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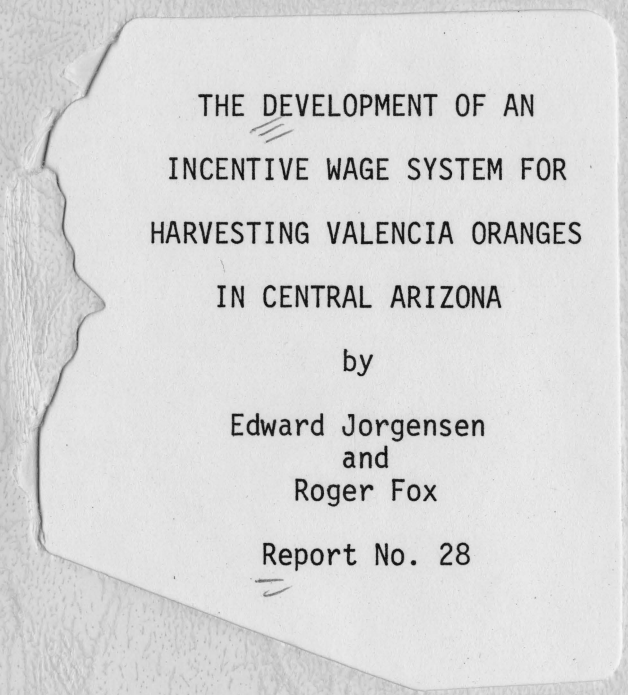

THE DEVELOPMENT OF AN INCENTIVE WAGE SYSTEM FOR HARVESTING VALENCIA ORANGES IN CENTRAL ARIZONA

by

Edward Jorgensen
and
Roger Fox

Report No. 28

COLLEGE OF AGRICULTURE
The University of Arizona
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PREFACE

In January of 1979, Peter Martori, Executive Director of the Central Arizona Citrus Harvesters Association approached the College of Agriculture concerning a possible study of the piece-rate wage system used in picking citrus. The Department of Agricultural Economics agreed to initiate a preliminary study designed to collect and analyze an initial set of data and to make recommendations concerning the nature of future research, if needed. The results of the preliminary study were published in October, 1979 (Report No. 20, An Incentive Wage System for Harvesting Oranges in Central Arizona: Preliminary Findings, by Roger Fox).

The current report expands on the earlier report by including new data and analysis. The research was conducted with the cooperation of Dean Bacon of the Tempe Citrus Research Farm and two packinghouses in the Phoenix area. The authors are grateful for the support and cooperation from the packinghouses and especially the crew foremen who helped collect the data.

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THE DEVELOPMENT OF AN INCENTIVE WAGE SYSTEM FOR HARVESTING VALENCIA ORANGES IN CENTRAL ARIZONA

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I. INTRODUCTION

Interest in developing an incentive wage system for harvesting citrus in Central Arizona was stimulated by the long experience of the Ventura County (California) lemon industry with such a system and concern over grower-picker relations in Arizona. The development and use of the system in Ventura County has been described in detail by Smith, Seamount and Mills in a 1965 bulletin published by the California Agricultural Experiment Station.[1/] Basically, the system used in Ventura County combines information on tree height, fruit size, yield per tree, picking rate (boxes per hour), and an "acceptable" average hourly wage rate to determine the cents per box rate that will be paid under a given set of conditions. After several years of studying the relationships between picking rates and the three factors determining picking conditions---tree height, fruit size, and yield per tree---an incentive piece-rate system was developed that is widely used for lemon harvesting in Ventura County.

1/ Roy J. Smith, Daniel T. Seamount and Bruce H. Mills, Lemon Picking and the Ventura County Tree Production Incentive Wage System, Bulletin 809, California Agricultural Experiment Station, University of California, January 1965.

Table 1 illustrates the end product of this system. The cents per box rate varies in accordance with the three factors. For example, for a given yield per tree (e.g., 0.75 - 0.99 boxes) and fruit size (e.g., less than 240 lemons per box), the rate in cents per box increases for each tree height class: 69¢, 80¢, 91¢, and $1.04 (circled). These rates reflect the decreasing productivity (boxes per hour) of pickers as they pick in successively higher trees. Likewise, for a given tree height and fruit size, the table shows a decreasing cents per box rate as yield increases. The grid of rates covers all anticipated conditions and does not penalize or favor pickers who happen to encounter bad or good picking conditions, a disadvantage of a system with a single rate per box. Also, pickers of differing abilities are paid according to their productivity, an advantage over a fixed hourly wage rate. Moreover, the grid of rates can be adjusted easily to reflect changes in the "acceptable" average hourly wage received by pickers using the system. The system does require acceptance by growers and pickers, and necessitates a series of measures in each block of trees picked. Tree height (point of highest fruit), fruit size, and yield per tree must be measured. The latter two items can be measured only after the fruit is picked, hence the appropriate pay rate cannot be determined in advance. This is why acceptance of and confidence in the system is required by both pickers and growers.

Packinghouses and growers in Central Arizona currently use a variety of pay systems for picking citrus. In some cases, a rate per box is fixed early in the season and is adjusted only if major changes in picking conditions occur. In other cases, the picking crews and the crew foreman negotiate a box rate for each grove they pick. This practice approximates an incentive system but substitutes subjective judgement for measurement of picking

Table 1. Incentive Wage System: An Example

COASTAL GROWERS ASSOCIATION
1700 EAST FIFTH ST. • POST OFFICE BOX 626
(805) 483-0185 • OXNARD, CALIFORNIA 93032

Scale to be used by Growers to establish price per box for picking lemons.

Tabla que usaran los cosecheros para calcular el precio por caja de limones.

