alternative specification separates nonfarm wage and unemployment rate.

[5] Off-shore workers in Florida citrus did not enter under the bracero program, but rather under the Immigration and Nationality Act, Public Law 414. We base the dummy variable on termination of the bracero program since it was an indicator of a significant change in governmental attitude toward off-shore labor for agriculture [6, p. 1].

[6] Note that as a result of the identity, equation (4), the amount of foreign labor depends on the wage rate as well as all other variables in the system.

[7] There is some concern that effect of the RESTCT dummy variable for the termination of the bracero program in December 1964 is confounded by the introduction of minimum wages for agriculture in 1967. However, the average wage in citrus harvesting was considerably above the minimum wage for agriculture of $1.00.

ESTIMATION OF THE SYSTEM

Equations (1-4) represent a system with four endogenous variables: quantities of domestic labor, total labor, foreign labor and wage rate. Remaining variables are argued to be predetermined with respect to this system. The fact that citrus is a tree crop permits this simplification of the system, allowing output to be taken as predetermined with respect to the harvesting labor market.

The stochastic assumptions are

$$E[\mu_{it}] = E[\mu_{it}\mu_{it'}] = 0$$

for

$$i = 1, 2, 3$$

and

$$t \neq t', E[\mu_{it}\mu_{jt}] = \sigma_{ij} \neq 0$$

for

$$i, j = 1, 2, 3 \text{ and all } t.$$

Thus, although equations (2) and (3) have only single endogenous variables, there is reason to believe that disturbances of the equations are correlated with each other as well as with that of equation (1). The estimation procedure is thus three stage least squares, although single equation estimates are given for comparative purposes.[8] All variables are measured as arithmetic values.

The Estimates

Two slightly different specifications are given in Table 1 for the estimates of the equation system. The first specification, shown in columns 1 and 3, corresponds with the specification set forth in equations (1-4), and is the one given most emphasis. The second specification includes nonfarm wage and unemployment rate separately, rather than as nonfarm wage multiplied by employment rate as in columns 1 and 3. These substitutions occur in supply and wage equations. Columns 1 and 2 are three stage least squares estimates, whereas columns 3 and 4 are two stage least squares estimates for the supply equation and ordinary least squares for the demand and wage equations.

There is a high degree of consistency in coefficient signs across the specification and estimation

TABLE 1. ESTIMATES OF CITRUS HARVESTING LABOR MODEL[a]

Equation[b]	Three stage least squares		Single equation methods[c]	
	(1)	(2)	(3)	(4)
Supply (DOMLAB × 10^{-4}):				
WAGE	96.7101 (26.4944)	41.0328 (55.9404)	56.6611 (42.2813)	6.4469 (65.7439)
NFWUN (× 100)	-1.9227 (.5618)		-1.0881 (.9210)	
CIVLF (× 10^{-4})	14.0597 (6.1267)	16.7138 (16.2814)	15.7860 (11.8625)	24.0676 (20.6873)
NFWG		-88.8590 (53.9301)		-48.5577 (60.4863)
UNMP (× 100)		.5055 (4.4126)		-1.6410 (5.4866)
Constant	112.6627 (35.5184)	49.4213 (30.8100)	52.7000 (58.2240)	34.4718 (41.5789)
d[d]			1.92	1.29
Demand (TOTLAB × 10^{-4}):				
CROPSZ (× 10^{-8})	10.7927 (1.3590)	10.8128 (1.4170)	12.0403 (1.6720)	12.0403 (1.6720)
FREEZE	-4.7477 (1.1330)	-4.1656 (1.1674)	-3.4260 (1.4363)	-3.4260 (1.4363)
Constant	11.6731 (2.1724)	11.4757 (2.2730)	9.3640 (2.6460)	9.3640 (2.6460)
R^2			.83	.83
d[d]			2.18	2.18
Wage:				
NFWUN (× 100)	.0167 (.0018)		.0175 (.0027)	
RESTCT	.1206 (.0449)	.0843 (.0595)	.0628 (.0714)	.0250 (.0721)
NFWG		1.5622 (.2158)		1.5455 (.2556)
UNMP (× 100)		-.0444 (.0199)		-.0613 (.0239)
Constant	-.8871 (.2403)	-.6242 (.3304)	-.9630 (.3407)	-.5002 (.3831)
R^2			.95	.96
d[d]			2.13	2.49

[a]Standard errors are in parentheses.

[b]Data sources: WAGE [10]; NFWG, UNMP, CIVLF [5]; DOMLAB, FORLAB, TOTLAB [2]; CROPSZ [4].

[c]The supply equation is estimated by two stage least squares and the remaining two equations by ordinary least squares.

[d]Durbin-Watson statistic.

procedures. In only one case is there a sign reversal—the unemployment rate coefficient in the supply equations, which has a standard error many times its magnitude. Comparison of columns 1 and 3 reveals a considerable gain in efficiency with three stage least squares—standard errors are nearly halved in the supply and wage equations. This comes about through the high degree of contemporaneous correlation between the equation disturbances. Table 2 gives the covariance matrix for the disturbances of the system corresponding to column 1, implying correlations of .84, —.96, and —.82 between supply and

[8]Since the contemporaneous disturbances between equations are not argued to be independent, the system is not recursive [11, pp. 460-462]. Ordinary least squares estimates of equation (1) would be both inconsistent and biased.

TABLE 2. ESTIMATED COVARIANCE MATRIX OF SYSTEM[a]

Equation	Supply	Demand	Wage
Supply	64.6933		
Demand	17.3606	6.6408	
Wage	-.5695	-.1547	.0053

[a]These are based on the three stage least squares residuals of the system specified in column (1) of Table 1.

demand equations, supply and wage equations, and demand and wage equations, respectively.

