PRODUCTIVELY DETERMINED PIECE-RATES FOR HARVESTING CITRUS IN CENTRAL ARIZONA.

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PRODUCTIVELY DETERMINED PIECE-RATES FOR HARVESTING CITRUS IN CENTRAL ARIZONA

by

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APPROVAL BY THESIS DIRECTOR

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Roger Fox — 16 June '82

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Date

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ABSTRACT

The major objective of this study was to develop productively determined piece-rates for picking citrus in central Arizona. A multiple regression model was used to determine the relationships between picker productivity and five field conditions: tree yield, fruit size, tree height, hedging of trees and interlocking of trees. The citrus varieties analyzed were navel oranges, grapefruit and lemons (both snap and ring/color picked lemons). Harvest crew observations were made for two harvest seasons, 1979-80 and 1980-81 for all the varieties studied except grapefruit (1979-80 season only). Hypothetical piece-rate schedules were determined for all varieties studied using the regressed productivity equations.

CHAPTER 1

INTRODUCTION

The Farm Labor Problem

In the past farmers in the United States essentially ignored efficient labor management practices. Instead they devoted their attention and efforts to cultural practices, equipment use and maintenance, and other facets of agricultural production. Modern personnel management practices have been in use for several decades in other sectors of the economy, yet it has been only recently that some farmers have become concerned about improving labor management.

Historically many important differences existed between the agricultural and non-agricultural sectors in our country. These differences existed in the work and production processes, and to the nature of employees and employers. Farm organizations and employers in the past systematically opposed the inclusion of agricultural employment under labor laws and regulations. These groups backed their positions by arguing that agricultural employment warranted different coverage than non-agricultural employers (Erven, 1981). Agricultural production is charactized by seasonal variations in activity in contrast to an industrial assembly line production system (Emerson, 1981). This unique characteristic was used to justify the opposition toward farm labor's inclusion under general labor laws and regulations.

Agriculture has become more industrialized in recent years. Included in this slow process are increasing farm sizes, increased sophistication and complexity of farm businesses, and the mechanization of many production processes (Erven, 1981). These changes have altered employment conditions for a small segment of the labor force. More steady employment opportunities involving supervisory or skilled and technical tasks are becoming available. Such positions are, however, quite limited and are a small percentage of the total workforce. Only 15 percent of hired farmworkers are employed year round in agriculture (Agricultural Labor in 1980s).

Agricultural employment in the United States is largely casual. Employees have limited attachment to particular employers and consequently have little job security or opportunity for advancement (Glover, 1981). A large portion of jobs available in agriculture involve the harvesting of fruit and vegetables. Harvest labor markets have a prominent seasonal component which arises due to the intensive demand for labor during harvest time (Emerson). Labor requirements are minimal during the remainder of the year.

Today's farmworkers are covered by most federal and state laws regulating employment safety, health and other labor force standards already in effect in non-agriculture industries. There has been increased pressure from farmworkers and increasing realization among employers of the necessity of reducing instability and improving inefficiency and economic practices would not provide a sufficient quantity of high quality workers. Instead, Coastal Growers chose to attempt to develop a stable labor force, hiring a manager skilled in labor management rather than relying on labor contractors or foreman for labor liaison. In 1965, Coastal Growers initiated a program of employee benefits to provide the cooperative with an adequate supply of labor, reduce worker turnover and increase worker efficiency (Hayes, 1978).

One of the main segments of Coastal Growers' benefit package was the unique wage system for harvest labor compensation. The benefits of this system have been substantial to both the growers and harvest labor. Records reveal that picker productivity, measured in boxes per hour, more than doubled between 1967 and 1977. The cost per box for harvesting lemons in 1977, $.69, was only 15 percent more than the 1967 cost, but average earnings per hour increased from $2.02 in 1967 to $4.34 in 1977 (Hayes, 1978). Job turnover was reduced significantly. Coastal Growers' program is considered to be quite innovative and progressive by labor authorities and experts.

The development of the wage system used by Coastal Growers is described in a 1965 California Experiment Station Bulletin by Smith, Seamount and Mills. The "Tree Production Incentive Wage System" is an "incentive" type wage system. The conceptual design of this pay system differs, however, from most incentive wage programs commonly found in agriculture. The traditional systems generally set a single piece rate that is applied to all working conditions encountered by harvest crews. The tree production system combines information on tree height, fruit size, yield per tree, picking rate (boxes per hour, and an "acceptable hourly wage" to determine the cents per box rate that will be paid under a given set of conditions.

In picking citrus a single box rate is grossly inequitable to pickers in slow picking conditions and is grossly inequitable to growers in faster picking (Smith, Seamount and Mills, 1965). Harvest crews are seldom willing to accept an average rate in all situations. By accepting a single rate it means the growers with poorer orchards have their fruit picked at an average rate of pay only because the better orchards subsidize their harvests.

The most common variation from a single rate system is the use of multiple rates set daily for each grove. A subjective determination of harvest conditions must be made to set the piece-rate used. This is in a sense an educated guess. If the rate is too low the crew may refuse to work or quit unless an upward adjustment is made. If the rate is too high the cost to the grower is excessive with no alternatives available except to stop picking. Under this system there can be a threat of work stoppage every day (Smith, Seamount and Mills, 1965).

The tree production system is also a multiple rate system. When differences in harvest conditions exist requiring different rates of pay, the subjective determination, however, is replaced by physical measurements or specifications. The tree production incentive wage system returns to the agricultural employment system. Growers are no longer in positions where they can unilaterally set the conditions for work. Competition will dictate more effective use of harvest labor in the future. Worker productivity, reduction in job turnover, worker education, maintenance of job morale, etc., are integral parts of any modern employee program. Agriculture will have to become as technically competent in managing labor as it has had to become in managing its financial and physical inputs (Agricultural Labor in 1980s).

The Arizona citrus industry has had recent problems in grower-picker relationships. Labor difficulties arose in the fall of 1979 and attest to the need for better labor management. Citrus harvests need to be both efficient and timely as dictated by market conditions. Grower returns can change drastically if the harvest is not started and completed at the proper time.

Harvest Labor History

California and Arizona farmers have relied on Mexican harvest labor for decades. Before 1924 Mexicans did not need permission to cross the United States/Mexican border. In 1942 wartime labor shortages prompted an agreement between Mexico and the United States to recruit Mexicans for farm jobs in the U.S. The wartime labor agreement ended in 1948, but American farmers continued to recruit Mexican labor privately. The Bracero Program (Public Law No. 78) was initiated in 1951. Recruitment of workers was transferred from private hands to the Mexican government, while the U.S. government guaranteed the work contracts that tied Mexican established varying box rates according to the joint influences imposed on the rate of pick by <u>average yield</u>, tree height, and fruit size. This requires three daily measurements as each orchard is being picked: (a) number of trees picked, (b) number of field boxes picked, and (c) a sample estimate of the average fruit count per box (Pelzel and Smith, 1966). In addition to these three measurements other field conditions, i.e., tree height, ground slope if any, etc., also need to be recorded.

Figure 1 illustrates the end product of the Tree Production Incentive Wage System. The piece rate, expressed in cents per box, varies in accordance with the three factors affecting productivity. A sample of trees in every citrus block is measured from ground to highest fruit to be picked. Each tree class in the table has its own set of piece rates. For example, for a given yield per tree (e.g., 0.75 - 0.99 boxes) and fruit size (e.g., 240 lemons per box) the rate in cents per box increases for each tree height class: $.69, $.91 and $1.04 (circled). These rates reflect the decreasing productivity (boxes per hour) of harvest crew members as they pick in successively taller trees.

The box rate also varies with different box tree yields. As yields increase the piece-rate decreases accordingly. In Figure 1, with tree height and fruit size constant the piece-rates in tree class 1, column 1 (less than 240 lemons per box) decrease from $.95 to $.59. This is reflective of the anticipated increase in productivity (boxes per hour) associated with the increased yields per tree.

Figure 1. The Tree Production Incentive Wage System. An Example of the Piece-Rate Table Used by the Coastal Growers Association.

COASTAL GROWERS ASSOCIATION

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 2326 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 2326 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:	CLASS 1 NO LADDER / SIN ESCALERA			CLASS 2 FRUIT UNDER 5½ FEET / FRUTA A MENOS DE 5½ PIES DE ALTO			CLASS 3 FRUIT 5½ TO 12 FEET / FRUTA DE 5½ A 12 PIES DE ALTO			CLASS 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		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0 - 0.24	95¢	$1.05	$1.12	$1.08	$1.16	$1.20	$1.72	$1.28	$1.40	$1.28	[illegible]	$1.62
0.25 - 0.49	82¢	[illegible]	$1.01	[illegible]	$1.04	$1.23	$1.08	$1.23	[illegible]	$1.10	[illegible]	[illegible]
0.50 - 0.74	74¢	[illegible]	94¢	[illegible]	[illegible]	$1.10	[illegible]	$1.13	$1.23	[illegible]	$1.18	[illegible]
0.75 - 0.99	69¢	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91¢	[illegible]	$1.14	$1.04	$1.06	$1.23
1.00 - 1.49	65¢	73¢	78¢	74¢	[illegible]	[illegible]	[illegible]	[illegible]	$1.10	[illegible]	$1.01	$1.19
1.50 - 1.99	[illegible]	[illegible]	67¢	[illegible]	74¢	[illegible]	78¢	[illegible]	$1.01	[illegible]	[illegible]	$1.08
2.00 - 2.99				[illegible]	71¢	81¢	72¢	[illegible]	[illegible]	[illegible]	[illegible]	$1.01
3.00 and Up					64¢	72¢	[illegible]	[illegible]	[illegible]	72¢	74¢	[illegible]

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 DESE COSECHAR.

Large fruit fills a box faster than small fruit. Fruit is sized according to fruit count per box. Figure 1 has three fruit sizes: under 240 lemons, 240 to 300 lemons and over 300 lemons per box. As fruit size decreases (more lemons per box), the piece rate increases.

The matrix of piece rates covers all anticipated harvest conditions. It does not penalize or favor pickers who happen to encounter slow or fast harvest conditions. With a single piece rate system no such compensation occurs. Harvest crew members of differing abilities are paid according to their productivity taking into account the harvest conditions they encounter.

Picking citrus is hard, dirty work, often done under unpleasant weather conditions. The worker on his own initiative and on his own standard of proper effort cannot be expected to exert himself as greatly under an hourly rate method as under an incentive pay system (Smith, Seamount and Mills, 1965). Another advantage of this system is that the piece rate schedules can easily be adjusted to reflect changes in the "acceptable" average hourly wage received by harvest crews involved in this program.

Productively Determined Piece Rates

The Tree Production Incentive Wage System is a more equitably derived piece-rate compensation system than single or subjective multiple piece-rate systems. Calling this an "incentive wage system," however, is strictly in the interest of citrus producers. It is a valueladen term that does not adequately account for labor's point of view. Granted wage rates are an important factor in both job satisfaction and worker productivity. However, other factors enter a worker's mind that provide incentives for him to work hard and efficiently. Each individual has his own set of motives or goals that he desires from his employment. Benefits besides basic compensation have motivational effects on labor. These include job stability, opportunity for advancement, job morale, training, plus many more job incentives. All can be important to labor.