LEMON PICKING RATES IN CENTS PER FIELD BOX OF 2926 CUBIC INCHES WHEN FILLED LEVEL TO TOP OF END CLEATS .....
(note: one bin equals 18 boxes)

ESCALA DE PRECIOS EN CENTAVOS A BASE DE CAJA DE 2926 PULGADAS CUBICAS CUANDO SE LLENA CON LIMONES AL RAS DE LA PARTE DE ARRIBA DE LOS BARROTES .....
(nota: una tina equivale 18 cajas)

A-B-C-D-E-F

J-K-L-N-Q-R

S-T-V-W-X-Y-Z

GA-GB-GK-GL-GM

EFFECTIVE: MAY 8, 1978
EFECTIVO: EL 8 DE MAYO DE 1978

AVERAGE YIELD OF FIELD BOXES PER TREE: PROMEDIO DE CAJA POR ARBOL: from: DE:	to: A:	CLASE 1 NO LADDER SIN ESCALERA			CLASE 2 FRUIT UNDER 9½ FEET FRUTA A MENOS DE 9½ PIES DE ALTO			CLASE 3 FRUIT 9½ TO 12 FEET FRUTA DE 9½ A 12 PIES DE ALTO			CLASE 4 FRUIT OVER 12 FEET FRUTA A MAS DE 12 PIES DE ALTO		
		Lemons per box Limones por caja			Lemons per box Limones por caja			Lemons per box Limones por caja			Lemons per box Limones por caja		
		(under) menos de 240	240 a (to) 300	(over) mas de 300	(under) menos de 240	240 a (to) 300	(over) mas de 300	(under) menos de 240	240 a (to) 300	(over) mas de 300	(under) menos de 240	240 a (to) 300	(over) mas de 300
0	0.24	95¢	$1.05	$1.12	$1.08	$1.16	$1.30	$1.12	$1.25	$1.46	$1.28	$1.39	$1.62
0.25	0.49	82¢	88¢	$1.01	99¢	$1.04	$1.23	$1.05	$1.23	$1.34	$1.16	$1.28	$1.39
0.50	0.74	74¢	83¢	94¢	86¢	99¢	$1.10	95¢	$1.13	$1.23	$1.08	$1.18	$1.28
0.75	0.99	69¢	80¢	83¢	80¢	90¢	99¢	91¢	$1.03	$1.14	$1.04	$1.06	$1.23
1.00	1.49	65¢	73¢	78¢	74¢	82¢	92¢	84¢	95¢	$1.10	99¢	$1.01	$1.19
1.50	1.99	59¢	63¢	67¢	66¢	74¢	85¢	78¢	86¢	$1.01	90¢	96¢	$1.08
2.00	2.99				60¢	71¢	81¢	72¢	80¢	90¢	82¢	85¢	$1.01
3.00 and Up						64¢	73¢	63¢	68¢	76¢	72¢	74¢	80¢

CLASSIFICATIONS ARE ESTABLISHED BY HEIGHT OF FRUIT MEASURED VERTICALLY FROM LOWEST GROUND LEVEL TO HIGHEST FRUIT TO BE PICKED.

LAS CLASIFICACIONES SE ESTABLECEN TOMANDOSE LA MEDIDA VERTICAL DESDE EL SUELO, HASTA LA FRUTA MAS ALTA QUE SE DEBE COSECHAR.

conditions. Fixed hourly rates also are used under certain circumstances (e.g., for picking young trees with few fruit). One grower is experimenting with a system that pays each crew, not the individual pickers, on a piece-rate per bin basis. The crew then divides the earnings among its members. All piece-rate systems are constrained by the minimum wage legislation which requires verification, on a weekly basis, that each picker has earned at least the minimum hourly wage.

This paper reports on a continuation of the research to develop an incentive wage system for harvesting Valencia oranges previously described in a preliminary report by Fox.[2/] Data for two more crop seasons have been gathered, statistically analyzed and are discussed in this report.

The results of the preliminary study were encouraging, but there existed differences in productivity between houses that were not explained by the independent variables representing fruit size, tree height and yield per tree. Also the data collected in Spring of 1979 did not fully represent the complete picking season. It was felt that new data should be collected covering the whole picking season and that future data should be modified to include a better description of cultural practices and field conditions.

The use of modified data has not led to a reduction in the amount of unexplained variation in worker productivity compared to the Spring 1979 study. The additional independent variables representing field conditions and cultural practices yielded no significant information. The significance

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[2/] R. Fox, An Incentive Wage System for Harvesting Oranges in Central Arizona: Preliminary Findings, Report No. 20, Department of Agricultural Economics, University of Arizona, October, 1979.

and signs of the independent variables, fruit size, tree height and yield, vary from house to house and change from year to year. The instability reflected in the new analyses has led to a decrease in the amount of explained variation in worker productivity and earnings, especially for the 1980-81 season.

II. THE DATA

Field data were obtained for crews picking Valencia oranges for the 1979-80 and 1980-81 crop seasons (only data for houses B and C were gathered as house A did not participate further in this study). Information was gathered on a working day basis for each crew during the months of February through June 1980 and March through May 1981. Data collected on each crew included:

1. Hours worked and boxes picked for each picker by name.[3/]
2. Number of trees picked.
3. An estimate of tree height (point of highest fruit).
4. An hourly sample of fruit per box.
5. The rate paid per box in cents.
6. The field conditions, i.e., whether or not the trees are hedged, interlocked or spaced and the ground conditions of weeds or bare ground.

