Department of Agricultural and Resource Economics
University of California Davis

Worker and Firm Determinants of Piece Rate Variation in an Agricultural Labor Market

by

Constance Newman and Lovell Jarvis

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Contact Information:
Lovell S. Jarvis
Department of Agricultural and Resource Economics
University of California Davis
One Shields Avenue
Davis, CA 95616
(530) 752-7221
lsjarvis@ucdavis.edu

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Worker and Firm Determinants of Piece Rate Variation in an Agricultural Labor Market

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Introduction

Most rural labor market studies focus on jobs that pay wages, yet a significant proportion of agricultural laborers in developing countries are paid a piece rate, i.e., a fixed amount per unit of output. This paper analyzes piece rate work and particularly, the reasons for the surprisingly large differences that we identified in the piece rates being paid by different firms for the same tasks in table grape packing plants in Chile.

Piece rates have been the focus of several important theoretical studies, nearly all of which have focused on the implications of piece rate use for incentives, productivity, and labor costs.[1] Such studies have suggested that a piece rate is used mainly to increase worker incentives and to eliminate the uncertainty about worker effort that employers face when paying a wage. In general, piece rates are expected to increase effort and output per worker and facilitate the incorporation of a more heterogeneous labor force. If output can be clearly measured, piece rates are considered simpler and more efficient than wages.[2] While employers need to monitor for quality control when piece rates are used, it is generally believed that employers do not need to monitor effort, nor do they need to screen workers, since workers are paid only for what they produce.[3] By improving incentives, piece rates may increase income for those who decide to work at piece rate, while simultaneously reducing employer unit labor costs. Since pay is dependent on what is actually produced rather than on time spent—implying greater income uncertainty, workers are thought to require a small increase in the average expected pay per time spent when working at piece rate instead of at a wage.[4]

Few empirical studies have tested piece rate theories. Important exceptions include Foster and Rosenzweig (1994, 1996), Lazear (1996), and Seiler (1984), each of which found that worker productivity increased when a piece rate was used instead of a wage. We have not found any studies of piece rate

[1] Important papers that examine the relationship between piece rates and productivity include Stiglitz (1975), Lazear (1990), Pencavel (1977), Mangum (1962), and Gibbons (1987).
[2] "Piece rates simply relate pay to output, so the question of monitoring is less important," Polachek and Siebert (1993).
[3] For example, piece rates are seen as a solution to the problems of adverse selection and worker shirking in the efficiency wage literature (Goldin (1986) and Akerlof and Yellen (1990)).
[4] See Pencavel (1977).

differentials.

In January-March, 1992, we undertook a survey of workers and managers in Chilean table grape processing sheds. We found that the piece rates paid for the same task varied by up to 100% among firms located within two relatively small areas and even more across the three regions studied. Among the firms surveyed in the two main areas, piece rates varied from 35 to 77 pesos for the workers who cleaned and trimmed the grape bunches and from 14 to 29 pesos per box for the workers who packed grapes. **See Table 1**.

The large variation in piece rates suggested either that the market was not working efficiently or that some unexpected economic function was being performed by piece rate differentiation. Since the piece rate differences across firms were so large and the labor market seemed so competitive, the latter view seemed the more plausible. Chilean unemployment was only 5.6% in 1992 and competition for workers was intense in fruit producing regions during the harvest season. Processing sheds were numerous within even a fairly small fruit-producing area, making it difficult for employers to collude in setting piece rates. Chilean law prohibited unions for and strikes by temporary workers, and there were virtually no laws restricting temporary contracts.

The evidence of large piece rate differentials called to mind the substantial literature on wage differentials. That literature attempts to explain why firms across and within industries pay different wages to workers having the same observable human capital characteristics (e.g., Willis 1986, Dickens and Katz 1987, Groshen 1991, Krueger and Summers 1998, Shaffner 1994, Abowd et al. 1993 and 1994, Brown 1980, Rosen 1986). Plausible reasons as to why wage differentials exist include systematic differences in the unobservable human capital characteristics of firms' workers, differences in other firm attributes and other explanations such as the use of an efficiency wage. Although evidence has been found to support many of these reasons, most empirical studies have found that large parts of the observed wage differentials are still not well explained by the available data (e.g., Brown and Medoff, 1989; Krueger and Summers, 1989).