The Tree Production Incentive Wage System is a productively determined piece-rate system. It is based upon historical production records with variable production conditions accounted for. A more appropriate title for this program is, "productively determined piece rate." This system will be referred to as such throughout the remainder of this thesis.

Acceptance by both groups directly involved in citrus harvesting, (i.e., labor and growers) is necessary for this system to operate. This program necessitates the measurement of tree height, fruit size and yield per tree in each block of trees harvested. The latter two items can be measured only after the fruit is picked, hence the appropriate piece rate cannot be determined in advance. This is why acceptance of and confidence in the system is required by both pickers and growers (Fox).

Pay Systems Used in Central Arizona Citrus Harvests

Packinghouses and growers in Central Arizona currently use one of the previously described pay systems for harvesting citrus. Many fix a single piece-rate early in the season that is adjusted only if major changes in harvest conditions occur. In other cases a subjectively determined multiple rate is used in which harvest crews and the crew foreman negotiate a box rate for each citrus block they pick. Fixed hourly rates are also used occasionally, generally involving young trees with low yields per tree. One of the packinghouse that participated in this study (house B) experimented with a new pay system for harvesting grapefruit during the 1980-81 season. A single piece-rate is used with this system, however, individual picker box-counts are not recorded. Instead each crew member is credited with an equal share of the total boxes picked by his crew. Both packinghouse B's labor and management felt that the experimental pay system was successful enough to apply it to all citrus varieties harvested during the 1981-82 crop season. All piece-rate pay 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.

Objective of this Study

The objective of this study is to develop productively determined piece-rates for harvesting citrus in Central Arizona (Maricopa County). Hypothetical piece-rate schedules will be determined for the following citrus varieties: grapefruit, navel oranges and lemons. The

California Experiment Station Bulletin by Smith, Seamount and Mills contains the basic descriptive and analytical approach required for development of this program. Harvest conditions differ between California and Arizona, therefore, a direct transfer of Coastal Growers' piece-rate schedules to Arizona is not feasible. New research is necessary to determine relationships between productivity and harvest conditions required to implement productively determined piece-rate schedules for Central Arizona citrus harvests.

CHAPTER 2

THE DATA

Citrus harvest crews from two cooperating Maricopa County citrus packinghouses were monitored for the 1979-1980 and 1980-1981 crop seasons. These packinghouses will be distinguished for research purposes simply as house A and B. Harvest crews for the following citrus varieties were observed: grapefruit, lemons, Valencia oranges and navel oranges. The analysis of Valencia oranges is included in the Jorgensen and Fox study (1981). Lemons were broken down into two sub-categories: ring/color and snap harvesting. These categories refer to the method of picking used to harvest lemons. Snap harvested lemons are stripped off the trees and used for processing purposes, i.e., lemonade, juice, oil, etc. The ring/color method of picking lemons involves clipping the fruit from the tree and a selection process where fruit must be of a certain size and color to satisfy domestic and export fresh market requirements. Table 1 summarizes the number of crew observations for each year in this study with their respective houses and varieties.

Information was gathered on a working day basis for each crew during the season when the respective citrus product was harvested. Data were collected on a daily basis for each crew by its foreman. These data included:

Table 1. Summary Statistics: Citrus Harvest Crew Observations, Maricopa County, Arizona.

	1979-1980		1980-1981	
	Packinghouse		Packinghouse	
Citrus Variety	A	B	A	B
Grapefruit	--	35	None	a/
Navel Oranges	20	--	27	--
Lemons:				
Ring/color	--	16	31	82
Snap	--	29	--	27

a/ Packinghouse B used an experimental picker compensation program during the 1980-1981 grapefruit harvest season. This new program made crew observations infeasible.

1. Hours worked and boxes picked for each crew member by name.
2. Number of trees picked.
3. An estimate of average tree height (point of highest fruit).
4. An hourly sample of fruit per box (fruit size).
5. The rate paid per box in cents.
6. The general field conditions of the grove. These included whether the trees were hedged, interlocked or spaced apart.
7. For lemon harvesting, whether the fruit was snapped for products or ring/color picked for fresh market uses.

In a few cases where a crew picked in more than one grove or block during a day, separate information was recorded for each block. The crew foreman recorded the data on special data forms developed jointly by the packinghouse managers and the research team. All of this information except the fruit size samples, field conditions, number of trees picked and tree heights had been recorded in the past by these houses for payroll purposes.

The data collected allowed the calculation, for each crew and block harvested, of the following statistical information:

1. Total hours worked and boxes picked.
2. Average yield per tree.
3. Average number of fruit per box based on hourly samples.
4. Picking rate in boxes per hour.
5. Dollar per hour earnings.

Tables 2 through 5 summarize these data for each year and packinghouse when applicable. For ring/color harvesting of lemons, the houses were separated for purposes of comparison. The two houses employ different methods of compensation, picking bags used, and work in largely different conditions. Separation by year allows comparisons of harvest seasons and conditions. These include fruit size and/or yields, tree heights, worker productivity and wage rates.

Packinghouse A's navel orange yields for the harvest seasons of 1979-1980 and 1980-1981 were statistically typical when compared with past Maricopa County data (Arizona Agricultural Statistics, 1980). Yields per tree (boxes per tree) were almost identical for the two years, as also were the average tree heights. Average fruit size for the 1980-1981 season was considerably smaller than the previous season. Pickers in the later season had to pick almost fifty more navel oranges in order to fill a box. Even with this handicap and with only a two cent increase in the average piece-rate per box, pickers in the 1980-1981 season with their increased productivity were able to average $1.05 more per hour than the previous season. This increase in productivity can possibly be explained with further investigation. Field conditions (more specific data) and time and motion studies where the skill levels of each crew can be identified may help explain these differences in productivity. Table 2 summarizes the navel orange harvest data and conditions for both seasons.

Table 2. Summary Statistics: Navel Orange Harvest Data, Maricopa County, Arizona.

ITEM	Packinghouse A 1979-80	Packinghouse A 1980-81
1. Number of observations[a/]	20	27
2. Avg. boxes/hour	6.82 (1.69)	7.38 (1.65)
3. Avg. $/hour	4.79 (0.97)	5.84 (1.12)
4. Avg. $/box	0.72 (0.08)	0.74 (0.06)
5. Avg. yield/tree (boxes)	2.41 (1.00)	2.49 (0.78)
6. Avg. fruit size[b/]	227.18 (43.63)	276.18 (39.81)
7. Avg. tree height (ft.)	16.70 (2.58)	16.63 (1.92)

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

[b/] Average number of navel oranges per standard field box based on an hourly sample.

Figures in parentheses are the corresponding standard deviations.

Table 3. Summary Statistics: Grapefruit Harvest Data, Maricopa County, Arizona.

ITEM	Packinghouse 3 1979-80
1. Number of observations[a/]	35
2. Avg. boxes/hour	22.41 (4.05)
3. Avg. $/hour	8.40 (1.52)
4. Avg. $/box	0.375 (0)
5. Avg. yield/tree (boxes)	9.73 (3.79)
6. Avg. fruit size[b/]	55.68 (12.21)
7. Avg. tree height (ft.)	13.11 (2.45)

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

[b/] Average number of grapefruit per standard field box based on an hourly sample.

Figures in parentheses are the corresponding standard deviations.

Grapefruit harvest crews for packinghouse B were monitored for the 1979-1980 season only. The summary statistical data in Table 3 reveal the basic characteristics of this variety. Grapefruit picking involves relatively small trees (13.11 feet), large fruit size (55.68 per box) and many boxes per tree (9.73). The average pay per box is the lowest of all varieties that were studied, but coupled with these relatively easy picking conditions, crew members were able to earn high hourly wages of $8.40 per hour for the 1979-1980 season.

Lemon harvest data make up the bulk of data for this investigation. The 1980-1981 season is the only instance where a comparison of the two packinghouses can occur. First, in comparing seasonal variations for house B, the poor yield of 1979-1980 in lemons is evident. Table 4 details the two seasons for snap-lemon harvesting. Fruit size was much larger and yields per tree were substantially smaller for the 1979-1980 season versus the following year. Yields almost tripled in the 1980-1981 season. Picker productivity also increased this year, but not as much as intuitively one would expect. One might expect that the smaller fruit size effect would more than be compensated by the tremendous yield increase; however, this was not the case. Pay per box was 3¢/box less for 1979-1980 than 1980-1981. Workers earned on the average $1.19 more per hour in 1980-1981 than the previous season. This situation of variable yields and fruit sizes with relatively constant compensation to the worker in pay per box indicates the need of a more progressive system such as the productively determined piece-rate wage system.

The 1980-1981 ring/color harvest season for lemons reveals many interesting differences between houses A and B. Table 4 contains the ring/color summary statistics. House A's crews picked on the average smaller trees, smaller fruit and worked blocks of trees with considerably smaller yields. Crews for house B were more productive than A's and consequently averaged $4.22 more per hour. The average pay per box only differed by one cent per box between the two houses. The statistics do not illustrate one big difference between the two houses. House A is a grower-cooperative packinghouse, while house B is a large privately owned firm. House A's crews move often from one grower to another. The picking conditions these crews encounter are much more variable. The large standard deviation values in both tree heights (3.96) and yields (2.56) illustrate this variance. House B, on the other hand owns the groves its workers harvest. The tree heights vary liggle and the groves are maintained in order to enable easy movement from tree to tree.

The two houses utilize different pay systems. House A uses a subjective multiple piece-rate to compensate their crews. The large standard deviation in the average piece-rate for the harvesting of ring/color lemons ($.19) illustrates the use of the multiple piece-rate. House B uses a single piece-rate compensation program. No variation in the piece-rate occurred for either year that ring/color lemon harvest crews were observed.

Table 4. Summary Statistics: Snap-Lemon Harvest Data, Maricopa County, Arizona.

ITEM	Packinghouse B	
	1979-80	1980-81
1. Number of observations[a/]	29	27
2. Avg. boxes/hour	6.55 (1.75)	7.91 (1.90)
3. Avg. $/hour	4.85 (1.31)	6.04 (1.45)
4. Avg. $/box	0.74 (0.03)	0.76 (0)
5. Avg. yield/tree (boxes)	3.29 (1.50)	12.72 (4.46)
6. Avg. fruit size[b/]	159.06 (17.43)	208.52 (37.67)
7. Avg. tree height (ft.)	17.83 (0.76)	19.82 (1.90)

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

[b/] Average number of snap-lemons per standard field box based on an hourly sample.

Figures in parentheses are the corresponding standard deviations.