From the field data it was possible to calculate the basic information necessary to develop the piece-rate system. Table 2 contains a summary of the basic data for spring 1979 and the 1979-80 and 1980-81 seasons. Data

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[3/] The data from house B for the 1980-81 crop season was recorded in total number of bins picked per crew and then converted to boxes as 1 bin = 16 field boxes. Information on individual pickers was not available.

collected in the spring of 1979 showed house C's crews picked smaller trees, smaller fruit and had lower yields than B's crews. Because of a higher price per box and greater productivity (boxes per hour), house C's crews averaged $1.10 per hour more than B's crews. For the 1979-80 season house C picked in groves with smaller trees, smaller fruit and lower yields than house B. Even though house C's average price per box was higher, it had a lower productivity and averaged $1.17 per hour less than house B's crews. Data from the 1980-81 season again showed house C picking in groves with slightly smaller trees, smaller fruit and lower yields than house B, the same situation as in the preceding crop season. However, because of a higher price per box and increased productivity is less compared to B; house C's crews averaged $1.50 per hour more than B's crews.

The summary statistics in Table 2 reflect the differences between packinghouses and their respective payroll systems, new characteristics (age, experience, health, etc.), picking methods, and field conditions. Consistent throughout the data collection period, from spring 1979 through the 1980-81 crop season, was that house C made frequent adjustments to the box rate while house B paid essentially the same box rate throughout the picking season. Picking methods differ between houses and may effect productivity, however, time and motion studies have not been conducted.[4/] Therefore, there is no information available as to which picking method is superior. Also field conditions vary between houses and could possibly effect picker productivity. Information on field conditions was gathered for house C and tested for its effect on productivity.

[4/] For example, house C uses two tractor and trailer rigs for each crew, thereby insuring that one rig will be in the grove with the pickers while the other is taking its full bins to the roadside and picking up empties. House B uses only one rig per crew which results in "dead" time while the rig is unloading and picking up empty bins.

Table 2. Summary Statistics: Valencia Orange Picking Data, Maricopa County.

Item	Packinghouse								
	Spring, 1979			1979-80			1980-81		
	B	C	All	B	C	All	B	C	All
1. Number of observations [a/]	23	39	62	107	82	189	53	26	79
2. Avg. boxes/hour	5.21	6.22	5.85	8.24	6.04	7.29	6.59	6.91	6.69
3. Avg. $/hour	3.12	4.22	3.74	5.38	4.21	4.87	4.36	5.86	4.86
4. Avg. $/box	0.60	0.70	0.66	0.65	0.72	0.68	0.66	0.85	0.73
5. Avg. yield/tree (boxes)	3.76	2.62	3.04	5.79	3.22	4.67	3.20	2.35	2.92
6. Avg. fruit size [b/]	129	197	172	158	189	171	129	209	155
7. Avg. tree height (ft.)	21.0	16.4	18.1	18.4	17.6	18.1	19.4	19.2	19.3

a/ An observation represents the activity of one crew for one day, or in the few cases where a crew picked in two groves each grove was counted as an observation.

b/ Number of oranges per standard field box based on an hourly sample.

III. ANALYSIS

The data collected for both the 1979-80 and 1980-81 Valencia orange crop seasons were analyzed statistically by multiple linear regression techniques. This approach estimates the amounts of variation in productivity (boxes per hour) and earnings (cents per hour) explained by the associated variations in fruit size, tree height and yield. The data for 1979-80 and 1980-81 extended the basic regression equations of the preliminary report by including three more independent variables:

1. H (hedged)[5/]
2. I (interlocked)[6/]
3. G (ground conditions)[7/]

These new independent variables were treated as dummy variables. If the trees were hedged the variable H was given the value one, if not hedged it was given the value zero. The variable I was assigned the value of one if the trees were interlocked and zero otherwise. Similarly, if the ground was bare, G was given the value one, if weed covered, it was given the value zero.

Scattergrams were prepared that plotted the dependent variables BPH (boxer per hour) and CPH (cents per hour) with each of the independent variables of FS (fruit size), TH (tree height), Y (yield), H, I and G. As expected, BPH and CPH were in general inversely rated to FS and TH and positively related to Y. The scattergrams indicated a linear relationship for

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[5/] Hedging is the pruning of the sides of the tree, but can also include the topping of the tree to a uniform height.

[6/] Interlocking is when the branches from two or more trees are intertwined.

[7/] Data concerning ground conditions was supplied by house C only.

FS and TH and positively related to Y. The scattergrams indicated a linear relationship for FS, TH and Y, but with a large degree of variation. While plots of H, I and G were inclusive, the addition of the independent variables H, I, and G both individually and in combination with FS, TH and Y in a regression equation did not produce any coefficients significantly different from zero at the 95 percent level. Because of the consistently poor results, the variables H, I and G were not included in any further analysis.

Regressions were run with FS, TH and Y for both houses together (pooled data) and each house individually. Table 3 summarizes this summarizes this regression analysis for the spring 1979, 1979-80 and 1980-81 crop seasons.

Regression analysis of the spring 1979 data from houses B and C showed that the three independent variables FS, TH and Y explained 49 percent of the variation in productivity and 13 percent of the variation in earnings. However, a number of the regression coefficients in the earnings equations were not significantly different from zero.

For the 1979-80 and 1980-81 seasons FS, TH and Y explained a higher proportion of the variation in productivity than in earnings when all of the data were used. For the 1979-80 season, 56 percent of the variation in productivity was explained, whereas 37 percent of the variation in earnings was explained. With the pooled data for the 1979-80 season all coefficients had the correct signs and were significantly different from zero at the 95 percent level of probability. The yield variable was the most important in explaining the variation in both productivity and earnings. When analyzing the 1979-80 data for the individual packinghouses, 69 percent of the variation in the productivity of house C was accounted for. However, the fruit size variable was not significant from zero, a reversal of the findings of the preliminary report.

