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LABOR PRODUCTIVITY OF APPLE HARVEST WORKERS

by

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This paper was prepared for presentation to the Northeast Agricultural Economics Council Annual Meetings at Durham, New Hampshire, on June 20, 1978. It is based on material contained in: Labor Productivity of Apple Harvest Workers in the Champlain Valley: 1970-1975 (A.E. Res. 77-7) by Dennis U. Fisher (published by the Department of Agricultural Economics, Cornell University, Ithaca, New York, July 1977).

Apple producers in New York's Champlain Valley have traditionally harvested their crop using local and migrant workers, and supplemented this labor force with temporary foreign workers (Jamaicans). In recent years, obtaining certification to use Jamaicans through the U. S. Department of Labor has become increasingly difficult. There has been some concern that the use of foreign workers might be stopped completely. Obtaining skilled migrant crews has also become increasingly difficult, and growers in this area have suggested that the quality and availability of local workers have substantially declined. Thus, Champlain Valley apple growers have been and will be experiencing shifts in the composition and productivity of their harvest labor forces.

Objective and Purpose of the Study:

The objectives of this study were to identify the differences in productivity of the three main sources of harvest labor, and to examine productivity changes over six seasons (1970-1975). Two sets of dependent variables were examined -- productivity per worker, both hourly and per season -- and three input variables measuring the amount of time spent harvesting. Three sets of explanatory variables were used: labor source variables, a harvest size variable, and grower variables.

Identification of the relative productivity of these three labor sources, and the ways in which these relationships have changed over the six seasons, should indicate the size of the adjustments necessary to maintain harvesting capacity, or to replace the Jamaican or migrant labor sources if such replacement becomes necessary. Estimates of the trends in productivity should suggest their importance, as well as the timing of future adjustments in the harvest labor force.

Data and Model Specification

Five multiple regression equations were estimated using ordinary least squares to examine patterns of labor productivity over time. The data included 10,549 worker observations on hand harvest workers picking apples in New York's Champlain Valley. The worker observations were taken from employers' labor records and included information on the activities of one worker for one season. If a particular worker was employed all six seasons, this would be six worker observations.

Variables were then included to describe the relative productivity of each labor source and how this was changing over time. The resulting equations are as follow:

The dependent variables are:

Y_{i1} = boxes of apples picked per worker per season

Y_{i2} = boxes of apples picked per worker per hour

Y_{i3} = hours worked per worker per season

Y_{i4} = hours worked per worker per day

Y_{i5} = days worked per worker per season

The common set of independent variables is:

Labor Source Variables

X_{i1} = 1 if the worker is migrant
0 otherwise

X_{i2} = 1 if the worker is Jamaican
0 otherwise

X_{i3} = 1 if the harvest year is 1970
2 if the harvest year is 1971
. .
. .
. .
6 if the harvest year is 1975

$$X_{i4} = X_{i1} X_{i3}$$

$$X_{i5} = X_{i2} X_{i3} \quad .$$

Harvest Variable

X_{i6} = the number of boxes harvested in the Champlain Valley each season divided by the average number of all six seasons and multiplied by 10.

Grower Variables

X_{ij} = 1 if the worker was employed by the j^{th} grower
0 otherwise

Where j = 7, 8, ... n with n dependent upon the number of growers included in the estimation of the regression equation.

e_i is the stochastic disturbance

The general form of the equation is as follows:

$$Y_i = a + b_i X_{i1} + b_2 X_{i2} + b_3 X_{i3} + b_4 X_{i4} + b_5 X_{i5} + b_6 X_{i6} + \sum_{j=7}^{n-1} b_i X_{ij} + e_i$$

The specifications of the regression models are completed by adding the basic assumptions of the classical normal linear regression model as stated in Kmenta (Kmenta, 1971, p. 348).