Table 5. Summary Statistics: Ring/Color Lemon Harvest Data, Maricopa County, Arizona

	Packinghouse		
	B	A	B
ITEM	1979-80	1980-81	1980-81
1. Number of observations	16	31	82
2. Avg. boxes/hour	5.61 (1.14)	4.24 (1.34)	7.42 (2.14)
3. Avg. $/hour	7.00 (1.42)	5.18 (1.02)	9.46 (2.73)
4. Avg. $/box	1.25 (0)	1.27 (0.19)	1.28 (0)
5. Avg. yield/tree (boxes)	6.94 (3.30)	3.73 (2.56)	12.06 (7.05)
6. Avg. fruit size	184.79 (33.76)	254.78 (46.43)	169.67 (35.16)
7. Avg. tree height (ft.)	18.94 (1.61)	14.03 (3.96)	18.10 (0.86)

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

[b/] Average number of ring/color lemons per standard field box based on an hourly sample.

Figures in parentheses are the corresponding standard deviations.

CHAPTER 3

ANALYSIS

The data for grapefruit, navel oranges, snap and ring/color lemon harvests described earlier were statistically analyzed by multiple linear regression techniques. This technique measures the amount of variation in productivity (boxes per hour) explained by the associated variation in conditions encountered by the observed crews. These conditions, detailed previously, include fruit size, tree height, yield, hedging and interlocking of trees. Hedging and interlocking were two new independent variables that were not included in previous work (Fox 1979, Smith, Seamount and Mills, 1965) or in the Coastal Growers' incentive payment program.[1] Hedging of trees involves pruning of trees to a certain height and/or width. Interlocking of trees occurs when trees are growing together and their branches become intertwined or interlocked. These two new independent variables were treated as dummy variables. If the grove of trees was hedged, the variable H was given a value of one, and if no hedging was evident, it was given the value zero. If interlocking among trees existed its corresponding variable I was assigned the value of one, a zero was used otherwise.

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1. The Coastal Growers system based upon the Smith, Seamont and Mills report does include ground slope. This is not necessary in Maricopa County since all citrus production takes place on level ground.

Initially, scattergrams were developed that plotted the dependent variable boxes per hour (BPH) with each of the five independent variables, fruit size (FS), tree height (TH), yield (Y), hedged (H) and interlocked (I). As in previous work (Fox, Jorgensen and Fox) the scattergrams verified the expected relationships. Productivity (BPH) was inversely related to the number of fruit per box (FS) and tree height (TH), and positively related to yeild (Y). The scattergrams indicated a linear relationship for FS, TH, and Y but with a large degree of variation. The two new independent variables H and I presented no clear visual relationship, in fact, occasionally the variable H displayed an opposite relationship than would be expected. Hedging of trees enables relatively easier picking of fruit for the crews. This cultural practice reduces the variation of tree height and should be positively related to productivity, but in some instances was negatively related. When trees are interlocked this condition should slow down crews picking citrus. Thus interlocking would be negatively associated with productivity, but in certain cases this variable was positively related to the dependent variable (BPH). Consequently, from the scattergrams, it appeared the new variables, H and I, might not be significantly related to BPH.

A multiple regression model was utilized to measure the relationships among the five independent variables and the dependent variable. The variables H and I both individually and in combination with FS, Y and TH did not produce any coefficients significantly different from zero at the 95 percent level. As in the Jorgensen and

Fox study (1981), due to these variables inconsistent results, H and I were excluded from further regression analyses.

Boxes per hour (BPH) was specified in equation form as follows:

$$BPH = a + \underset{(-)}{bFs} + \underset{(+)}{cY} + \underset{(-)}{dTH}$$

where,

FS is fruit size as measured by the average number of fruit per box, Y is yield in boxes per tree, and TH is tree height in feet.

The regression model estimated the values of the coefficients a, b, c, and d. It also determined the signs of the coefficients (+ or -, the expected signs are in parentheses). This model determined the amount of variation in productivity explained by the three independent variables. Information was also obtained concerning the relibility of the results. Regressions were run with FS, TH, and Y for each season, house, and in ring/color lemons for houses combined. Table A-1 summarizes the regression analyses for the two seasons and their respective citrus varieties.

Navel Oranges

Packinghouse A's navel oranges regression results for the 1979-1980 and 1980-1981 crop seasons are included in Table 6. The three independent variables FS, TH, and Y explained 28 percent of total variation in worker productivity (BPH) for the 1979-1980 season. All variables displayed the correct signs and all were significant at the 80 percent level. The yield variable was the most important in explaining the variation in productivity. It also was the only variable significant at the 95 percent level. The importance of yield was in contrast to previous work with Valencia oranges (Fox, 1979) where fruit size was the most important variable in explaining productivity variations.

During the 1980-81 season the three independent variables explained a higher proportion of the variation in production than the previous season. The results are presented in Table 6. The BPH equation explained 46 percent of total productivity variation. As in the previous year all three independent variables displayed the correct signs. Both FS and Y were significant at the 95 percent level. Tree height was significant at the 90 percent level. Yield again proved to be the most important variable in explaining variations in productivity.

The data for the two seasons were pooled together. The analysis of covariance method described in the appendix was used to analyze the differences in regression equations of BPH between the two seasons. The appendix contains in detail the actual results of this test. Table A-3.1 shows that the hypothesis of a common intercept value was not rejected. There was, however, a significant difference in slope values. The regression equations for productivity for each season, therefore, should not be pooled together in a single equation. The estimated equations for each season and their coefficient values are contained in Table A-1.

Table 6. Summary of Regression Analyses: Navel Orange Harvest Data, Maricopa County, Arizona.[a]

Season	Dependent Variable[b]	Coefficients[c] (FS)	(Y)	(TH)	Adjusted R^2 [d]
1979-80	BPH (House A)	-0.017[NS] [1.49]	+0.979[S] [2.82]	-0.177[NS] [1.34]	.28
1980-81	BPH (House A)	-0.027[S] [2.95]	+1.114[S] [3.63]	-0.234[NS] [1.85]	.46

[a] See Table A-1 for detailed statistical results.

[b] BPH is boxes per hour.

[c] Figures in brackets are the calculated T statistic values. S indicates that the coefficient is significantly different from zero at 95 percent or better lelvel 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.

As mentioned previously pickers during the 1980-1981 season had to pick on the average almost 50 more navel oranges to fill a box than during the 1979-1980 season. Yields per tree were almost indentical for the two seasons as were tree heights. Productivity, however, increased by almost 1.2 boxes per hour during the 1980-1981 season. No real explanation was hypothesized for this productivity increase. The fact that it was not possible to explain the productivity increase for the 1980-81 season and that the analysis of covariance indicated that separate seasonal BPH equations are necessary limits the future use of the proposed system for deriving piece-rates in picking navel oranges.

Grapefruit

Table 7 contains the summary of the regression analysis computed for packinghouse B's 1979-1980 grapefruit harvest season. The three independent variables FS, TH, and Y explained 37 percent of the variation in worker productivity. The FS variable was not significantly different from zero. Tree height (TH) was significant at the 80 percent level. Yield (Y) was significant at the 95 percent level and most important in explaining total variation. Table A-1 contains the actual equation and the numerical values for the coefficients estimated by the regression model.

Table 7. Summary of Regression Analysis: Grapefruit Harvest Data, Maricopa County, Arizona. a/

Season	Dependent Variable b/	Coefficients c/ (FS)	(Y)	(TH)	Adjusted R^2 d/
1979-80	BPH (House A)	-0.038^{NS} [0.79]	$+0.751^{S}$ [4.52]	-0.386^{NS} [1.43]	.37

a/See Table A-1 for detailed statistical results.

b/BPH is boxes per hour.

c/Figures in brackets are the calculated T statistic values. 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.

Snap-Lemons

The snap-lemon regression results for the 1979-1980 and 1980-1981 seasons are presented in Table 8. The results for the 1979-1980 season were very poor. Only 14 percent of total variation in productivity was explained by the BPH equation. The sign for the FS variable was incorrect and insignificant. The results were somewhat better for the other two variables. Tree height (TH) was significant at the 90 percent level. The yield variable was the most important in explanation of total variation and was statistically significant at the 95 percent level. No clear explanation exists for these poor results, which, in fact, were the worst for the total project. The 1979-1980 season was a low yielding year for Maricopa County lemon producers (Arizona Agricultural Statistics, 1980). Snap-lemons are strictly used for products, i.e. juice, oil, etc., and not intended for fresh market purposes. The harvesting of snap-lemons generally occurs after the trees have been picked for the more lucrative foreign and domestic fresh markets (ring/color lemons). Other factors that do not appear in the data obviously affected the workers' productivity. These could include whether the trees had been previously picked, whether conditions, crew experience and unknown factors that may be assiciated with poor yield years.

Table 8 also contains the results for the 1980-1981 seasonal regressions. In contrast to 1979-1980 season's poor results this season had statistically the best results for any of the citrus

Table 8. Summary of Regression Analyses: Snap-Lemon Harvest Data, Maricopa County Arizona.[a]

Season	Dependent Variable[b]	Coefficients[c] (FS)	(Y)	(TH)	Adjusted R^2 [d]
1979-80	BPH (House B)	+0.006[NS] [0.33]	+0.612[S] [2.66]	-0.858[NS] [1.83]	.14
1980-81	BPH (House B)	-0.250[S] [4.14]	+0.170[S] [2.66]	-0.122[NS] [1.07]	.85
1979-80 & 1980-81 (pooled)	BPH (House B)	-0.018[S] [2.58]	+0.229[S] [5.97]	-0.154[NS] [0.95]	.43

[a]See Table A-1 for detailed statistical results.

[b]BPH is boxes per hour.

[c]Figures in brackets are the calculated T statistic values. 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.

varieties. All variables exhibited the correct signs and explained 85 percent of total variation in worker productivity. Both the fruit size (FS) and yield (Y) variables were significant at the 95 percent level. Tree height (TH) was significant only at the 70 percent level. These results were encouraging after the poor results working with the previous season's data.

An analysis of covariance test was used to determine if the two seasons could be pooled together. Page one of the appendix contains the specifics of this statistical procedure. The test results indicated that regression equations for productivity for each season in snap-lemon harvesting are statistically similar. The equations have common slopes and intercepts with no seasonal variation existing, which allows a single regression equation for productivity to be used for the two seasons. The pooled equation explained 43 percent of total variation. Correct signs for each of the variable's coefficients were obtained. Both variables Y and FS were significant at the 95 percent level. Tree height (TH) again was insignificant at this level, but was retained in the equation since its exclusion did not alter results significantly. The inclusion of TH will also aid in developing the piece-rate schedules later on in this project. There was little variation in tree height; the standard deviation was only 1.31 feet for the two seasons. Small variation in tree height can partly explain the poor results for this variable. All of the snap-lemon data as mentioned earlier came from packinghouse B. The low variation in tree height is an indication of the firm's uniform cultural practices. Their trees are hedged every few years to maintain a relatively constant height and width.[1]

The pooled productivity equation for the 1979-1980 and 1980-1981 snap-lemon harvest season was used for further research. The individual productivity equations were not used even though the 1980-1981 season had very good statistical results. The pooled equation represents the more variable conditions that may occur over a several year period. The 1980-1981 season includes only a portion of the historical production conditions that have occurred in the past.

Ring/Color Lemons

Individual regressions were estimated for ring/color harvesting of lemons for the 1979-1980 and 1980/1981 seasons. Two regressions were estimated for the latter season, one for each packinghouse (A and B). The results are summarized in Table 9.