The choice between separate versus combined nonfarm wage and unemployment variables (i.e. columns 1 and 2 of Table 1) is based on what appear to be somewhat spurious results when the two variables are separated. Although examination of the Durbin-Watson statistics in column 3 of Table 1 reveals no evidence of serial correlation, results in column 4 (where nonfarm wage and unemployment are separated) yield statistics in the indeterminant range. Application of first-order autoregressive techniques to the supply and wage equations of column 4 led to unreasonable results in the wage equation ($\hat{\rho} < -1$), while coefficients became more unstable. It appears that the problem is an ill-defined data matrix resulting from including nonfarm wage and unemployment rate separately rather than serial correlation. The appropriate empirical specification is thus argued to be column 1, with nonfarm wage and unemployment rate combined, and estimation by three stage least squares. Discussion of results will be based on this set.

Supply of domestic labor is found to be highly elastic, 6.14 when evaluated at the mean, although this is one coefficient for which there is considerable variation across specifications and estimation methods. However, in all cases it is positive, and a mean elasticity of 2.60 is obtained from column 2, still highly elastic. Thus, substantive implications are no different in the two cases: both are highly elastic.

Opportunities in nonfarm employment have an inverse effect on labor supply as expected. Again, there is an extremely elastic response, −11.18 evaluated at the means. This indicates the tremendous impact which nonfarm markets have on agricultural labor supply. As nonfarm labor markets deteriorate, there is considerable movement into agriculture. With improved economic conditions, the movement is less pronounced. The civilian labor force coefficient is positive, as expected.

Demand equation estimates are consistent with expectations. It is worth noting at this point that as a check on assumption of fixed proportions, an alternative specification with the wage rate in the demand equation was tried. As expected, the coefficient was not significantly different than zero.

CONCLUSIONS AND IMPLICATIONS

Domestic labor is found to be highly responsive to wages in the citrus harvesting labor market. Although positive supply elasticities for aggregate agricultural labor markets have been found in previous studies [1, 8, 12, 15], they have not been as highly elastic as is the case for the harvesting labor market. Estimated supply elasticity for citrus harvesting labor in excess of six, corroborates estimates obtained by Wise of 2.7 and 3.4 in California strawberries and melons, respectively.

There is considerable interaction with nonfarm labor markets as well. A reduction of one percent is expected nonfarm income opportunities (nonfarm wage times percent employed) implies an 11-percent increase in the supply of harvesting labor, *ceteris paribus*. Of course, this is not all transmitted, since a reduction in expected nonfarm income opportunities reduces the wage rate in citrus harvesting. The interaction is best characterized as an intensified movement of nonfarm labor to harvesting during periods of decreased income opportunities outside agriculture. In the 1974-75 season, for example, nonfarm opportunities declined considerably, resulting in both a decrease in the piece rate (in real terms) and a considerable increase in availability of harvesting labor.

Representation of the labor market was designed to explicitly recognize the question of labor importation. The first test of effects of such importation is whether or not domestic labor supply is responsive to wage changes, a finding common to all other studies on agricultural labor (only Wise, however, has similarly restricted his data to harvesting labor [16]). Given an elastic supply of labor and a wage inelastic demand for labor (although the latter is not essential so long as it is not upward sloping), the only way in which an equilibrium can be obtained with a "deficit" of labor is if the wage rate is determined by forces outside the system. The external force in this case is certification by the U.S. Department of Labor of requests to import labor.

Governmental action is represented by the wage equation in the system. Decisions upon whether or not to certify the request for off-shore labor are based on arguments relative to availability of labor at the prevailing wage rate. Expected nonfarm income opportunities are taken as an indicator of the prevailing wage rate. The higher is the latter, the higher the harvesting wage rate. The indicator of the effect of a change in governmental attitude, however, is reflected by the dummy variable representing the termination of the bracero program. This coefficient is positive, indicating that the change in governmental attitude for given nonfarm income opportunities did have the effect of increasing the wage rate for harvesting labor. Alternatively, during the bracero years, the relatively nonrestrictive attitude toward agricultural labor importation had the effect of depressing the harvesting wage below what it otherwise would have been. The government's action, in effect, held the wage rate for harvesting labor below what it otherwise would have been, had the domestic market been left to reach an equilibrium without off-shore labor. At the same time, domestic employment was held below what it would have been without off-shore labor.

Additional interesting considerations pertain to mechanization and unionization. There is currently little mechanization in the harvesting of citrus; available technology is largely infeasible at current price ratios for inputs. If and when mechanization is available for harvesting citrus, effects on employment could be substantial. Demand for labor in such a case would no longer be perfectly inelastic, but would be downward sloping and to the left of the current demand curve (assuming no increase in demand for the product or significant cost reduction in harvesting below current levels). Given a highly elastic supply curve, the shift in demand will largely determine employment. The end result would be a significant reduction in employment with a less pronounced effect on the wage rate (ignoring labor importation).

From the viewpoint of workers, unionization offers the obvious advantage of a collective voice in matters such as technological displacement, which directly affect them. Historically, agricultural workers have borne the full cost of such displacement [7]. From a welfare standpoint, compensation of injured parties is necessary to insure a welfare gain for movement from a Pareto-point. A second instance would be a more organized effort to restrict off-shore labor importation. It would appear from the results presented in this paper that the government has not always represented best interests of labor with respect to labor importation.

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