Table 3. Summary of Regression Analyses: Valencia Orange Picking Data, Maricopa County.[a/]

Season	Dependent Variable [b/]	Coefficients [c/]			Adjusted R^2 [d/]
		Fruit Size (FS)	Yield (Y)	Tree Height (TH)	
Spring, 1979	BPH (all data)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.49
	CPH (all data)	$(+)^{NS}$	$(+)^{NS}$	$(-)^{S}$	0.13
	BPH (House B)	$(-)^{S}$	$(+)^{NS}$	$(-)^{S}$	0.37
	BPH (House C)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.72
	CPH (House B)	$(-)^{S}$	$(+)^{NS}$	$(-)^{NS}$	0.32
	CPH (House C)	$(-)^{S}$	$(+)^{S}$	$(-)^{NS}$	0.48
1979-80	BPH (all data)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.56
	CPH (all data)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.37
	BPH (House B)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.33
	BPH (House C)	$(+)^{NS}$	$(+)^{S}$	$(-)^{S}$	0.69
	CPH (House B)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.32
	CPH (House C)	$(-)^{NS}$	$(+)^{S}$	$(-)^{NS}$	0.14
1980-81	BPH (all data)	$(-)^{NS}$	$(+)^{NS}$	$(-)^{S}$	0.19
	CPH (all data)	$(+)^{S}$	$(+)^{NS}$	$(-)^{S}$	0.18
	BPH (House B)	$(-)^{S}$	$(+)^{S}$	$(-)^{S}$	0.25
	BPH (House C)	$(-)^{S}$	$(+)^{NS}$	$(-)^{NS}$	0.28
	CPH (House B)	$(-)^{NS}$	$(+)^{S}$	$(-)^{S}$	0.25
	CPH (House C)	$(-)^{S}$	$(+)^{NS}$	$(-)^{NS}$	0.20

a/ See Attachment I for detailed statistical results.

b/ BPH is boxes per hour; CPH is cents per hour.

c/ Signs of the regression coefficients are in parentheses. S indicates that the coefficient is significantly different from zero at a 95 percent or better level of confidence. NS indicates that the coefficient is not statistically different from zero at the 95 percent confidence level.

d/ R^2 is a measure of the proportion of variation in the dependent variable explained by the independent variables.

The regression analysis of data from the 1980-81 season shows a reduction in the amount of explained variation in both productivity and earnings. When all data were used only 19 percent of the total variation in productivity and 18 percent of earnings was explained. The only significant variable in the productivity equation was tree height. The variables for fruit size and tree height were significant in the earnings equation, however, the fruit size variable had the wrong sign. In the analysis of data from the individual houses, house C had a higher level of the variation in productivity explained than house B, 28 percent to 25 percent respectively. All variables were significant in the productivity equations for house B, however, only the fruit size variable was significant for house C.

Of concern is the complete reversal in the significance of the yield variable for the 1979-80 and 1980-81 crop seasons. The variable was significant in the equations representing both the productivity and earnings for the 1979-80 season. This situation had disastrous effects on the amount of variation explained by the regression equations as the adjusted R^2 dropped from .56 to .19 for productivity and .37 to .18 for earnings.

Tables 4, 5, and 6 give the estimated incentive pay rates for each sample period and packinghouse. These tables were developed by estimating productivity (BPH) by substituting the class midpoint values for FS, TH and Y into the productivity equations for each packinghouse. The class midpoint values used for FS were 135, 175, and 215; for TH they were 14, 18.5, and 22.5; and for Y they were 1.30, 2.10, 2.90, 3.70 and 4.5. The next step was to convert these productivity values to an incentive wage. This conversion requires the use of an acceptable hourly wage. In this study,

Table 4. Estimated Incentive Pay Rates for Picking Valencia Oranges, Dollars Per Box, Maricopa County, Spring, 1979.

Average Yield-Boxes per Tree	Class I 12-16 Ft.			Class II 17-20 Ft.			Class III 21-24 Ft.		
	Oranges per Box			Oranges per Box			Oranges per Box		
	<150	150-200	>200	<150	150-200	>200	<150	150-200	>200
<1.70	B = 0.72 C = 0.52	B = 0.84 C = 0.58	B = 1.01 C = 0.66	B = 0.87 C = 0.60	B = 1.06 C = 0.68	B = 1.36 C = 0.79	B = 1.08 C = 0.69	B = 1.39 C = 0.80	B = 1.93 C = 0.95
1.70-2.50	B = 0.66 C = 0.49	B = 0.76 C = 0.54	B = 0.90 C = 0.61	B = 0.79 C = 0.56	B = 0.94 C = 0.63	B = 1.17 C = 0.72	B = 0.96 C = 0.63	B = 1.19 C = 0.73	B = 1.57 C = 0.85
2.51-3.31	B = 0.61 C = 0.46	B = 0.70 C = 0.51	B = 0.81 C = 0.57	B = 0.72 C = 0.52	B = 0.85 C = 0.58	B = 1.02 C = 0.66	B = 0.86 C = 0.59	B = 1.04 C = 0.67	B = 1.32 C = 0.77
3.32-4.12	B = 0.57 C = 0.44	B = 0.65 C = 0.48	B = 0.74 C = 0.53	B = 0.67 C = 0.49	B = 0.77 C = 0.54	B = 0.91 C = 0.61	B = 0.78 C = 0.55	B = 0.93 C = 0.62	B = 1.14 C = 0.71
>4.12	B = 0.53 C = 0.42	B = 0.60 C = 0.45	B = 0.68 C = 0.50	B = 0.62 C = 0.46	B = 0.70 C = 0.51	B = 0.82 C = 0.57	B = 0.71 C = 0.52	B = 0.83 C = 0.58	B = 1.01 C = 0.65

Key: B = House B
C = House C

Table 5. Estimated Incentive Pay Rates for Picking Valencia Oranges, Dollars Per Box, Maricopa County, 1979 - 80.