We find that similar reasons to those mentioned in the wage differential literature help explain observed piece rate differentials, but other factors peculiar to the use of piece rates are also important. Firms with higher levels of fringe benefits or other attributes that are valued by workers pay lower piece rates. The resulting piece rate reduction, multiplied by a worker's output, is analogous to a compensating wage differential. However,

firms whose superior technology and management allow their workers to achieve higher productivity pay lower, not higher piece rates. Workers expect to earn their opportunity cost. Since workers' earnings are the product of the piece rate and their productivity, the firm should pay a lower piece rate if the firm's attributes are responsible for the higher productivity. This piece rate differential has no analogous wage differential. Finally, workers whose superior skills allow them to achieve higher productivity receive higher piece rates. Accordingly, firms that select a labor force with higher skills will pay a higher piece rate (or the firm will hire workers with a range of skills and internally differentiate piece rates). The magnitude of this piece rate differential depends on the firm's savings when fewer, more productive workers are hired.

Our analysis suggests that piece rate variation plays an economic function, that of allowing heterogeneous workers to be efficiently allocated among heterogeneous firms. Our empirical results provide tentative support for this hypothesis and, accordingly, for a variation of the theory of equalizing differences (Brown 1980, Rosen 1986). We find that a fairly large number of factors affect piece rates in the Chilean case studied. Given the apparent ability of firms and workers to acquire and utilize information about each other's characteristics, our empirical results also suggest that the operation of rural labor markets in developing countries can be surprisingly complex. Moreover, we are able to explain a larger part of the observed piece rate differentials than analogous models have been able to achieve for wage differentials. We believe this success is largely due to the micro-economic detail of the data set, including our ability to directly link firms and workers.

The Data

From January to March 1992, data were collected from 56 processing sheds and 690 workers in three separate table grape growing regions of Chile. Three regions were chosen to ensure coverage of the most important, yet distinct, production zones: Santa Maria, Buin/Paine, and Lontue.[5] As some firms were not in full operation and/or were paying wages on the day they were surveyed, the sample for this analysis was reduced to 42 firms and 411 workers.

[5] Santa Maria is in the Aconcagua Valley about 160 km. north of Santiago. Buin/Paine and Lontue are in the Central Valley about 60 km and 300 km, respectively, south of Santiago. In Santa Maria and in Buin, we sampled every processing shed that could be identified within an approximately 30 km. square region. In Lontue, we could interview only four processing sheds because of time constraints. In Santa Maria, of 27 processing sheds surveyed, nine were paying a daily wage and/or were unable to provide all of the data requested, reducing the sample for the analysis of piece rates to 18 firms for that region. In Buin, of 26 processing sheds surveyed, four were

The data set featured a number of rare qualities. Most studies of wage differentials have been forced to pool workers from different occupations and industries and to use dummy variables to explain observed wage differentials, but we were able to compare workers in exactly the same task. Each worker was matched to her employer, allowing direct linking of plant and worker characteristics in the analysis. We also obtained information regarding worker and manager preferences and/or attitudes toward many work-related phenomena, and worker output for the three days prior to the survey, providing a measure of productivity and firm output. Data on the availability of fringe benefits and workers' evaluations of such benefits also permitted analysis of certain non-wage pecuniary components (Rosen 1986).

Chilean Table Grape Processing Sheds

Sheds processed grapes for export. Grapes were picked throughout the day, then fumigated, cooled and carried to the processing sheds. There the grapes were delivered to piece rate workers (*limpiadoras* or "cleaners") who sequentially sorted the grapes according to variety, color and size and then cleaned them. Cleaning involved inspecting each bunch and, using small scissors, removing grapes that were damaged or diseased and pruning to improve their appearance. When sufficient grapes had been cleaned to fill a box (by weight),[6] the cleaner sent it forward for weighing and inspection. If the box passed inspection, the grapes were delivered to another piece rate worker (*embaladora* or "packer") who wrapped the individual bunches in paper and placed them in a standard export box. The cleaners and packers were often the only ones in the sheds paid a piece rate; they were almost always women (99% in our sample); and they comprised about two thirds of total shed workers. The remaining workers, those who nailed shut the boxes, stacked the pallets, drove fork-lifts, supervised piece rate workers, weighed labeled, and moved boxes, plus managers and clerical staff, were paid a wage.