An analysis of covariance test was performed to determine if lemons from packinghouse B could be pooled together, i.e., snap lemons and ring/color lemons. The results of this test are contained in Table A-3.4 in the appendix. They indicate that although the intercept values had no real significant difference, the hypothesis of common slopes was rejected. A single productivity equation for these two harvest methods therefore cannot be used. This seems logical since the harvest techniques and the product (processing vs. fresh lemons) do in

[1]Conversation with packinghouse B's farm manager, 9/2/81.

fact differ. The differences that occur in the picking processes were stated earlier.

The regression for the 1979-1980 ring/color production data for house B explained 35 percent of total variation in picker productivity. The signs of all the variables were correct with FS being the most important in explaining total variation. This is in contrast to the other varieties investigated in this project where yield per tree (Y) was the most important variable. The poor yields for the 1979-1980 season coupled with the ring/color selection process may provide a reason why this trend differed. Fruit size (FS) was also the only variable significant at the 95 percent level. The two other variables, Y and TH, were significant at the 80 percent level. Their poor performance of the equation can partially be explained by the small amount of actual crew observations; only sixteen occurred in the 1979-1980 harvest season.

The 1980-1981 BPH regressions explained a higher percentage of total variation in house B's crew's production than for the previous year; 71 percent of total variation was explained by the productivity equation. Both Y and FS were significant at the 95 percent level. Tree height was, as in sna-lemon harvesting, not significantly different from zero. Yield (Y) was the most important variable for this season, whereas fruit size (FS) was in the previous season. This harvest season (1980-1981) saw a large increase in yields per tree for lemons. They nearly were doubled from the previous year. Table 9 summarizes the regression equations for both seasons.

The results for house A's regression did not explain as high as a percentage in total variation as house B for the 1980-1981 season (Table 9). The BPH equation explained 50 percent of total variation in picker productivity. Fruit size and yield were significant at the 95 percent level. The variable TH was nonsignificant, even though a large variation in tree height (standard deviation was 3.96 feet) did occur. The lack of significance in this variable is a mystery. Logically, tree height should play an important role in harvest productivity. Possibly the amount of fruit decreases significantly past a certain height or level, thereby rendering the measurement of tree height inappropriate. Future research in this area may be able to increase this variable's significance in explaining picker productivity.

The analysis of covariance method was used to determine if harvest data from the two packinghouses could be used. First, however, seasonal differences were tested for the two seasons for house B. The results indicated that no real differences existed between the two seasons. This allowed pooling of the data for the two years. Next testing for packinghouse differences was performed. The results were very encouraging with no significant differences existing in slopes or intercepts. The equations are, in fact, similar and can be pooled together. The appendix contains the statistical results of these tests in Tables A-3.4 and A-3.5.

Pooling the two seasons for the two packinghouses resulted in a higher explanation of productivity variation than in any one of the

Table 9. Summary of Regression Analyses: Ring/Color Lemon Harvest Data, Maricopa County, Arizona.[a]

Season	Dependent Variable[b]	Coefficients[c]			Adjusted R^2 [d]
		(FS)	(Y)	(TH)	
1979-80	BPH (House B)	-0.018^{S} [2.38]	+0.096^{NS} [1.30]	-0.212^{NS} [1.35]	.35
1980-81	BPH (House A)	-0.019^{S} [4.09]	+0.253^{S} [3.63]	-0.007^{NS} [0.13]	.50
1980-81	BPH (House B)	-0.015^{S} [3.26]	+0.204^{S} [8.96]	-0.123^{NS} [0.81]	.71
1979-80 & 1980-81 (pooled)	BPH (House A & B)	-0.013^{S} [8.04]	+0.199^{S} [11.53]	-0.036^{NS} [1.00]	.77

[a] See Table A-1 for detailed statistical results.

[b] BPH is boxes per hour.

[c] Figures in brackets are the calculated T statistic values. 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.

individual equations (Table 9). The BPH regression equation explained 77 percent of total variation. The signs for the coefficients were all correct. Tree height (TH) again was insignificant. Both the variables FS and Y were significant at the 95 percent level. Yield per tree was most important in accounting for total variation in BPH. These results seem to indicate that in the future if more harvest data can be collected and incorporated into this model, better statistical results may occur.

CHAPTER 4

DEVELOPMENT OF THE PIECE-RATE TABLES

This chapter contains the estimated productively based piece-rates for each of the citrus varieties and their corresponding years of observations. Tables or matrices were developed by first breaking up the variables describing harvest conditions (fruit size, yield and tree height) into logical separations with the known data. The breakdown of these variables is contained in Table A-4 of the appendix. Next, midpoint values from these variable classes for FS, TH and Y were substituted into the previously estimated productivity equations. The actual equations used with their coefficient values are indicated by an asterisk in Table A-1 of the appendix. The resulting productivity values were converted to productively based piece-rates. It was decided in illustrating this conversion that actual means wages per hour for each season and variety would be used. In practice this "acceptable hourly wage" would be negotiated by the two interest groups involved: labor and growers. The hourly wage was divided by the productivity figure calculated earlier to derive the piece-rate. An example of this calculation and conversion process is given below:

PRODUCTIVITY CALCULATION

Variety: Grapefruit

Season: 1979-1980

Productivity equation:

$$BPH = 22.3033 - 0.0384(FS) + 0.7510(Y) - 0.3858(TH)$$

Variable values (Midpoint values):

TH = 14.0 feet

FS - 50.0 fruit/bos

Y = 10.0 boxes/tree

$$BPH = 22.3033 - 0.0384(50.0) + 0.7510(10.0) - 0.3858(14.0)$$

$$BPH = 22.49$$

PIECE-RATE CONVERSION

Mean hourly wage: $8.40/hour

$8.40/22.49 BPH = $ .37/box (circled in Table 12)

Tables 10, 12, 14, and 16 give estimated piece-rates under specified variable conditions. Pay tables such as these would be distributed to workers and posted where they congregate so that they may estimate their pay per box given the conditions of the grove. In practice hourly samples of fruit size would continue, along with the daily recording of the number of trees harvested, boxes picked per work and average tree height of each grove harvested. At the end of the day the calculation of the average fruit size, worker productivity and yields per tree for each grove would occur. These mean values substituted into the specific variety production equation would determine a boxes per hour calculation. The BPH figure then would be converted into a piece-rate using an "acceptable hourly wage."

The proposed daily calculation and insertion of the mean harvest condition values into the specific BPH equation to derive a piece-rate differs slightly from the Coastal Growers system. The Coastal Growers simply take the mean harvest condition values for FS, TH and Y and go to their piece-rate table and find the corresponding box rate. Subjectivity still exists to a small extent. Subjective decisions must be made in defining the table breakdowns for FS, TH and Y. The proposed system eliminates any such subjectivity by using the specific productivity equation to derive a BPH value and converting this to an acceptable piece-rate. The existence of programmable calculators and small computer systems make the necessary calculations a very simple and accurate process.

Navel Oranges

Table 10 contains the estimated piece-rates in navel orange picking for the 1979-80 and 1980-81 seasons for packinghouse A. The mean hourly wage of $4.80 was used for the 1979-80 season, while $5.85 per hour was used for 1980-81. Table 11 contains the actual versus estimated piece-rate values. No major changes would have occurred under the proposed piece-rate system. The piece-rate on the average would increase approximately one cent per box. Average hourly wages would slightly increase by one cent per hour in the 1979-80 navel orange season. The 1980-81 season would have had small changes, too. Average piece-rate would increase approximately 1.5 cents which would

Table 10. Estimated Per Box Piece-Rate, for Harvesting Navel
1980-81 Seasons, Maricopa County, Arizona.

Average Yield Boxes Per Tree	Year	Class I 10-15 Ft.					Or	
		Oranges Per Box						
		<130	130-150	150-170	170-200	>200	<130	130-150
<1.00	79-80	.73	.78	.82	.89	.98	.84	.90
	80-81	.66	.71	.76	.84	.95	.76	.83
1.01-2.00	79-80	.65	.66	.73	.78	.85	.74	.79
	80-81	.60	.65	.69	.75	.83	.71	.77
2.01-3.00	79-80	.58	.61	.63	.67	.72	.64	.68
	80-81	.54	.58	.61	.65	.72	.61	.65
3.01-4.00	79-80	.52	.54	.51	.59	.63	.57	.60
	80-81	.49	.52	.55	.58	.63	.54	.58
>4.00	79-80	.47	.49	.50	.53	.56	.51	.53
	80-81	.45	.47	.49	.52	.56	.49	.52

Note: FS intervals include up to upper level, eg. 130-150 includes up

Productivity equations used (House A):

1979-80 BPH = 10.0469 - 0.0170 (FS) + 0.9798 (Y) - 0.1770 (TH). F

1980-81 BPH = 14.0235 - 0.2688 (FS) + 1.1137 (Y) - 0.2336 (TH). F

Avg. $/hour used:
1979-80 $4.80/hour
1980-81 $5.85/hour

Navel Oranges, Dollars Per Box, Packinghouse A, 1979-80 and

Class II 16-19 Ft.				Class III 20-22 Ft.				
Oranges Per Box				Oranges Per Box				
130-150	150-170	170-200	>200	<130	130-150	150-170	170-200	>200
.90	.97	1.06	1.19	.94	1.02	1.10	1.22	1.40
.83	.90	1.01	1.17	.85	.94	1.03	1.17	1.39
.79	.84	.91	1.01	.82	.88	.94	1.03	1.16
.77	.83	.91	1.04	.76	.83	.90	1.00	1.16
.68	.72	.77	.83	.70	.75	.79	.85	.94
.65	.69	.75	.84	.66	.72	.77	.84	.95
.60	.63	.66	.71	.61	.65	.68	.72	.79
.58	.61	.66	.72	.59	.63	.67	.73	.81
.53	.56	.58	.62	.55	.57	.60	.63	.68
.52	.55	.59	.64	.53	.56	.59	.64	.70

des up to 150.00

TH). $\overline{R^2}$ = .28

TH). $\overline{R^2}$ = .46

Table 11. Comparison of Actual and Estimated Wage Data: Navel Orange Harvest Data, Packinghouse A, 1979-80 and 1980-81 Seasons, Maricopa County, Arizona.

ITEM	Packinghouse A 1979-80	Packinghouse A 1980-81
Avg. $/box		
Actual	.7125	.7352
Estimated	.7222	.7494
Avg. $/hour		
Actual	4.79	5.84
Estimated	4.80	5.85
Standard Deviation $/hour		
Actual	.9716	1.1197
Estimated	.8916	.9019
Coefficient of Variation $/hour[a]		
Actual (%)	20.3	19.2
Estimated (%)	18.6	15.4

[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.

increase estimated mean hourly wages by 1 cent. While the estimated piece-rates would not change drastically, the overall variation in hourly earnings would be reduced. The coefficient of variation for hourly wages indicates a reduction in variation of 8.4 percent and 11.5 percent for the 1979-1980 and 1980-1981 seasons respectively.