Average Yield-Boxes per Tree	Class I 12-16 Ft.			Class II 17-20 Ft.			Class III 21-24 Ft.		
	Oranges per Box			Oranges Per Box			Oranges Per Box		
	<150	150-200	>200	<150	150-200	>200	<150	150-200	>200
<1.70	B = 0.78 C = 0.63	B = 0.79 C = 0.64	B = 0.81 C = 0.65	B = 1.05 C = 0.79	B = 1.07 C = 0.80	B = 1.08 C = 0.81	B = 1.51 C = 1.03	B = 1.55 C = 1.04	B = 1.58 C = 1.06
1.70-2.50	B = 0.74 C = 0.59	B = 0.75 C = 0.61	B = 0.76 C = 0.63	B = 0.97 C = 0.74	B = 0.99 C = 0.75	B = 1.00 C = 0.77	B = 1.35 C = 0.95	B = 1.38 C = 0.97	B = 1.41 C = 0.99
2.51-3.31	B = 0.69 C = 0.57	B = 0.71 C = 0.58	B = 0.72 C = 0.60	B = 0.90 C = 0.70	B = 0.92 C = 0.71	B = 0.93 C = 0.72	B = 1.22 C = 0.88	B = 1.25 C = 0.90	B = 1.27 C = 0.94
3.32-4.12	B = 0.66 C = 0.52	B = 0.67 C = 0.55	B = 0.69 C = 0.57	B = 0.84 C = 0.66	B = 0.86 C = 0.68	B = 0.87 C = 0.71	B = 1.11 C = 0.82	B = 1.14 C = 0.84	B = 1.17 C = 0.88
>4.12	B = 0.63 C = 0.51	B = 0.64 C = 0.53	B = 0.66 C = 0.58	B = 0.77 C = 0.64	B = 0.80 C = 0.67	B = 0.82 C = 0.69	B = 1.02 C = 0.78	B = 1.05 C = 0.79	B = 1.08 C = 0.81

Key: B = House B
C = House C

Table 6. Estimated Incentive Pay Rates for Picking Valencia Oranges, Dollars Per Box, Maricopa County, 1980 - 81.

Average Yield-Boxes per Tree	Class I 12-16 Ft.			Class II 17-20 Ft.			Class III 21-24 Ft.		
	Oranges per Box			Oranges per Box			Oranges per Box		
	<150	150-200	>200	<150	150-200	>200	<150	150-200	>200
<1.70	B = 0.52 C = 0.60	B = 0.56 C = 0.66	B = 0.61 C = 0.72	B = 0.60 C = 0.71	B = 0.67 C = 0.80	B = 0.73 C = 0.89	B = 0.70 C = 0.87	B = 0.79 C = 0.98	B = 0.89 C = 1.14
1.70-2.50	B = 0.51 C = 0.59	B = 0.55 C = 0.64	B = 0.62 C = 0.70	B = 0.60 C = 0.71	B = 0.65 C = 0.78	B = 0.71 C = 0.87	B = 0.69 C = 0.84	B = 0.77 C = 0.95	B = 0.86 C = 1.09
2.51-3.31	B = 0.50 C = 0.58	B = 0.54 C = 0.63	B = 0.59 C = 0.69	B = 0.58 C = 0.68	B = 0.64 C = 0.75	B = 0.70 C = 0.84	B = 0.68 C = 0.82	B = 0.75 C = 0.92	B = 0.83 C = 1.05
3.32-4.12	B = 0.49 C = 0.56	B = 0.53 C = 0.61	B = 0.57 C = 0.67	B = 0.56 C = 0.66	B = 0.62 C = 0.73	B = 0.68 C = 0.82	B = 0.66 C = 0.79	B = 0.73 C = 0.89	B = 0.81 C = 1.01
>4.12	B = 0.48 C = 0.55	B = 0.52 C = 0.60	B = 0.56 C = 0.65	B = 0.55 C = 0.64	B = 0.61 C = 0.71	B = 0.66 C = 0.79	B = 0.65 C = 0.77	B = 0.71 C = 0.87	B = 0.79 C = 0.98

Key: B = House B
C = House C

the actual overall average hourly wage was rounded off and used. For spring 1979, $3.70 per hour was used, while $4.90 per hour was used for the 1979-80 and 1980-81 crop seasons. These acceptable hourly wages were divided by the estimated productivity figures to derive the incentive pay rates.[8/]

Table 7 gives a comparison of actual and estimated incentive wage data for each sample period. The comparison was made by entering the tables of estimated incentive pay rates with the actual picking conditions on a day by day and crew by crew basis. The total number of field observations were used to determine what would have been earned under the estimated incentive wages. Consistent throughout the calculations was the assumption that the incentive wages would not effect productivity (boxes per hour).

The data from spring 1979 showed the actual and estimated average rate per box for all 62 observations to be 66 cents per box. However, large changes at the packinghouse level would occur if the incentive wage system were used. House B would have paid 16 cents per box more and house C 12 cents per box less. These changes in the piece-rates would be reflected in the hourly wages. The overall average, hourly wage was 8 cents per hour less than actual, while the hourly wages for house B increased by 79 cents per hour and house C decreased by 67 cents per hour. The coefficient of variation indicates the overall variation in hourly earnings would have been reduced by incentive wages, while variation at the packinghouse would decrease for house B and increase for house C.

Wage data for the 1979-80 crop season showed the actual and estimated average rate per box for all observations to be 68 cents per box. There

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[8/] See Fox, op. cit., pp. 14-17 for more detail on the procedure used to develop the estimated incentive pay rates.

Table 7. Comparison of Actual and Estimated Wage Data: Valencia Orange Picking Data, Maricopa County.