Grape picking began in the morning, but grapes did not begin to arrive at the processing sheds until early afternoon. Processing sheds began work at 2:00 p.m. and continued until all of the grapes picked that day had been packed. On average, cleaners worked 9.6 hours per day and packers 10.3 hours, not counting time

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dropped from the sample for the same reasons, and in Lontue, of 4, 1 was dropped.

[6] Because firms utilized two box sizes, 5 kg and 8.2 kg, in accordance with the requirements of different export markets, we

spent for coffee breaks and dinner. Workers commonly finished work well after midnight and, during the seasonal peak, as late as 6:00 a.m.

Processing sheds and their work forces were surprisingly heterogeneous. We suspect this heterogeneity is at least partly due to the industry's rapid growth in the period 1974-1989, resulting in a packing sector composed of firms of different vintage. Most of the early sheds were very large, operated by export firms that packed grapes for a number of different fruit producers. The export firms and their shareholders usually owned some grape orchards and their grapes were processed in the same plants, though the firms mainly packed for others. Because exporting grapes was highly profitable, many middle-sized growers then began to process their own grapes. This allowed them to export their output directly and gave them greater control over processing, which could strongly influence grape condition and thereby the export price. Some small growers later developed processing sheds, usually processing for others via a sub-contract with an export firm.

As shown in Table 2a, the firms differed significantly by size, years of experience, length of operating season, and technology. Years of operation varied from one to thirty years and the number of days of operated in 1991 varied from 20 days to 151 days. The largest firm could process twenty times more than the smallest firm could in terms of daily production capacity.[7] The variation in each of these characteristics was highly similar in the two areas for which a large sample of firms was available, i.e. the areas around Santa Maria and around Buin/Paine.[8] The mean characteristics of firms' labor forces also varied greatly, suggesting that different sheds had access to different labor pools and/or preferred different types of workers. See Table 2b. Some sheds had a very young labor force while others had a relatively mature labor force. In some sheds, workers were predominantly single; in others predominantly married. Mean schooling and mean industry experience, as well as mean worker productivity, varied greatly.[9]

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converted all piece rates to an 8.2 kg box standard on the basis of pesos paid per kg.

[7] Most plants were fairly small: in 1991, 19 of 42 packed fewer than 50,000 boxes and another 9 firms packed less than 100,000 boxes. The 6 largest plants packed 280,000 to 800,000 boxes in 1991, 57% of the grapes processed by the 42 plants in the sample.

[8] Statistics for the three Lontue firms are not shown here.

[9] Cleaners and packers averaged earnings of 2,800 pesos and 3,800 pesos per day, respectively, or about $8 and $11, using an exchange rate of 350 pesos per $1. The expected seasonal earnings for cleaners and packers were $507 and $716, respectively. The coefficients of variation of cleaner and packer seasonal earnings were both high, about 0.65, indicating a wide dispersion in productivity and in the number of days worked. For comparison, the standard annual wage in 1992 for a permanent male agricultural worker was about $1,300.

Hypothesized Determinants of Piece Rates and Econometric Results

We estimated a single equation of piece rate determination that includes supply and demand characteristics affecting the observed piece rate.[10] The use of ordinary least squares introduces a potentially serious problem of bias, as a few of the independent variables can be considered endogenous. In the most evident cases, we do not have sufficient information to give confidence to the use of instrumental variables or other simultaneous equation estimators. Since the ordinary least squares estimates are conditional on the values of the independent variables, the results presented must be taken as suggestive in terms of explaining the phenomenon of piece rate variation.

Effects of compliance with tax and social security contributions

Firms were legally required to withhold 20% of each worker's gross income to pay income taxes and mandatory social security contributions and medical insurance. Approximately seventy percent of firms complied with the law. That some firms did not comply was a potential source of piece rate variation because firms that did not withhold faced a lower cost of paying a given net piece rate. Most workers did not want firms to withhold any earnings, clearly not caring about taxes and usually preferring a higher cash income to uncertain future health or social security benefits.