As mentioned previously, packinghouse A's crews increased their productivity during the 1980-1981 season on the average by almost 1.2 boxes per hour. No explanation was discovered for this increase even though the fruit size was considerably smaller than during the 1979-1980 season. Both yields per tree and tree height were almost identical for both seasons. This productivity increase significantly affected the proposed piece-rates for the two seasons. The 1980-1981 piece-rates are lower than 1979-1980 piece-rates in almost every instance. In some cases there is a seven cent per box differential. The unexplained increase in worker productivity necessitated the use of separate BPH equations for each season. Decreases in the piece-rates were a direct result of the unexplained increase in worker productivity over the two seasons. Acceptance of the piece-rate decrease by labor would be very doubtful, especially with smaller fruit to be picked than in the previous season.

Grapefruit

The estimated productively based piece-rates for grapefruit picking for the 1979-1980 season are given in Table 12. In using packinghouse B's mean hourly wage ($8.40) the estimated piece-rates would only increase by .5 cents on the average. The average hourly

Table 12. Estimated Per Box Piece-Rates for Harves
1979-80 Season, Maricopa County, Arizona

Average Yield Boxes Per Tree	Class I 6-12 Ft.				
	Grapefruit Per Box				G
	<45	45-55	55-65	>65	<45
<5.00	.41	.42	.43	.44	.45
5.01-7.00	.38	.39	.40	.41	.42
7.01-9.00	.36	.37	.37	.38	.40
9.01-11.00	.34	.35	.36	.36	.36
11.01-13.00	.32	.33	.33	.34	.34
13.01-15.00	.30	.31	.32	.32	.32
>15.00	.29	.29	.30	.30	.30

Note: FS intervals include up to upper level,

Productivity equation used (House B):

1979-80 BPH = 22.3034 (FS) + 0.7510 (Y) -

Average $/hour used: 1979-80 $8.40/hour

ates for Harvesting Grapefruit, Dollar Per Box, Packinghouse A,
County, Arizona.

	Class II 13-15 Ft.				Class III 16-20 Ft.			
ox	Grapefruit Per Box				Grapefruit Per Box			
>65	<45	45-55	55-65	>65	<45	45-55	55-65	>65
.44	.45	.47	.48	.49	.49	.51	.52	.54
.41	.42	.43	.44	.45	.45	.47	.48	.49
.38	.40	.40	.41	.42	.42	.43	.44	.45
.36	.36	.37	.38	.39	.39	.40	.41	.42
.34	.34	.35	.36	.36	.36	.37	.38	.39
.32	.32	.33	.33	.34	.34	.35	.35	.36
.30	.30	.31	.32	.32	.32	.33	.34	.34

to upper level, eg. 45-55 includes up to 55.00.

se B):

+ 0.7510 (Y) - 0.3858 (TH). $\bar{R}^2 = .37$

3.40/hour

wages would remain constant with this slight increase in the piece-rate, however, the variation in hourly wages would decrease by 18.2 percent.

Packinghouse B, as mentioned previously, has very consistent and well-maintained citrus groves. Without statistically determining via multiple regression techniques the worker productivity in harvesting their groves, the management has been able to set stable piece-rates throughout the citrus variety season. By eliminating unnecessary variation in harvest conditions through the use of uniform cultural practices they have eliminated wide variations in hourly wages. The comparison of actual and estimated wage data in Table 13 indicates the low variations packinghouse B has in grapefruit picking and hourly wages.

Snap Lemons

Table 14 contains the estimated production based piece-rates for packinghouse B's snap-lemon harvest data. One equation was used for the two seasons, 1979-80 and 1980-81, to derive the productivity figures. The mean hourly wages for each season were used to convert BPH estimates into piece-rates. The 1979-80 seasonal average hourly wage was $4.85 and for 1980-81 it was $6.04. The estimated and actual piece-rates with the corresponding hourly wages are contained in Table 15.

A decrease of almost 5 cents per box in the average box-rate would occur for the 1979-80 season with the assumed system. Average hourly wages would decrease by 34 cents. The variation in hourly wages

Table 13. Comparison of Actual and Estimated Wage Data: Grapefruit Harvest Data, Packinghouse B, 1979-80 Season, Maricopa County, Arizona.

ITEM	Packinghouse B 1979-80
Avg. $/box	
Actual	.3750
Estimated	.3798
Avg. $/hour	
Actual	8.40
Estimated	8.40
Standard Deviation $/hour	
Actual	1.5193
Estimated	1.2397
Coefficient of Variation $/hour[a]	
Actual (%)	18.1
Estimated (%)	14.8

[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.

Table 14. Estimated Per Box Piece Rate for Snap-Picking Lemons, [
and 1980-81 Seasons, Maricopa County, Arizona.

Average Yield Boxes Per Tree	Year	Class I 12-16 Ft. Lemons Per Box <150	150-200	200-250	>250	Cla 17- Lemons <150	150-200
<2.00	79-80	.65	.72	.83	.94	.72	.80
	80-81	.81	.90	1.03	1.17	.90	1.00
2.00-4.00	79-80	.62	.68	.77	.87	.67	.75
	80-81	.77	.84	.96	1.08	.84	.93
4.01-6.00	79-80	.58	.63	.72	.80	.63	.70
	80-81	.72	.79	.89	1.00	.79	.87
6.01-8.00	79-80	.55	.60	.67	.74	.60	.66
	80-81	.69	.75	.84	.93	.75	.82
8.01-10.00	79-80	.52	.75	.63	.70	.57	.62
	80-81	.65	.71	.79	.87	.71	.77
10.01-12.00	79-80	.50	.54	.60	.65	.54	.58
	80-81	.62	.67	.74	.81	.67	.73
12.01-14.00	79-80	.47	.51	.56	.61	.51	.55
	79-81	.59	.64	.70	.77	.64	.69
14.01-16.00	79-80	.46	.49	.54	.58	.49	.53
	80-81	.57	.61	.67	.72	.61	.65
>16.00	79-80	.44	.47	.51	.55	.47	.50
	80-81	.54	.58	.64	.69	.58	.62

Note: FS intervals include up to upper level, eg. 150-200 includes up to

Productivity equation used (House B): 1979-80, 1980-81 BPH = 11.7323 - (

Avg. $/hour used: 1979-80 $4.85/hour; 1980-1981 $6.04/hour

ıg Lemons, Dollars Per Box, Packinghouse B, 1979-80
ıa.

	Class II 17-20 Ft.			Class III 21-24 Ft.			
	Lemons Per Box			Lemons Per Box			
0	150-200	200-250	>250	<150	150-200	200-250	>250
2	.80	.94	1.09	.79	.90	1.07	1.27
0	1.00	1.17	1.36	.99	1.12	1.33	1.58
7	.75	.86	.99	.74	.83	.97	1.13
4	.93	1.08	1.23	.92	1.03	1.21	1.43
3	.70	.80	.90	.69	.77	.89	1.02
9	.87	1.00	1.13	.86	.95	1.11	1.27
0	.66	.74	.83	.65	.71	.82	.93
5	.82	.93	1.04	.81	.89	1.02	1.16
7	.62	.69	.77	.61	.67	.76	.86
[illegible]	.77	.87	.96	.76	.83	.95	1.07
[illegible]	.58	.65	.72	.58	.63	.71	.79
[illegible]	.73	.82	.90	.72	.78	.89	.99
[illegible]	.55	.61	.67	.55	.59	.67	.74
[illegible]	.69	.76	.84	.68	.74	.83	.92
[illegible]	.53	.58	.63	.52	.56	.63	.69
[illegible]	.65	.72	.79	.65	.70	.78	.86
[illegible]	.50	.55	.60	.50	.53	.59	.65
[illegible]	.62	.69	.74	.62	.67	.74	.81

ludes up to 200.00.

11.7323 - 0.0176 (FS) + 0.2290 (Y) - 0.1543 (TS)

Table 15. Comparison of Actual and Estimated Wage Data: Snap-Lemon Harvest Data, Packinghouse B, 1979-80 and 1980-81 Seasons, Maricopa County, Arizona

ITEM	Packinghouse B 1979-80	1980-81
Avg. $/box		
Actual	.7394	.7630
Estimated	.6924	.8002
Avg. $/hour		
Actual	4.84	6.04
Estimated	4.50	6.04
Standard Deviation $/hour		
Actual	1.3050	1.4474
Estimated	1.1274	0.5937
Coefficients of Variation $/hour[a]		
Actual (%)	27.0	24.0
Estimated (%)	25.1	9.3

[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 decrease by 5.9 percent. Labor's acceptance of this decrease in both piecerates and average hourly earnings for a slight decrease in their variation in earnings seems to be highly unlikely.

In contrast to the 197980 season, the estimated average piece-rate would increase almost 4 cents per box for the 1980-81 season. Average hourly wages would remain unchanged with the increase in the piece-rate. Variation in hourly wages would, however, decrease dramatically using the proposed productivity based piece-rate program. Total variation would decrease almost 60 percent using the derived piece-rates.

Ring/Color Lemons

The derived piece rate schedule for harvesting ring/color lemons for both packinghouses A and B is contained in Table 16. The average estimated and actual piece-rates are detailed in Table 17 for both houses. Comparisons of actual earnings per hour and estimated earnings per hour are also in this table. One production equation for the two seasons and both houses was used. The mean actual earnings per hour for each respective season and house was used. The mean hourly wage for the two houses in 1980-81 was also used as an "acceptable hourly wage."

During the 1979-1980 season, packinghouse B's harvest crews' mean earnings were $7.00 per hour. A decrease in the average piecerate of approximately 6 cents would have occurred using this model. Hourly wages on the average would decrease by 46 cents per hour. Total variation in hourly earnings would decrease by 16.3 percent if the estimated piece-rates were in effect.

Table 16. Estimated Per Box Piece-Rates for Ring/Color Picking … and 1980-81 Seasons, Maricopa County, Arizona.