* e_i is normally distributed

* $E(e_i) = 0$, zero mean

* $E(e_i^2) = \sigma^2$, homoskedasticity

* $E(e_{ij}) = 0$ $(i \neq j)$, nonautoregressive

* Each explanatory variable is nonstochastic with values fixed in repeated samples and such that for any sample size,

$\sum_{n} (X_{ik} - \bar{X}_k)^2 / n$ is a finite number different from zero for every

$k = 2, 3, \ldots, K.$

The coefficients would be interpreted as follows:

b_1 - is the difference between the initial estimated level of Y for local workers and that estimated for migrant workers = (Y for migrant workers minus Y for local workers). The model specification sets this initial level for 1969. This level must be adjusted to 1970, using b_4 to correspond to the first year for which data were collected.

b_2 - is the difference between the initial estimated level of Y for local workers and that estimated for Jamaican workers (Y for Jamaican workers minus Y for local workers). The coefficient b_5 would be used to adjust this figure to 1970.

b_3 - is the estimated change in Y for local workers from one season to the next.

b_4 - is the estimated difference in the change in Y for local workers and for migrant workers. The sum of the two coefficients, $b_3 + b_4$, is the estimated change in Y for migrant workers from one season to the next.

b_5 - is the estimated difference in the change in Y for local workers and for Jamaican workers. The sum of the two coefficients, $b_3 + b_5$, is the estimated change in Y for Jamaican workers from one season to the next.

b_6 - is the estimated change in Y due to a 10 percent change in the total Champlain Valley apple harvest. The percent change is based on the average harvest level for the six years studied.

b_j - where j = 7, 8, ... n-1 is the difference in the effect of grower j and the one grower who was omitted from the equation to facilitate estimation of the equations. b_j = the effect of the $j^{\underline{th}}$ grower minus the effect of the omitted grower (Kmenta, 1971).

Empirical Results and Implications:

The estimated coefficients for the five regressions are reported on the table following.* Jamaican and migrant workers harvested substantially more per worker per season than local workers. For the six years studied, local workers averaged 285 boxes per worker per season, while Jamaicans and migrants averaged 1,295 and 1,203 boxes, respectively. However, based on the regression analysis, the seasonal productivity of the local workers remained relatively constant over the six seasons, while the amount harvested per worker per season declined by 77 boxes and 40 boxes with each passing season for migrant and Jamaican workers. Thus a declining harvesting capacity is evidenced for migrant and Jamaican workers, but not for local workers.

Jamaican and migrant workers spent substantially more time harvesting apples than did local workers. For the six harvest seasons, Jamaican workers averaged 174 hours per worker per season; migrant workers, 132 hours; and local workers, 47 hours. During the 1975 season, 34.4 percent of the local workers harvested apples for 10 hours or less; 64.9 percent harvested for 40 hours or less.

*The common set of independent variables explained between 31.6 and 55.3 percent of the variation in the five dependent variables. In part because of the large sample size, all of the equations exhibited a statistically significant relationship between the set of independent variables and each of the dependent variables, and the most individual coefficients were statistically different from zero at the 0.01 level. Fewer observations were used to estimate three of the equations because 30 percent of the worker observations lacked information on hours worked.

The dichotomous variables identifying growers were included to remove the variance which would be associated with particular management practices, differences between orchards, and other causal factors which would be peculiar to the individual grower. Only the extreme values of the estimated coefficients were included to avoid disclosure problems. The size of these coefficients indicates that grower-related factors exercised significant effects, both statistically and practically, on the dependent variables. In addition, a variable (x_6) was included to remove the variance associated with individual harvests. Causal factors associated with the harvest were assumed to be positively correlated with the relative size of the harvest.

The coefficients for x_1 and x_2 are the intercept values with the three trend variables (x_3, x_4, and x_5) set to zero. This condition holds for 1969, the year preceding the first year of data. In the discussion these two intercepts will be adjusted to 1970 without further comment.