We faced the issue of compliance by constructing three different versions of the dependent variable for each of the two piece rate tasks, cleaning and packing. See Table 3. The first dependent variable was the piece rate that firms paid, including taxes and contributions, if any. The second and third dependent variables were two different calculations of the piece rates that workers received.[11] The second dependent variable assumed that workers did not value taxes paid on their behalf, but did value withheld contributions for social security and health benefits, albeit at a discounted rate.[12] The third dependent variable assumed that workers placed no value on

[10] The piece rate equation also takes the form of a hedonic price model in which the implicit prices of job attributes are estimated. Wage differentials have been estimated using hedonic models in several papers. Montgomery, Shaw, and Benedict (1992) estimate what they term a "hedonic price equation" (HPE) for a market wage-pension tradeoff, and they follow the work of Ehrenberg and Smith (1985) in proposing an HPE function related to the Mincer earnings equation. The HPE represents an equilibrium locus of piece rates (in this case) associated with different levels of job attributes.

[11] Piece rates paid less contributions withheld, if any, equal piece rates received when workers place no value on contributions. If workers value contributions to some degree, the value that workers place on withheld contributions is imputed to the workers' piece rate.

[12] To form the second variable, reported gross piece rates were reduced by 20% whenever a plant withheld taxes and contributions. This

either the taxes or the social security and health contributions withheld on their behalf. Somewhat surprisingly, the piece rate paid by firms showed the least variation.

Use of different versions of the dependent variable produced highly similar econometric results. We therefore report the results from only two of the dependent variable formulations, one for firm cost and another for worker receipts, that for which we assume workers value social security contributions at a discounted rate. The piece rate at firm cost was denoted PRPF for packers and PRCF for cleaners, and the piece rate received by workers was PRPW12 and PRCW12 for packers and cleaners, respectively. Independent variables are defined in Table 4.

The estimated equations are shown in Tables 5a and 5b. We show two variations of each equation. In the first, we included all of the variables that we thought relevant. In the second specification, we excluded most of the variables from the first specification that had not been significant in that regression. The signs and general magnitudes of nearly all of the variables were robust to different specifications. The number of degrees of freedom was relatively small, 42 observations, less 14 to 23 independent variables, yielding 19 to 28 degrees of freedom, but the F test for each equation was highly significant. Nearly all of the estimated coefficients had the expected sign and most coefficients were significant, especially in the truncated regressions. Each of the main hypotheses advanced to explain piece rate variation was supported by the coefficient on at least one independent variable. Since most of the variability in piece rates was explained by variables that represented either explicit or implicit negotiation and/or choices between sheds and workers, the results provide evidence that this labor market involving temporary, primarily female, rural workers was complex and sophisticated.

Tax Compliance

Firms that withheld taxes and contributions paid higher piece rates as expected. The coefficient on TAX, a dummy variable equal to 1 if the firm deducted taxes, was always positive and always significant in the packer piece rate equations. It was significant in the cleaner piece rate equation for the piece rate at firm cost.

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adjustment implicitly assumed that workers attributed no value to future social security and health benefits or to having paid taxes. If the firm withheld no taxes or contributions, the net piece rate was included in the series without adjustment. To form the third variable, the gross piece rate was reduced by 12% when firms withheld no taxes or contributions. This adjustment assumed that workers attributed no value to having paid taxes, but that they valued future social security and health benefits at 80% of firm cost.

The estimated coefficients suggest that withholding firms paid piece rates that were about 15% higher, and workers in those firms received piece rates that were about 10% higher, including the imputation of their social security and medical contributions at about 80% of their nominal amount. Given that these contributions amounted to about 10% of actual pay, it appears that worker cash receipts were essentially the same across plants, irrespective of whether they paid taxes. Plants that withheld taxes thus operated at a competitive disadvantage.