	PACKINGHOUSE								
	Spring 1979			1979-80			1980-81		
ITEM	B	C	ALL	B	C	ALL	B	C	ALL
Avg. $/Box									
Actual	0.60	0.70	0.66	0.65	0.72	0.68	0.66	0.86	0.73
Estimated	0.76	0.58	0.66	0.64	0.72	0.68	0.70	0.77	0.73
Avg. $/hour									
Actual	3.12	4.22	3.74	5.38	4.21	4.87	4.36	5.86	4.86
Estimated	3.91	3.55	3.68	5.26	5.11	5.19	4.64	4.68	4.62
Standard Deviation $/hour									
Actual	0.46	0.54	0.88	1.26	0.55	1.16	0.94	1.25	1.26
Estimated	0.55	0.59	0.58	1.07	0.72	0.94	0.90	0.99	0.93
Coefficient of Variation $/hour[a/]									
Actual (%)	14.7	12.7	23.4	23.4	13.1	23.8	21.6	21.3	25.9
Estimated (%)	14.1	16.7	15.8	20.3	14.1	18.1	19.4	21.1	20.1

[a/] The coefficient of variation equals the standard deviation divided by the average (mean) and multiplied by 100 to give a percentage figure of relative variation.

would be only a small change in the piece-rate of 1 cent per box for house B and no change for house C under incentive wages. The overall average hourly wage increased by 32 cents per hour; however, the hourly wage for house B decreased by 12 cents per hour and increased 90 cents per hour for house C. Implementation of incentive wages would reduce the overall variation, while the variation at the packinghouse level would decrease for house B and increase for house C.

Data from the 1980-81 season showed the actual and estimated average rate per box for all 79 observations to be 73 cents per box. Acceptance of an incentive wage program would cause house B to increase its rate per box by 4 cents and house C to reduce its rate per box by 9 cents. The overall average hourly wage would decrease by 24 cents per hour, while at the packinghouse level it would increase by 28 cents per hour for house B and decrease by $1.18 per hour for house C. Incentive wages would reduce overall variation, but the variation for house B would decrease and increase for house C.

The incentive wage system reduces the overall variation in hourly earnings. However, this reduction does not occur for both houses at the packinghouse level. For each sample period incentive wages reduce the variation in hourly earnings for house B, but increases the variation for house C.

IV. CONCLUSION AND RECOMMENDATIONS

Tables 4, 5, and 6 should be considered as illustrative of the approach required to develop a workable incentive wage system and are not offered as

recommendations. They could, however, be used experimentally to test picker reactions and feasibility of the system before or after adjustment of the "acceptable" hourly wage.

The analysis of additional information gathered since the preliminary study has allowed for more complete comparison of packinghouses B and C. However, the data collected during the 1979-80 and 1980-81 crop season have not reduced the unexplained variation in worker productivity (BPH). There is still a large amount of variation in productivity that remains unexplained after taking into account differences between houses. Two problem areas are apparent. One concerns the unexplained productivity differences among packinghouses and the other concerns improvement in the productivity equations with respect to better measurement of fruit size, tree height, and orchard conditions.

Observed productivity differences between packinghouses can be associated with, (1) the use of different pay systems, (2) the use of different picking systems, and/or (3) differences in picking ability among crews. The separation and measurement of the effects of these three possible causes of productivity differences is very complex and difficult to quantify. An effort was made to measure differences between experienced and inexperienced pickers but it proved to be inconclusive because of difficulty with the data collection procedures.

Data on field conditions were collected to refine the description of field quality. The additional independent variables H, I, G added no significant information. The significance and sign of the independent variables FS, TH and Y vary from house B to C and change from season to season.

In this study, fruit size was based on an hourly sample. This technique was used as it could be accomplished without additional workers and offered

the least amount of disruption in the picking system. However, Pelzel and Smith[9/] suggest the hourly sampling of fruit biases the sample towards smaller fruit. If the orchard has a large variation in fruit sizes, more time is spent picking in the section with smaller fruit. With an hourly sample, proportionately more samples would be taken in the sections having the smaller sizes. They recommend the random sampling of trees before picking to determine an accurate fruit count. Since the independent variable representing fruit size has been shown to be unstable in the regression equation of productivity for the 1979-80 and 1980-81 crop seasons, new sampling procedure should be considered. However, the random sampling technique of Pelzel and Smith would involve additional costs.

Future data should reflect differences in the payroll systems and picking methods between houses. House C makes frequent adjustments to the box rate while house B pays essentially the same rate throughout the picking season. It could be the case that one payroll system has a greater effort on productivity than the other. Also picking methods differ sharply between packinghouses. Again the possibility exists that one picking system could have a greater impact on productivity than the other. The payroll system and picking method of each house needs further investigation to properly explain productivity differences between houses.

9/ Jon Pelzel and Roy J. Smith, "The Tree Production Incentive Wage System and Accuracy in Fruit Count," Department of Horticultural Science, University of California at Riverside, August 16, 1966, revised November 9, 1966 (mimeo).

APPENDIX

Statistical Methodology

The analysis of covariance method was used to analyze the differences in regression equations of BPH (productivity) between houses B and C. Table 8 is a complete analysis of covariance table for productivity used to test the significance of groups of regression coefficients. An appropriate F test statistic is calculated from the values in this table to test for significant differences in slope coefficients, intercepts and the overall relationship between houses. Table 9 gives the F test statistics used in the hypothesis testing of the regreesion equations. Attachment I summarizes the regression analysis of the data for all three sample periods using only the independent variables FS, Y and TS. Attachment II is a summary of the regression equations taking into account differences in the intercept value. Attachment III gives the relationship of individual regression variables and identifies the variable's contribution in the regression equation.

The analysis of the data collected during the spring 1979 sample period showed the hypothesis of a common slope was not rejected, however, there was a significant difference in intercept values, with house B less than house C. When the difference in intercept was accounted for the adjusted R^2 for the productivity equation increased from .49 to .71 (see Attachments I and II). The regression equations of productivity for each house are not homogeneous and cannot be pooled into a single equation suitable for use by both houses. See Table 9 for results.