Average Yield Boxes Per Tree	Year	Class I 6-12 Ft.					
		Lemons Per Box				Lem…	
		<150	150-200	200-250	>250	<150	150-2…
<4.00	79-80 80-81	B=1.11 A=0.82 B=1.50	B=1.26 A=0.93 B=1.70	B=1.50 A=1.11 B=2.03	B=1.77 A=1.31 B=2.40	B=1.15 A=0.85 B=1.58	B=1. A=0. B=1.
4.00-8.00	79-80 80-81	B=0.99 A=0.73 B=1.33	B=1.10 A=0.81 B=1.48	B=1.28 A=0.95 B=1.73	B=1.48 A=1.09 B=2.00	B=1.02 A=0.75 B=1.38	B=1. A=0. B=1.
8.01-12.00	79-80 80-81	B=0.89 A=0.66 B=1.20	B=0.98 A=0.73 B=1.33	B=1.12 A=0.83 B=1.52	B=1.27 A=0.94 B=1.72	B=0.91 A=0.68 B=1.24	B=1. A=0. B=1.
12.01-16.00	79-80 80-81	B=0.81 A=0.60 B=1.09	B=0.88 A=0.65 B=1.19	B=1.00 A=0.74 B=1.35	B=1.11 A=0.82 B=1.50	B=0.83 A=0.61 B=1.12	B=0. A=0.6 B=1.2
16.01-20.00	79-80 80-81	B=0.74 A=0.55 B=1.00	B=0.80 A=0.59 B=1.08	B=0.90 A=0.66 B=1.21	B=0.99 A=0.73 B=1.33	B=0.76 A=0.56 B=1.02	B=1.2 A=0.6 B=1.1
20.01-24.00	79-80 80-81	B=0.68 A=0.51 B=0.92	B=0.74 A=0.54 B=0.99	B=0.81 A=0.60 B=1.10	B=0.89 A=0.66 B=1.20	B=0.70 A=0.51 B=0.94	B=0.7 A=0.5 B=1.0
>24.00	79-80 80-81	B=0.63 A=0.47 B=0.86	B=0.68 A=0.50 B=0.92	B=0.74 A=0.55 B=1.00	B=0.81 A=0.60 B=1.09	B=0.64 A=0.48 B=0.87	B=0.6 A=0.5 B=0.9

Key: A = Packinghouse A; B = Packinghouse B

Note: FS intervals include up to the upper level, eg. 150-200 includes up to 2…

Productivity equation used (House A and B): 1979-80, 1980-81 BPH = 8.6693 - 0…

Avg. $/hour used: 1979-80 $7.00/hour (B); 1980-81 $5.18/hour (A); 1980-81 $…

/Color Picking Lemons, Dollars Per Box, Packinghouses A and B, 1979-80
Arizona.

Class II 13-17 Ft.				Class III 18-22 Ft.			
Lemons Per Box				Lemons Per Box			
<150	150-200	200-250	>250	<150	150-200	200-250	>250
B=1.15 A=0.85 B=1.58	B=1.31 A=0.97 B=1.77	B=1.57 A=1.16 B=2.13	B=1.88 A=1.39 B=2.54	B=1.19 A=0.88 B=1.60	B=1.35 A=1.00 B=1.83	B=1.64 A=1.21 B=2.22	B=1.98 A=1.41 B=2.67
B=1.02 A=0.75 B=1.38	B=1.14 A=0.84 B=1.54	B=1.33 A=0.99 B=1.80	B=1.55 A=1.15 B=2.09	B=1.05 A=0.77 B=1.41	B=1.17 A=0.87 B=1.58	B=1.38 A=1.02 B=1.87	B=1.61 A=1.19 B=2.18
B=0.91 A=0.68 B=1.24	B=1.01 A=0.75 B=1.42	B=1.16 A=0.86 B=1.57	B=1.32 A=0.97 B=1.78	B=0.93 A=0.69 B=1.26	B=1.03 A=0.77 B=1.40	B=1.19 A=0.88 B=1.61	B=1.36 A=1.01 B=1.84
B=0.83 A=0.61 B=1.12	B=0.90 A=0.67 B=1.22	B=1.02 A=0.76 B=1.38	B=1.14 A=0.85 B=1.55	B=0.84 A=0.63 B=1.14	B=0.93 A=0.68 B=1.25	B=1.05 A=0.78 B=1.42	B=1.18 A=0.87 B=1.59
B=0.76 A=0.56 B=1.02	B=1.22 A=0.61 B=1.11	B=0.92 A=0.68 B=1.24	B=1.01 A=0.75 B=1.37	B=0.77 A=0.57 B=1.04	B=0.84 A=0.62 B=1.13	B=0.94 A=0.69 B=1.27	B=1.04 A=0.77 B=1.41
B=0.70 A=0.51 B=0.94	B=0.75 A=0.55 B=1.01	B=0.83 A=0.61 B=1.12	B=0.91 A=0.67 B=1.23	B=0.71 A=0.52 B=0.96	B=0.76 A=0.57 B=1.03	B=0.85 A=0.63 B=1.15	B=0.93 A=0.69 B=1.26
B=0.64 A=0.48 B=0.87	B=0.69 A=0.51 B=0.93	B=0.76 A=0.56 B=1.02	B=0.82 A=0.61 B=1.11	B=0.66 A=0.49 B=0.89	B=0.70 A=0.52 B=0.95	B=0.77 A=0.57 B=1.05	B=0.84 A=0.62 B=1.14

ncludes up to 200.00

$PH = 8.6693 - 0.0181 (FS) + 0.1993 (Y) - 0.0364 (TH)$

(A); 1980-81 $9.46/hour (B)

Table 17. Comparison of Actual and Estimated Wage Data: Ring/Color Lemon Harvest Data, Packinghouse A and B, 1979-80 and 1980-81 seasons, Maricopa County, Arizona.

	Packinghouse			
	1979-80	1980-81		
ITEM	B	A	B	ALL[b/]
Avg. $/box				
Actual	1.2496	1.2677	1.2750	1.2730
Estimated	1.1857	1.2711	1.3695	1.4274
Avg. $/hour				
Actual	7.00	5.18	9.46	8.28
Estimated	6.54	5.12	9.57	8.32
Standard Deviation $/hour				
Actual	1.4191	1.0183	2.7302	3.0583
Estimated	1.1084	1.0752	1.3626	1.3518
Coefficients of Variations $/hour				
Actual (%)	20.3	19.7	28.9	36.9
Estimated (%)	17.0	21.0	14.2	16.3

[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.

[b/] All equals the weighted means of A and B.

Packinghouse B's crews averaged $9.46 per hour during the 1980-81 season. This mean value was used in conjunction with the estimated productivity values to estimate the piece-rates. The average estimated piece-rates would increase 9.5 cents per box and hourly earnings would increases by approximately 11 cents. The overall variation in hourly earnings would decrease by 43.9 percents.

Packinghouse A's crews only averaged $5.18 per hour ring/color picking lemons during the 1980-1981 season. Under the proposed system their piece-rates would only increase by .5 cents and mean hourly wages would decrease by 6 cents per hour. Total overall variation in hourly earnings would increase 6.2 percent. This in the only instance throughout this study where increased variation in hourly earnings occur.

Combining the two houses for the 1980-81 season resulted in a mean hourly earnings of $8.28. Using this value the average productively determined piece-rate increases by 15 cents per box, and estimated hourly wages would increase by 4 cents to $8.32 per hour. The variation in average hourly earnings would decrease by 55.8 percent using the estimated piece-rates.

CHAPTER 5

SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

Summary

The objective of this study was to develop productively determined piece-rates for picking citrus in Central Arizona. Multiple regression model were used to determine the relationships between picker productivity and harvest conditions. The citrus varieties analyzed were navel oranges, grapefruit and lemons (bothe snap and ring/color picked lemons). Five field conditions were investigated for their influence on picker productivity: tree yield (Y), fruit size (FS), tree height (TH), hedging of trees (H) and interlocking of trees (I). The independent variables H and I had not been investigated in previous works dealing with citrus picker productivity (Smith, et al. 1965; Pelzel and Smith 1966; Hicks 1979; Fox and Murphy 1978). The inclusion of these two new variables, however, proved to be inconclusive as was the case in the Jorgenson and Fox study. (1981) In all but one instance (1979-80 Ring/Color Lemon Season) yield (Y) was the most important variable in predicting worker productivity and was also significant at the 95 percent level. The variables FS and TH were generally second and third in importance in explaining worker productivity. The resulting order of variable importance in predicting citrus productivity: (1) yield, (2) fruit size and (3) tree height, coincided with the results obtained by Hicks and Murphy (1979).

Harvest crew observations were made for two harvest seasons, 1979-80 and 1980-81, for all the varieties studied except grapefruit (1979-80 season only). Regression analyses of productivity (BPH) were made for each individual variety and season. The resulting BPH equations for grapefruit, navel oranges (both seasons) and snap-lemons (1979-80 season) had a very poor statistical results. Large amounts of unexplained variation in worker productivity were evident. No real explanations could be hypothesized for these poor results. The 1980-81 snap-lemon and the ring/color lemon (both seasons) BPH regressions were able to explain larger proportions of variation in picker productivity.

Pooling of data from each season into a single variety productivity equation was tested by the analysis of covariance statistical procedure. Pooling harvest data allows more observations to be used and also provides a historical basis of worker productivity in citrus picking. Results from the analysis of covariance indicated that snap-lemons and ring/color lemons could each be pooled into a single BPH equation for the two seasons. Navel oranges could not be pooled into a single equation. Therefore, separate equations for each season were required. The analysis of covariance also indicated that ring/color harvest data from packinghouses A and B could be pooled, which was in contrast to the valencia orange results of Jorgensen and Fox. The pooled BPH equation for ring/color lemons explained a larger percentage of picker productivity than any of the separate BPH equations.

The regressed BPH equations were used to estimate piece-rates for each of the varieties studied. The actual mean hourly wages were used as "acceptable hourly wages" to convert estimated BPH values under variable conditions into their corresponding piece-rates. Piece-rate schedules were presented that breakdown the three variables FS, TH and Y into classes and include the estimated piece-rate using the proposed process. To eliminate subjectivity that exists when breaking down the three variable classes it was suggested that tables be used for worker estimation uses only. In practice the mean values of each citrus grove picked for FS, TH and Y would be inserted into the specific citrus variety BPH equation to derive the "exact" piece-rate.

The productively determined piece-rates were compared to the actual piece-rates used by the two packinghouses. In all but one case, ring/color lemon picking for house A during 1980-81, overall variation in worker hourly earnings were reduced using the proposed system. However, two cases occurred where labor's acceptance of the proposed piece rates would be doubtful. The snap-lemon 1979-80 season estimated piece-rates were on the average lower as were the resulting average hourly earnings. Navel oranges illustrated another problem. Two separate equations were necessary to explain each season's worker productivity. The 1980-81 season proposed box-rates are lower in almost all cases than the 1979-80 season. Needless to say it would be hard to convince labor in either case to accept these reductions even if their variation in overall earnings would be reduced.

Recommendations for Future Research

The regressed BPH equations for packinghouse A's 1980-81 snap-lemon season and for both houses 1979-80 and 1980-81 ring/color lemons are encouraging. In both cases large percentages of worker productivity are explained. The R^2's for both equations are higher than those obtained by Hicks and Murphy in their study involving harvest data from the Coastal Growers Association. However, a substantial amount of unexplained variation still exists as does with the other varieties and seasons studied in this project. Improvement of the BPH equations would probably be necessary before actual implementation and acceptance by both labor and management can occur.

The Fox, (1979) and Jorgensen and Fox (1981) papers make recommendations on ways of improving citrus harvesting BPH equations. The main area of improvement they hypothesize needs to be made is in the collection of data involving the picking conditions. Fruit size is a major area in need of more accurate data. Pelzel and Smith (1966) suggest random sampling of trees to eliminate the bias hourly samples have toward smaller fruit. Identifying the differences in picking abilities among crews also should be done as Fox (1979) recommends. Time and motion studies would aid in identifying skill levels of pickers. The lack of significance in TH in any of the BPH equations in this study is a mystery. Logically, this variable should have a definite influence on picker productivity. The Hicks and Murphy (1918) study had similar results. Further research could investigate the relationships between tree heights and yields per tree. Work with pomology experts may also reveal more information about the TH variable.