Location Factors and Firm Size

The three areas surveyed had different population densities and faced different agricultural and non-agricultural employment opportunities. The area around Buin is closest to Santiago and because of the range of competing commercial, construction, and industrial jobs, we expected that piece rates would be highest in this region. The area around Santa Maria has more grape orchards and is closer to Santiago than is Lontue; thus Santa Maria was expected to have the second highest piece rates among the three areas. These expectations were only partly upheld. Sheds located in the Buin region (REG2) paid higher piece rates for cleaners relative to the Santa Maria region, but lower piece rates for packers. The results suggest that packers and cleaners were more differentiated by skills than expected, so that their incomes could vary in different directions across regions. Sheds located in the Lontue region (REG3) paid lower piece rates for packers, as expected. The estimated coefficient for cleaners in this region also had a negative sign, but was statistically insignificant.

We expected that larger sheds would pay higher piece rates because larger firm size implies a relative labor scarcity and larger firms are usually observed to pay higher wages (e.g., Brown and Medoff, 1989). Somewhat surprisingly, the simple correlation between piece rates and plant size was negative, but it turned out that this was because large plants were located close to urban areas where the supply of labor was greater. The location of a processing shed required a balance between placing the shed closer to a larger labor pool and placing it closer to a larger source of grapes. It was costly to induce workers to travel longer distances to work, but also costly to transport grapes longer distances. Sheds built to pack a given grower's production were inevitably located on that grower's farm. Sheds that were designed to process a large amount of grapes were

invariably located close to a large labor pool, i.e. a town. Firm size was measured using the firm's own declaration of its maximum daily processing capacity (MAXBOX). The coefficients on MAXBOX were always positive and significant in the equation for packers, though not in the equation for cleaners. These coefficients again suggested that packing was a more specialized task, requiring greater responsibility. Packing skills were presumably in scarcer supply than cleaning skills.

Sheds that were located farther from a reasonably-sized labor pool were also expected to pay higher piece rates as a result of having to attract workers from a greater distance to fill their employment needs. We also anticipated that the predominantly female piece rate workers would be concerned for their safety at night since many indicated that they walked home from work, and many also declared that they wanted to be able to deal with any household emergencies that arose. These concerns were expected to make firm proximity to the worker's home an unusually attractive job characteristic. In fact, workers traveled more than we expected. We asked workers how far they traveled, how, and how much time this travel required. The mean of the mean distance traveled by shed workers was 6.2 km. (3.7 miles); the median was 5.6 km. Of individual workers, 75% traveled more than 7.8 km. Nonetheless, the coefficient on AVDIST, the mean distance traveled by a firm's workers, was always positive and strongly significant for both worker types, cleaners and packers.[13] The result is not easy to interpret. It could be that firms are compensating workers for traveling a greater distance and/or that, if piece rates are higher for other reasons, workers will travel farther to obtain them. Regardless, the result supports the argument that the equilibrium piece rate involves a tradeoff between distance and earnings. A more elaborate model is needed to sort out the relative effects.[14]

Length of Season

Discussions with firm managers and with piece rate workers indicated that the piece rate is essentially fixed for the whole season.[15] Since women in Chile's rural regions have relatively few employment

[13] We observed very few migrant workers.

[14] Although paying higher piece rates was one way to attract workers from a longer distance, most firms also provided transportation for their workers. Thus, a firm could balance the costs of providing transportation for the marginal worker versus that of increasing the piece rate.

[15] Firms and workers that were interviewed at the end of our survey period provided information on the piece rate as if it were the piece rate that had prevailed throughout the season. In several plants we were able to obtain complete plant records and in each of these the piece rate was the same throughout the season. In most plants, firms shifted to a daily wage if grapes were of unusually poor

opportunities during the off-season and wages fall dramatically, by about 50%, when the summer harvest season ends (Jarvis and Newman, unpublished), workers should prefer jobs in firms that have longer operating seasons. Analogous to the theory of equalizing wage differences (Rosen 1986), we expected that the length of the firm's processing season and the piece rate it paid would be negatively associated. The expected length of season was measured by the actual length of the previous season worked in 1991 (SEASON), which was closely correlated with managers' declared expectations regarding the 1992 season. The coefficient on SEASON was negative and significant in each regression, as hypothesized, indicating that workers were willing to work for a lower piece rate during the peak season if they had a reasonable expectation that a shed would offer them more total employment during the season.