Statistical analysis of the 1979-80 crop season showed significant differences in the slope coefficients and intercept values of the

Table 8. Analysis of Covariance Table on Productivity (BPH): Valencia Orange Picking Data, Maricopa County.

Season	Source [a/]	Sum of Squares	Degrees of Freedom	Mean Square
Spring, 1979	S_4	26.1144	$df_4 = 54$	0.4836
	S_3	0.6496	$df_3 = 3$	0.2165
	S_2	26.7640	$df_2 = 57$	0.4695
	S_1	20.7084	$df_1 = 1$	20.7084
	S	47.4724	df = 58	
1979-80	S_4	282.2649	$df_4 = 181$	1.5595
	S_3	19.0995	$df_3 = 3$	6.3665
	S_2	301.3644	$df_2 = 184$	1.6379
	S_1	22.6237	$df_1 = 1$	22.6237
	S	323.9881	df = 185	
1980-81	S_4	118.9587	$df_4 = 71$	1.6755
	S_3	1.3915	$df_3 = 3$	0.4638
	S_2	120.3502	$df_2 = 74$	1.6264
	S_1	17.8328	$df_1 = 1$	17.8328
	S	138.1830	df = 75	

[a/] This column indicates from which regression equation the residual sum of squares is taken. S_4 is the residual sum of squares generated by fitting a separate regression to data for each house and than summing the residuals from both houses. S_2 is the residual sum of squares of the regression that allows each house a different intercept but imposes common slope coefficients on both houses. S is the residual sum of squares from the regression using pooled data. Also, S_3 and S_2 are found by subtraction, $S_3 = S_2 - S_4$ and $S_1 - S - S_2$. See J. Johnston, Econometric Methods, McGraw - Hill Book Co., New York, 2nd Edition, 1972, pp. 192 - 207 for a more complete explanation.

Table 9. Calculation of the F Test Statistic: Valencia Orange Picking Data, Maricopa County.

Season	F_1	$F_{0.05}(df_3, df_4)$ [a/]	F_2	$F_{0.05}(df_1, df_2)$	F_3	$F_{0.05}(df_1 + df_3, df_4)$
Spring, 1979	0.4478	2.78	44.1073	4.01	11.0412	2.55
1979-80	4.0824	2.60	13.8130	3.84	6.6886	2.37
1980-81	0.2768	2.75	10.9641	3.99	2.8684	2.52

The three following F tests are used to test the regression equations for differences in slope, intercepts and overall homogeneity [b/]:

1. Test for differentials in slope

$$F_3 = \frac{S_3/df_3}{S_4/df_4}$$

2. Test of differential intercepts

$$F_2 = \frac{S_1/df_1}{S_2/df_2}$$

3. Test of overall homogeneity

$$F_3 = \frac{(S_1+S_3)/(df_1+df_3)}{S_4/df_4}$$

[a/] Tabulated F distribution value at the 95 percent level, given degrees of freedom.

[b/] The hypothesis of a common regression slope, intercept or overall homogeneity is rejected if the calculated F value is greater than the tabular value.

productivity equations for each house. House B had a greater sensitivity to both FS (fruit size) and TH (tree height) variables than house C, while the intercept for house B was significantly greater than house C. When these differences are taken into account the adjusted R^2 increased from .56 to .61 (see Attachment III). Because of the significant differences between houses, a regression equation for productivity based upon pooled data is not reliable. See Table 9 for results.

Analysis of the regression equation for productivity for the 1980-81 season showed the hypothesis of a common regression slope was accepted, but there was a significant difference between the intercepts, with the intercept for house B less than house C. Attachment II shows that when this difference is taken into account the adjusted R^2 increased from .19 to .28. As in the preceding two sample periods the data from both houses cannot be pooled into a single regression equation for both houses (see Table 9).

ATTACHMENT I. REGRESSION EQUATIONS FOR BOXES PER HOUR (BPH) AND CENTS PER HOUR (CPH): Valencia Orange Picking Data, Maricopa County.

SEASON	DEPENDENT VARIABLE	NUMBER OF OBSERVATIONS	CONSTANT TERM	COEFFICIENTS OF THE INDEPENDENT VARIABLES FS	TH	Y	ADJUSTED R^2	S_{yx}
SPRING 1979	BPH (ALL DATA)	62	+12.4026	-0.0109 (0.0030)	-0.3247 (0.0431)	+0.3914 (0.1341)	.49	0.9047 [20.2512]
	CPH (ALL DATA)	62	+639.3931	+0.3019 (0.2769)	-13.7625 (3.9125)	+12.1569 (12.1775)	.13	82.1415 [4.1279]
	BPH (HOUSE B)	23	+11.4116	-0.0173 (0.0078)	-0.2469 (0.0962)	+0.3213 (0.1878)	.37	0.6837 [5.2847]
	BPH (HOUSE C)	39	+11.9196	-0.0201 (0.0030)	-0.1913 (0.0451)	+0.5345 (0.1337)	.72	0.6999 [33.3216]
	CPH (HOUSE B)	23	+603.4716	-0.9990 (0.4293)	-10.9286 (5.2989)	+17.6491 (10.3511)	.32	37.6792 [4.5184]
	CPH (HOUSE C)	39	+532.8362	-0.7504 (0.1670)	-0.5827 (2.5121)	+17.8169 (7.4447)	.48	38.7096 [12.7936]
1979-80	BPH (ALL DATA)	189	+12.4087	-0.0146 (0.0033)	-0.2985 (0.0462)	+0.5944 (0.5532)	.56	1.3234 [79.7833]
	CPH (ALL DATA)	189	+609.9510	-0.7714 (0.2296)	-7.3145 (3.2268)	+30.4019 (3.8609)	.37	92.3529 [38.4771]
	BPH (HOUSE B)	107	+17.4762	-0.0164 (0.0051)	-0.4944 (0.1037)	+0.4273 (0.0943)	.33	1.5119 [18.7358]
	BPH (HOUSE C)	82	+9.1515	-0.0004 (0.0033)	-0.2895 (0.0333)	+0.5914 (0.0734)	.69	0.7747 [60.0829]
	CPH (HOUSE B)	107	+1096.7424	-0.9556 (0.3541)	-31.8058 (7.1374)	+31.0346 (6.4911)	.32	104.3239 [17.3214]
	CPH (HOUSE C)	82	+421.3765	-0.0451 (0.2185)	-2.5237 (2.1951)	+16.3245 (4.8316)	.14	50.9877 [5.3747]