Table 18 contains the mean hourly wages earned by the harvest crews of the two packinghouse studied in this project. Two points can

Table 18. Mean Hourly Wages for Harvesting Citrus, Packinghouse A and B, 1979-80 and 1980-81 Seasons, Maricopa County, Arizona.

Citrus Variety	MEAN HOURLY WAGES 1979-80	1980-81
Navel Oranges (A)	4.79	5.84
Grapefruit (B)	8.40	-
Snap-Lemons (B)	4.84	6.04
Ring/Color Lemons (A)	-	5.18
Ring/Color Lemons (B)	7.00	9.46

Key: A = Packinghouse A

B = Packinghouse B

be identified from this table that have not been discussed previously in this paper. First, workers on the average earn less per hour snap-picking lemons than ring/color picking lemons. Packinghouse B's crews earned on the average $1.20 and $2.46 less per hour for the 1979-80 and 1980-81 seasons respectively. Snap-lemons are processing lemons not used for the fresh market. Returns to growers for snap-lemons have been negative since the 1975-76 season (Arizona Agricultural Statistics, 1980). Labor is consequently in a difficult position. Growers may decide not to harvest their snap-lemons if the projected marginal returns are not greater than the estimated marginal costs (picking and packing costs). Generally, snap-lemons are picked during slow periods when other citrus varieties are not available to harvest. Labor management can essentially dictate a piece-rate for snap-lemon harvesting without any labor participation. Both groups know that it is not essential that the snap-lemons be picked. Labor realizes, however, that they can buffer their variations in seasonal earnings by accepting the low snap-lemon piece-rate versus not working at all. Snap lemons thus provide labor a means of extending the citrus harvest season.

The second issue that Table 18 illustrates is the large difference in average hourly earnings between house A and B for ring-color picking lemons during the 1980-81 season. House A's crews averaged $5.19 per hour while house B's crews averaged $9.46 per hour. The average piece-rate paid by each house differed by only one cent. Harvest crews from house B, therefore, were able to pick more boxes per hour than A's crews. These differences and similarities raise an important question. Was the productivity difference between the two packinghouse harvest crews simply due to field conditions alone or is there a difference in the skill levels of the crews? Time and motion studies would reveal if any differences did exist in the crews' skill levels. The labor forces from both houses are comprised of almost 80 percent experienced H-2 citrus pickers.[1] Assuming that the difference in skill levels are negligible between each house's crews, the difference in average earnings can be attributed to the field conditions. The groves that house A's crews ring/color picked averaged 14 feet tall, 254 lemons per box and 3.73 boxes per tree. House B's groves averaged 18 feet tall, 169 lemons per box and 12 boxes per tree. Crews from house B had much easier picking conditions, yet both houses essentially paid the same piece-rate. Such large differences in hourly earnings would not exist under free market conditions. Future research needs to address why this situation exists. Is the H-2 program, by assigning pickers to one packinghouse, keeping free market forces from working? Packinghouse B's harvest labor have a union, house A's do not. Is the union restricting entry and/or demanding and receiving relatively higher piece-rates? The answers to these questions and/or others may reveal why free market theory is not affecting relative piece-rates and earnings.

Conclusions

Single piece-rates are in general an inequitable means to compensate citrus harvest labor. Multiple piece-rates set for each grove

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[1]Conversations with packinghouse A and B's managers 4/16/82.

are more equitable, but they are influenced by subjective decisions. Productively determined piece-rates are multiple rates, however, the subjective decisions are replaced by physical measurements or specifications. Multiple regression equations for picker productivity (BPH) are established that take into account the joint influences of field conditions (average yield, fruit size and tree height).

Productivity (BPH) equations for harvesting grapefruit, navel oranges, snap-lemons and ring/color lemons in Central Arizona were developed in this thesis. The equations for grapefruit and navel oranges had poor statistical results. It is not recommended at this time that Central Arizona packinghouses, growers or labor contractors use these equations to establish piece-rates. The snap-lemon and ring/color lemon BPH equations had fairly good results. Their use by labor and management in establishing piece-rates is recommended on an experimental level. Future research in improving all of the citrus varieties BPH equations may make the use of productively determined piece-rates not only feasible but commonplace in the central Arizona citrus industry.

The sole use of productively determined piece-rates is not a panacea for improving harvest labor relations and productivity. A 1974 case study by Rosedale and Mamer describing employee benefits and labor management practices of the Coastal Growers Association concluded that although equitable "incentive" piecerates are important, they are only a part of the successful management of harvest labor. The use of non-wage benefit packages can markedly improve both the welfare of the workers and the stability of labor supply to employers. In order to raise labor productivity, agricultural employers need to move away from high casual labor patterns and towards more employment stability. Employee training and accumulated experience are necessary to raise productivity and employers will need to retain employees longer in order to recoup investments they make in developing these work skills (Agricultural Labor in 1980).

Packinghouse B and the Coastal Growers Association have very similar non-wage benefit programs for their harvest labor. In fact, Coastal Growers program served as a model for packinghouse B. Some of the benefits included in the Coastal Grower program are: health and hospitalization insurance, comprehensive personnel and job records, housing, recreational facilities, paid vacations, established grievance procedures, seniority and collective bargaining. Packinghouse B, by initiating a similar benefit program, hopes to obtain similar results in improving their harvest labor relations and productivity as the Coastal Growers Association has in recent years. These results included increased labor productivity and efficiency, decreased labor turnover, and no labor shortages since the initiation of their program. The Coastal Growers have developed experienced, efficient and professional citrus pickers. The Central Arizona citrus industry needs to strive for the same accomplishments. In order to remain competitive it appears the Arizona citrus industry in the near future may have to implement more efficient labor management practices.

APPENDIX

Table A-1 summarizes the regression analyses of the data for the citrus varieties and their respective seasons using only the independent variables Y, FS and TH. The analysis of covariance method was used to analyze the differences in regression equations of BPH (productivity) between seasons, packinghouses and picking methods. Tables A-2.1 through A-2.5 contain the complete analysis of covariance tables for productivity used to test the significance of groups of regression coefficients. Appropriate F test statistics are calculated from the values in these tables to test for significant differences in slope coefficients, intercepts and the overall relationships between seasons, houses and picking methods. Tables A-3.1 through A-3.5 give the F test statistics used and the results of the hypothesis testing of the regression equations. Table A-4 contains the data for determining BPH classes required to make up the estimated piece-rate tables for each of the citrus varieties studied.

Table A-1. Regression Equations for Boxes per Hour (BPH): Citrus Harvest Data, Maricopa County, Arizona.

Variety/ Season	Dependent Variable	Number of Observations	Constant Term	Coefficients of the Independent Variables FS	Y	TH	Adjusted R^2	S_{yx}
*Navel Oranges 1979-80	BPH (House A)	20	10.0469	-0.0170 (0.0114)	+0.9789 (0.3462)	-0.1770 (0.1293)	.28	1.4332 [3.4381]
*Navel Oranges 1980-81	BPH (House A)	27	14.0235	-0.0268 (0.0091)	+1.1137 (0.3065)	-0.2336 (0.1265)	.46	1.2139 [8.3413]
*Grapefruit	BPH (House B)	35	22.3033	-0.0384 (0.0492)	+0.7510 (0.1661)	-0.3858 (0.2703)	.37	3.2158 [7.6543]
Snap-Lemons 1979-80	BPH (House B)	29	18.8711	+0.0060 (0.0182)	+0.6121 (0.2305)	-0.8576 (0.4683)	.14	1.6181 [2.5098]
Snap-Lemons 1980-81	BPH (House B)	27	13.3626	-0.0250 (0.0060)	+0.1699 (0.0638)	-0.1217 (0.1142)	.85	0.7244 [51.7764]
*Snap-Lemons 1979-80, 1980-81 (pooled)	BPH (House B)	56	11.7323	-0.0176 (0.0068)	+0.2290 (0.0384)	-0.1543 (0.1630)	.43	1.4659 [14.8205]
Ring/Color Lemons 1979-80	BPH (House B)	16	12.2985	-0.0181 (0.0076)	+0.0956 (0.0738)	-0.2117 (0.1574)	.35	0.9172 [3.6646]
Ring/Color Lemons 1980-81	BPH (House A)	31	8.3240	-0.0193 (0.0047)	+0.2533 (0.0699)	-0.0070 (0.0541)	.50	0.9499 [10.9984]

Table A-1.--Continued

Variety/ Season	Dependent Variable	Number of Observations	Constant Term	Coefficients of the Independent Variables FS	Y	TH	Adjusted R^2	S_{yx}
Ring/Color Lemons 1980-81	BPH (House B)	82	9.7061	-0.0149 (0.0046)	+0.2037 (0.0277)	-0.1226 (0.1521)	.71	1.1549 [66.8210]
*Ring/Color Lemons 1979-80, 1980-81 (pooled)	BPH (House A & B)	129	8.6693	-0.0181 (0.0022)	+0.1993 (0.0173)	-0.0364 (0.0365)	.77	1.0975 [145.9245]

FS is fruit size in number of oranges, grapefruit and lemons per box.

TH is tree height in feet.

Y is yield in boxed per tree.

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

Figures in brackets are the calculated F ratios.

* indicates BPH equation used in deriving estimated piece-rate tables in Chapter 4.

Table A-2. Analysis of Covariance Tables on Productivity (BPH): Citrus Harvest Data, Maricopa County, Arizona.

A-2.1) Pooled Navel Orange Harvest Data, Packinghouse A, 1979-80 and 1980-81 Seasons.

Seasons	Source	Sum of Squares	Degrees of Freedom	Mean Square
1979-80 and 1980-81	S_4	66.7546	$df_4 = 39$	1.7117
	S_3	1.0149	$df_3 = 3$	0.3383
	S_2	67.7695	$df_2 = 42$	1.6136
	S_1	24.9103	$df_1 = 1$	24.9103
	S	92.6798	$df = 43$	

A-2.2) Pooled Snap-Lemon Harvest Data, Packinghouse B, 1979-80 and 1980-81 Seasons.

Seasons	Source	Sum of Squares	Degrees of Freedom	Mean Square
1979-80 and 1980-81	S_4	104.1129	$df_4 = 48$	2.1690
	S_3	7.5550	$df_3 = 3$	2.5183
	S_2	111.6679	$df_2 = 51$	2.1895
	S_1	0.0790	$df_1 = 1$	0.0790
	S	111.7469	$df = 52$	

Table A-2.--Continued

A-2.3) Pooled Ring/Color Lemon Harvest Data, Packinghouse B, 1979-80 and 1980-81 Seasons.