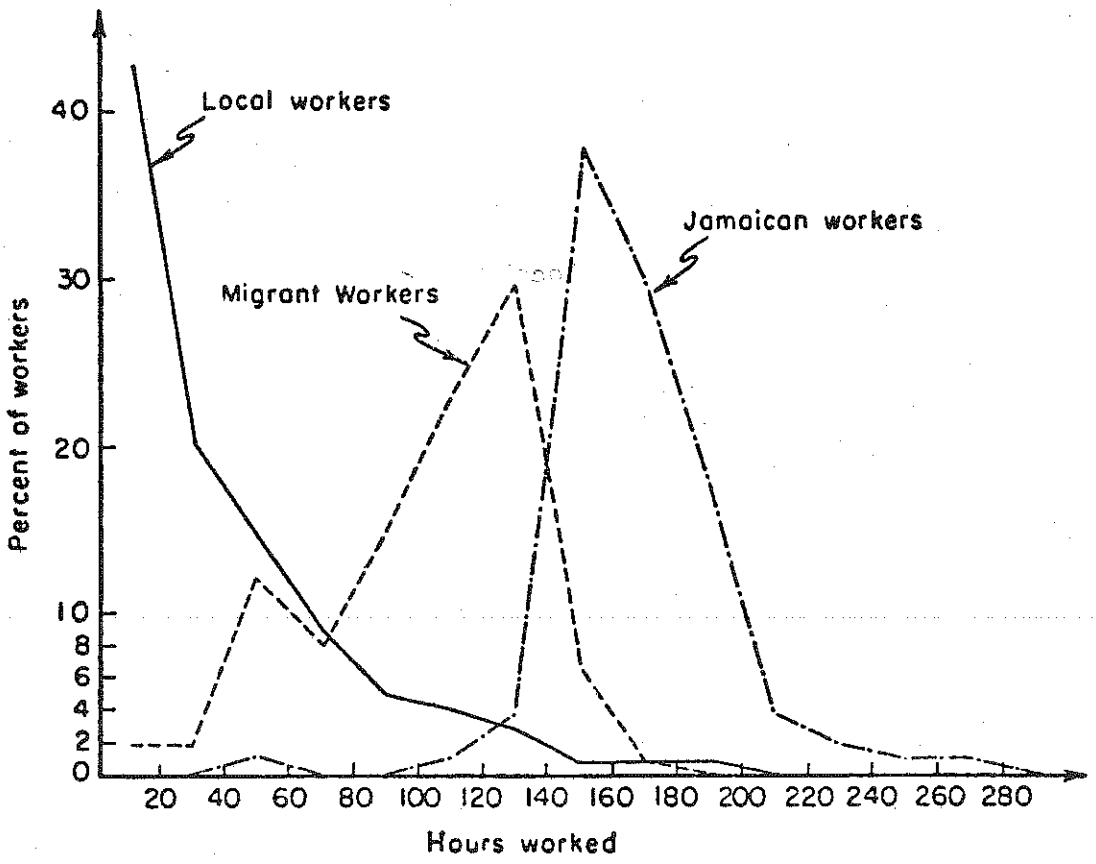
Regression Coefficients and Standard Errors for Regression Equations

ependent Variables	Boxes Per Worker Per Season		Hours Per Worker Per Season		Days Per Worker Per Season		Hours Per Worker Per Day		Boxes Per Worker Per Hour	
dependent Variables	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error
X_1	1,154.819**	34.201	75.584**	4.798	11.300**	0.614	0.309	0.161	4.931**	0.192
X_2	1,209.990**	32.317	145.514**	3.990	21.300**	0.580	1.040**	0.134	1.825**	0.160
X_3	- 1.511	2.836	- 1.407**	0.436	0.168**	0.051	- 0.185**	0.015	0.001	0.018
X_4	- 75.358**	8.830	0.553	1.165	- 0.395*	0.158	0.289**	0.039	- 0.486**	0.047
X_5	- 38.423**	7.030	- 3.219**	0.865	- 1.050**	0.126	0.278**	0.029	- 0.116**	0.035
X_6	25.837**	3.415	3.317**	0.503	0.496**	0.061	0.073**	0.017	- 0.058**	0.020
Max b_i a/	93.363**	34.396	- 9.436	5.763	- 3.564**	0.617	1.479**	0.194	3.029**	0.288
Min b_i	- 301.088**	26.148	- 54.031**	7.188	- 10.509**	0.692	- 1.043**	0.179	- 1.969**	0.206
where i =	7 - 20		7 - 17		7 - 20		7 - 17		7 - 17	
Constant	180.376		55.728		8.513		4.749		6.990	
Other Statistics										
R^2	0.518		0.553		0.420		0.355		0.316	
F Statistic	565.247		539.406		381.358		239.224		201.403	
n	10,549		7,429		10,549		7,409		7,429	

Significantly different from zero at the 0.05 level.