ATTACHMENT I. Continued

SEASON	DEPENDENT VARIABLE	NUMBER OF OBSERVATIONS	CONSTANT TERM	COEFFICIENTS OF THE INDEPENDENT VARIABLES FS	TH	Y	ADJUSTED R^2	S_{yx}
	BPH (ALL DATA)	79	+13.3902	-0.0017 (0.0035)	-0.3688 (0.0952)	+0.2393 (0.1272)	.19	1.3574 [7.0778]
	CPH (ALL DATA)	79	+899.1665	+0.8537 (0.2973)	-29.4874 (8.0093)	+8.0245 (10.7009)	.18	114.1910 [6.7665]
1980-81	BPH (HOUSE B)	53	+13.0329	-0.0153 (0.0086)	-0.2718 (0.0991)	+0.2510 (0.1290)	.25	1.2286 [6.8282]
	BPH (HOUSE C)	26	+15.9583	-0.0189 (0.0090)	-0.3291 (0.2472)	+0.5104 (0.3784)	.28	1.4301 [4.1916]
	CPH (HOUSE B)	53	+862.7795	-1.0096 (0.5705)	-17.9960 (6.5636)	+16.6185 (8.5415)	.25	81.3332 [6.8282]
	CPH (HOUSE C)	26	+1285.8941	-1.4506 (0.7058)	-21.4886 (19.4088)	+6.0736 (0.7059)	.20	112.2720 [3.0701]

FS is fruit size in number of oranges per box.

TH is tree height in feet.

Y is yield in boxes per tree.

Figures in parentheses are the standard errors of the net regression coefficients.

Figures in brackets are the calculated F ratios.

ATTACHMENT II. REGRESSION EQUATIONS FOR TESTING PACKINGHOUSE DIFFERENCE: Valencia Orange Picking Data, Maricopa County.

SEASON	DEPENDENT VARIABLE	NUMBER OF OBSERVATIONS	CONSTANT TERM	COEFFICIENTS OF THE INDEPENDENT VARIABLES B	FS	TH	Y	ADJUSTED R^2	S_{yx}
SPRING 1979	BPH	62	12.0363	-2.0188 (0.3039)	-0.0199 (0.0027)	-0.1945 (0.0381)	+0.4839 (0.1025)	.71	0.6852 [37.5016]
	CPH	62	604.3829	-207.9313 (24.3459)	-1.2294 (0.2145)	-0.3558 (3.0491)	+21.6872 (8.2118)	.61	54.8781 [25.1721]
1979-80	BPH	189	+12.5116	+ 1.0196 (0.2743)	-0.0102 (0.0034)	-0.3309 (0.0461)	+0.4498 (0.0662)	.59	1.2797 [67.4350]
	CPH	189	614.6683	+46.6867 (19.5502)	-0.5723 (0.2417)	-9.2136 (3.2843)	23.7770 (4.7148)	.39	91.2004 [31.0181]
1980-81	BPH	79	+15.3332	-1.8173 (0.5488)	-0.0168 (0.0056)	-0.2910 (0.0925)	+0.2805 (0.1202)	.28	1.2753 [8.7547]
	CPH	79	+1179.621	-262.4358 (38.9466)	-1.3293 (0.0401)	-18.2415 (6.5634)	+13.9705 (8.5267)	.49	90.5005 [19.4309]

BPH, CPH, FS, TH, and Y are defined in the text and in Attachment I.

B has a value of one for house B's observations and zero otherwise.

Figures in parentheses are the standard errors of the next regression coefficients.

Figures in brackets are the calculated F ratios.

ATTACHMENT III. REGRESSION EQUATIONS FOR TESTING THE SIGNIFICANCE OF INDEPENDENT VARIABLES:
Valencia Orange Picking Data, Maricopa County.

SEASON	DEPENDENT VARIABLE	NUMBER OF OBSERVATIONS	CONSTANT TERM	COEFFICIENTS OF THE INDEPENDENT VARIABLES							ADJUSTED R^2	Syx
				B	FS	TH	Y	BFS	BTH	BY		
SPRING 1979	BPH	62	11.9196	-0.5013 (3.035)	-0.0201 (0.0030)	-0.1913 (0.4513)	+0.5345 (0.1337)	+0.0028 (0.0085)	-0.0555 (0.1077)	-0.2135 (0.2332)	.70	0.6954 [20.9985]
1979-80	BPH	189	9.1515	+8.3248 (2.1965)	+0.0004 (0.0054)	-0.2895 (0.0538)	+0.5914 (0.1183)	-0.0168 (0.0068)	-0.2049 (0.1011)	-0.1640 (0.1417)	.61	1.2487 [42.2206]
1980-81	BPH	79	15.9583	-2.9254 (4.6873)	-0.0189 (0.0081)	-0.3291 (0.2238)	+0.5104 (0.3425)	+0.0037 (0.0122)	-0.0573 (0.2469)	-0.2593 (0.3684)	.26	1.2944 [4.9747]

BPH, FS, TH, Y are defined in the text.

B has a value of one for house B's observations and zero otherwise.

Figures in parentheses are the standard errors of the net regression coefficients.

Figures in brackets are the spare calculated F ratios.