Seasons	Source	Sum of Squares	Degrees of Freedom	Mean Square
	S_4	117.0979	df_4 = 90	1.3011
1979-80 and 1980-81	S_3	4.0124	df_3 = 3	1.3375
	S_2	121.1103	df_2 = 93	1.3023
	S_1	0.5182	df_1 = 1	0.5182
	S	121.6285	df = 94	

A-2.4) Pooled Snap-Picking and Ring/Color Lemon Harvest Data, Packinghouse B, 1979-80 and 1980-81 Seasons

Seasons	Source	Sum of Squares	Degrees of Freedom	Mean Square
	S_4	233.3754	df_4 = 146	1.5985
1979-80 and 1980-81	S_3	9.2453	df_3 = 4	2.3113
	S_2	242.6207	df_2 = 150	1.6175
	S_1	43.6578	df_1 = 1	43.6578
	S	286.2785	df = 151	

Table A-2.--Continued

A-2.5) Pooled Ring/Color Lemon Harvest Data, Packinghouses A and B, 1979-80 and 1980-81 Seasons.

Season	Source	Sum of Squares	Degrees of Freedom	Mean Square
	S_4	145.9916	df_4 = 121	1.2065
1979-80 and 1980-81	S_3	4.0461	df_3 = 3	1.3487
	S_2	150.0377	df_2 = 124	1.2100
	S_1	0.5267	df_1 = 1	0.5267
	S	150.5644	df = 125	

Note: The source 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, season or harvest method and then summing the residuals from both houses, seasons or harvest methods. S_2 is the residual sum of squares that allows each house, season or harvest method a different intercept but imposes common slope coefficients on both houses, seasons or harvest methods. S is residual sum of squares from the regression using pooled data. Also, S_3 and S_2 are found by subractraction, $S = S_4 - S_2$ 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 A-3. Calculations of the F Test Statisitcs: Citrus Harvest Data, 1979-80 and 1980-81 Seasons, Maricopa County, Arizona

Note: The three following F-tests were used to test the regression equations for differences in slopes, intercepts and overall homogeneity.

1. Test for differentials in slope

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

2. Test of differential intercepts

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

3. Test of overall homogeneity

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

All tabulated F distribution values were at the 95 percent level, given degrees of freedom. The hypothesis of a common regression slope, interecpt or overall homogeneity is rejected if the calculated F value is greater than the tabular values.

A-3.1) Testing for Seasonal Differences When Pooling Naval Orange Harvest Data, Packinghouse A, 1979-80 and 1980-81 Seasons

Seasons	F_1	$F_{0.05}$ (df_3, df_4)	F_2	$F_{0.05}$ (df_1, df_2)	F_3	$F_{0.05}$ (df_1+df_3, df_4)
1979-80 and 1980-81	1,009	2.83	15.4377	4.07	14.7510	2.62

Results: 1. Hypothesis of Common Slopes (F_1) is not rejected.

2. Hypothesis of Common Intercepts (F_2) is rejected.

3. Hypothesis of a single regression productivity equation is rejected.

A-3.2 Testing for Seasonal Differences When Pooling Snap-Lemon Harvest Data, Packinghouse B, 1979-80 and 1980-81 Seasons.

Seasons	F_1	$F_{0.05}$ (df_3, df_4)	F_2	$F_{0.05}$ (df_1, df_2)	F_3	$F_{0.05}$ (df_1+df_3, df_4)
1979-80 and 1980-81	1.1610	2.81	0.0361	4.04	1.0459	2.58

Results: 1. Hypothesis of Common Slope (F_1) is not, rejected.

2. Hypothesis of Common Intercepts (F_2) is not rejected.

3. Hypothesis of a single regression productivity equation (F_3) is not rejected.

A-3.3) Testing for Seasonal Differences When Pooling Ring/Color Lemon Harvest Data, Packinghouse B, 1979-80 and 1980-81 Seasons.

Seasons	F_1	$F_{0.05}$ (df_3, df_4)	F_2	$F_{0.05}$ (df_1, df_2)	F_3	$F_{0.05}$ (df_1+df_3, df_4)
1979-80 and 1980-81	1.0280	2.72	0.3979	3.96	1.4262	2.49

Results: 1. Hypothesis of Common Slopes (F_1) is not rejected.

2. Hypothesis of Common Intercepts (F_2) is not rejected

3. Hypothesis of a single regression productivity equation (F_3) is not rejected.

A-3.4) Testing for Differences in Methods of Harvesting i.e. Snap-Picking and Ring/Color Picking Lemons, Packinghouse B, 1979-80 and 1980-81 Seasons.

Seasons	F_1	$F_{0.05}$ (df_3, df_4)	F_2	$F_{0.05}$ (df_1, df_2)	F_3	$F_{0.09}$ (df_1+df_3, df_4)
1979-80 and 1980-81	1.4459	2.37	26.3909	3.87	28.7576	2.21

Results: 1. Hypothesis of Common Slopes (F_1) is not rejected.

2. Hypothesis of Common Intercepts (F_2) is rejected.

3. Hypothesis of a single regression productivity equation (F_3) is rejected.

A-3.5) Testing Packinghouse Differences in Ring/Color Picking of Lemons, Packinghouse A and B, 1979-80 and 1980-81 Seasons.

Seasons	F_1	$F_{0.05}$ (df_3, df_4)	F_2	$F_{0.05}$ (df_1, df_2)	F_3	$F_{0.05}$ (df_1+df_3, df_4)
1979-80 and 1980-81	1.1179	2.58	0.4353	3.92	1.5548	2.45

Results: 1. Hypothesis of Common Slopes (F_1) is not rejected.

2. Hypothesis of Common Intercepts (F_2) is not rejected.

3. Hypothesis of a single regression productivity equation (F_3) is not rejected.

Table A-4.

Note:

Field Conditions data (FS, TH and Y) were broken down into logical and representative classes to make up each citrus variety's productively determined piece rates table. The following tables include the classes and the number of observations in each class. If this piece-rate system is adopted, the packinghouse may want to arrange these classes differently. The purpose of this project is to illustrate how the proposed system is set up and in no way endorses these or other class breakdowns.

Table A-4.1)
Data for Determing Boxes Per Hour (BPH) Classes for Harvesting Navel Oranges 1979-80, 1980-81 Seasons.

A. Tree Height (TH) - Feet

Range:	10-12 (79-80)	11-20 (80-81)
Average:	16.70 (79-80)	16.30 (80-81)
Standard deviation:	2.57 (79-80)	1.92 (80-81)

Class	Frequency 1979-80	Frequency 1980-81
10-15	6	5
16-19	10	20
20-22	4	2
	20	27

B. Fruit Size (FS) - average number fruit per box

Range:	114.63-249.00 (79-80)	144.80-275.00 (80-81)
Average:	227.18 (79-80)	276.18 (80-81)
Standard deviation:	43.63 (79-80)	37.81 (80-81)

Class	Frequency 1979-80	Frequency 1980-81
<130	4	0
130-150	8	2
150-170	4	5
170-200	3	16
>200	1	4
	20	27

Table A-4.1)--Continued

C. Yield (Y) - Boxes per tree

Range:	0.61-4.30 (79-80)	1.17-3.85 (80-81)
Average:	2.41 (79-80)	2.49 (80-81)
Standard deviation:	1.00 (79-80)	0.78 (80-81)

Class	Frequency 1979-80	Frequency 1980-81
<1.00	2	0
1.01-2.00	3	8
2.01-3.00	12	11
3.01-4.00	2	8
>4.00	1	0
	20	27

Table A-4.2)

Data For Determining Boxes Per Hour (BPH) Classes for Harvesting Grapefruit, Maricopa County, Arizona, 1979-80 Season

A. Tree Height (TH) - Feet

Range:	7-18
Average:	13.11
Standard deviation:	2.45

Class	Frequency
6-12	13
13-15	18
16-20	4
	35

B. Fruit Size (FS) - average number fruit per box

Range:	40.31-96.50
Average:	55.68
Standard deviation:	2.45

Class	Frequency
<45	5
45-55	15
55-65	9
>65	7
	35

Table A-4.3)--Continued

C. Yield (Y) - Boxes Per Tree

Range:	1.39-9.01 (79-80)	6.04-22.55 (80-81)
Average:	3.29 (79-80)	12.72 (80-81)
Standard deviation:	1.50 (79-80)	4.46 (80-81)

Class	Frequency 1979-80	1980-81
<2.00	3	0
2.00-4.00	19	0
4.01-6.00	6	0
6.01-8.00	0	3
8.01-10.00	1	4
10.01-12.00	0	8
12.01-14.00	0	3
14.01-16.00	0	3
>16.00	0	6
	29	27

Table A-4.4) Data for Determining Boxes Per Hour (BPH) Classes for Harvesting Ring/Color Lemons, Maricopa County, Arizona, 1979-80 and 1980-81 Seasons

A. Tree Height (TH) - Feet

Range:	15-20 (79-80)	6-22 (80-81)
Average:	18.94 (79-80)	16.98 (80-81)
Standard deviation:	1.61 (79-80)	1.71 (80-81)

Class	Frequency 1979-80	1980-81
6-12	0	8
13-17	2	23
18-22	14	82
	16	113

B. Fruit Size (FS) - Average number of fruit

Range:	138.55-238.37 (79-80)	101.41-343.64 (80-81)
Average:	184.79 (79-80)	193.02 (80-81)
Standard deviation:	33.76 (79-80)	1.71 (80-81)

Class	Frequency 1979-80	1980-81
<150.00	3	32
150.00-200.00	7	38
201.00-250.00	6	27
>250.00	0	16
	16	113

Table A-4.2)--Continued

C. Yield (Y) - Boxes per tree

Range:	2.42-19.62
Average:	9.73
Standard deviation:	3.79

Class	Frequency
<5.00	3
5.01-7.00	6
7.01-9.00	7
9.01-11.00	5
11.01-13.00	8
13.01-15.00	3
>15.00	3
	35

Table A-4.3)

Data for Determining Boxes Per Hour (BPH) Classes for Harvesting Snap-Lemons, Maricopa County, Arizona, 1979-80 and 1980-81 Seasons

A. Tree Height (TH) - Feet

Range:	16-20 (79-80)	17-24 (80-81)
Average:	17.83 (79-80)	19.82 (80-81)
Standard deviation:	0.76 (79-80)	1.90 (80-81)

Class	Frequency 1979-80	1980-81
12-16	3	0
17-20	26	20
21-24	0	7
	29	27

B. Fruit Size (FS) - Average number of furit per box

Range:	125.43-189.78 (79-80)	125.10-296.56 (80-81)
Average:	159.06 (79-80)	208.52 (80-81)
Standard deviation:	17.43 (79-80)	37.67 (80-81)

Class	Frequency 1979-80	1980-81
<150.00	7	1
150.00-200.00	22	8
201.00-250.00	0	15
>250.00	0	3
	29	27

Table A-4.4)--Continued

C. Yield (Y) - Boxes per Tree

Range:	1.61-14.78 (79-80)	0.83-29.94 (80-81)
Average:	6.94 (79-80)	9.77 (80-81)
Standard deviation:	3.30 (79-80)	5.82 (80-81)

Class	Frequency 1979-80	Frequency 1980-81
<4.00	2	29
4.00-8.00	9	30
8.01-12.00	4	21
12.01-16.00	1	11
16.01-20.00	0	10
20.01-24.00	0	4
>24.00	0	8
	16	113

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