Significantly different from zero at the 0.01 level.

DISTRIBUTION OF WORKERS BY HOURS WORKED AND BY LABOR SOURCE DURING THE 1975 CHAMPLAIN VALLEY APPLE HARVEST



Local workers exhibited a decline of 1.4 hours per worker per season with each passing season, which was due to the net effect of a slight increase in days per worker per season and a slight decrease in hours per worker per day. Jamaican workers exhibited a decrease of 3.2 hours per worker per season, which is due to a decline of 1.1 days per worker per season with each passing season and is offset slightly by an increase in hours per worker per day. Migrant workers exhibited no significant change in the time spent harvesting apples.

While local workers spent considerably less time harvesting apples during the season than either migrant or Jamaican workers, their hourly productivity rates were much closer to the rates of these other two labor sources. For the six years studied, migrant workers averaged 9.0 boxes per worker per hour, Jamaican workers, 7.4 boxes, and local workers, 5.9 boxes. Local workers exhibited no statistically significant change in hourly productivity, while the picking rate for both of the other labor sources declined. Migrant workers exhibited a relatively large decline of 0.49 boxes per hour with each passing season. This rate of decline in hourly productivity is large when compared to the six year average of 9.0 boxes per worker per hour for this labor source.

Summary and Conclusions:

This study was initiated in response to a changing apple harvest labor supply situation in New York's Champlain Valley. Traditionally, three main sources of labor have been used: for the harvest years 1970 through 1975, local workers have comprised the bulk of the labor force (81 to 86 percent); migrant workers have comprised from 5 to 8 percent; and these two sources of of domestic workers have been supplemented with Jamaican workers (8 to 13 percent). This study of the labor productivity of these three sources over the

six year period reveals findings which have implications for future changes in these labor sources and for corrective action to increase harvesting capacity.

The harvesting capacity of migrant workers declined significantly over the six years studied. The average amount harvested per worker per season dropped 77 boxes with each passing season. This was due to declining hourly productivity. No research was initiated to determine the basic causes of this phenomenon, but if this pattern continues, the harvesting capacity of this labor source will be seriously curtailed.

The harvesting capacity of local workers remained relatively constant. The decline in productivity per worker per season of Jamaican workers was about one-half as much as that experienced by migrant workers. This change in harvesting capacity was expected to be a short run phenomenon. The number of days spent harvesting was declining somewhat.

In addition to indicating some past trends, the empirical results suggest some potential areas for corrective action.

Five to six local workers would be required to replace one migrant or Jamaican worker. The average harvesting capacity per worker per season varied greatly, and local workers harvested considerably less than did either Jamaican or migrant workers.

In addition to the average differences in productivity among the three major labor sources, there were large differences among workers employed by different growers, and among individual workers. This suggests that some increase in harvesting capacity might be gained by making changes in labor management practices, providing some worker training, and otherwise changing the work environment.

During the 1975 season, local workers averaged 39 hours per worker harvesting apples. If these workers had harvested an additional 5 hours each, at the same average rate of productivity, the harvesting capacity of the local workers would have increased by 13 percent, and the harvesting capacity of all three labor sources combined would have increased by 10 percent.

Finally, if the harvesting capacity of the labor force continues to decline, growers will continue to request additional foreign workers. The findings of this study suggest that there will be an increase in the demand for these workers in New York's Champlain Valley, unless action is taken to increase the productivity of the current labor force, or unless there is a decline in the demand for harvest workers.

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