The coefficients on SEASON have interesting implications regarding the implicit marginal wage cleaners and packers were willing to accept at the end of the packing season. Let expected total seasonal income for the average worker be $Y = pqD$, where D is the number of days of expected work. Differentiating seasonal income with respect to days worked yields $dY/dD = pq + dP/dD(qD)$, assuming no change in productivity as the season lengthens. The first term is the expected income from working one additional day and the second term is the reduction in income over the previous period worked from accepting a lower piece rate to get that extra day of work. Taking the average of the estimated coefficients on SEASON as dP/dD, it appears that cleaners and packers were willing to accept a piece rate reduction of 0.16 pesos and 0.115 pesos, respectively, for each extra day of expected packing shed work. The average shed operated for 73 days and the average cleaner and packer earned 2,787 and 3782 pesos, respectively throughout the season, including the 73rd day. Evaluating dY/dD at the point of means, we estimate that the average cleaner and packer was willing to accept a net income of 2172 pesos and 2148 pesos, respectively, to be able to work a 74th day. See Table 6. Implicitly, cleaners and packers were willing to accept an income for the 74th day that was 22 percent and 43 percent lower, respectively, relative to the income earned on the 73rd day.

Although the results suggest that packers were willing to accept a larger absolute and percentage

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quality or in short supply. We heard of a few cases where the rate had been increased as the result of a work stoppage. In at least one case, the rate decreased when conditions returned to normal. Varying the piece rate over the course of the season either in keeping

discount than cleaners, the expected net incomes obtained by the two types of workers on the 74th day were similar, 2,171 pesos and 2,148 pesos, respectively. This similarity seems plausible since the two types of workers faced similar opportunity costs in the off season when only jobs requiring few skills were available.

The specification used also indicates that workers were willing to accept a progressively smaller net daily income as the season extended. The magnitudes remained reasonable in terms of the large drop off in expected wages for these workers during the off season.[16] The magnitudes were also consistent with qualitative responses received during our survey regarding job preferences. Workers were asked their preference regarding three mutually exclusive employment contracts for the year: 1) three months at 100,000 pesos per month; 2) six months at 60,000 pesos per month; or 3) 12 months at 35,000 pesos per month. A longer hypothetical contract offered higher total annual income, but a significant decline in the marginal wage. Nonetheless, longer contracts were preferred by most workers: 48% preferred twelve months at 35,000 pesos, 27% preferred six months at 60,000 pesos, and only 25% preferred three months at 100,000 pesos. Many who wanted a longer contract indicated they had a severe need for additional income. Some also indicated that saving money during the processing season to finance expenditures later in the year was difficult due to their limited access to financial institutions and to requests from friends and relatives for loans and assistance. Many who preferred the shorter contracts were women who, usually for family or educational reasons, did not want to work the entire year anyway.

Our results underscore the strong desire on the part of most female temporary laborers to obtain employment for longer periods of time. Workers consistently indicated that they had been attracted to the labor force by the high wages available in table grape packing jobs, but had then decided that they wanted additional work. Many eagerly sought permanent employment, though little of this was available in rural areas. This finding is at odds with the assertion of some observers that most temporary female workers in Chile do not want permanent work. The finding has importance for packing plant employers who wish to maintain a skilled and

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with external labor conditions or changing product prices would have been costly to negotiate and potentially disruptive to labor relations.

[16] The longest season of any plant was 118 days. The marginal wages for cleaners and packers for the 118th day was estimated to be 1,448 pesos and 228 pesos, respectively. From other work, we estimate that the actual wage in the off-season, holding constant a worker's human capital, was half that during the packing season.

reliable work force at reasonable cost. Several firm managers sought to develop activities that could occupy their employees in the off-season. Most, however, were restricted in that there were few opportunities for establishing profitable agricultural activities during the off-season.

Worker- and firm-controlled productivity-increasing factors

We initially thought that firm piece rates would be positively correlated with average worker productivity. However, the estimated coefficient on this variable was insignificant, leading us to wholly rethink our conceptual framework. In the new framework, measured worker productivity is the outcome of factors that are controlled partly by firms and partly by workers. Each factor owner is entitled to a return to his/her assets. To the extent that workers possess characteristics that increase productivity, thereby allowing the firm to save on other costly inputs, firms have an incentive to pay higher piece rates to adequately reward such labor. However, if firms possess characteristics that increase workers' productivity, the firm should pay a lower piece rate to thus reward its own factors of production.

Worker-controlled productivity-increasing factors. We expected that worker-controlled productivity-increasing characteristics would be associated with higher piece rates, although the piece rate literature suggests that a firm should be indifferent to worker productivity since the firm pays workers the value of their specific output. Indeed, one reason commonly given in the economics literature for piece rate use is their facility for incorporating a heterogeneous labor force.[17] However, if other costs vary directly with the number of piece rate workers employed, firms will prefer more productive workers and in competition will bid up the piece rate of such workers until unit processing costs are the same whether firms use low or high productivity workers. We explain this in more detail in the following paragraphs.

Packing sheds hired supervisors that ensured that each piece rate worker had the required inputs (e.g., grapes, boxes, and scissors) and that her output was inspected and recorded. Other administrative workers paid the piece rate worker the correct amount for the work performed and in most plants, forwarded deductions for taxes and contributions to the appropriate institutions. Supervisors also dealt with specific problems that

[17] Worker's measured productivity varied greatly within processing sheds. Workers in the 90th percentile consistently processed about three times as many boxes per day as did workers in the 10th percentile.

inevitably occurred with a labor force, e.g., absences due to illness or family emergencies, a need for assistance—like a small loan, and the settlement of grievances with the firm or another worker. The cost of supervision and administration was likely to be directly related, perhaps exponentially, to the number of workers in the plant. Accordingly, since the total supervisory cost of processing a given amount of grapes rose as the average inherent skills of a firm's workers declined, firms had an incentive to attract more productive piece rate workers by paying a higher piece rate.

By hiring fewer workers of greater skill, firms would also save on per-worker costs that must be paid regardless of the plant's or the worker's productivity on a given day. Most firms paid a "guaranteed daily wage" if for example the plant was unable to provide its workers with sufficient grapes that allowed them to earn this amount via piece rate work. The guaranteed daily wage was close to the legal minimum wage and varied little from plant to plant. The size of the expected cost of maintaining labor when it could not be fully employed was thus positively correlated with the number of workers employed. And even in days of average plant-level production, low-productive workers would be more likely than high-productive workers to earn less than the daily minimum in piece rate pay, thus entailing a greater cost to the firm. This again implied an expected saving to the firm from hiring fewer, more-productive workers rather than more, less-productive workers.

Firms also probably preferred higher productivity workers as a result of capital costs. For example, all firms provided each worker with a physical workstation such as a table and work implements. Assuming that each firm provided exactly the same workstation and implements to each worker, total capital cost rose with the number of workers that a firm employed

In our interviews, firm managers mentioned having a preference for workers that required little supervision, had good relationships with other workers and with management and were willing to work longer hours when needed. Theoretically, each of these worker characteristics, if identifiable, warranted a higher piece rate, with the premium in each case depending on the firm's savings in other costs. If output is produced by piece rate labor alone, productivity does not affect piece rates. If other factors are involved and if their use depends on worker productivity, there is scope for piece rate differentiation. The premium paid high

productivity workers depends on the cost of the complementary resources that are saved when high productivity workers are employed instead of low productivity workers. Different firms can hire one type of labor and pay the piece rate that corresponds to this labor, or a firm can hire different types of labor and pay workers of different ability different piece rates.[18]

To measure each firm's workers' characteristics, we used the mean value of those characteristics for all sampled workers in the firm. A quadratic term was introduced for each variable to allow for a non-linear effect.[19] Age and education (MAGE and MSCH) were observable characteristics though likely to be correlated with productivity and other desirable worker characteristics. The signs of the estimated coefficients were almost always positive as expected, but the significance of the coefficients differed by task. For example, the coefficient on MAGE was more significant in the equations for cleaners than packers, while the coefficient on MSCH was significant only in the equations for packers.[20] The quadratic terms were normally significant and of opposite sign, as expected, implying a decreasing marginal effect of each worker characteristic. As a result of comments from plant managers that married workers were more mature and focused on their work, we included the mean number of married workers in the labor force (MMARST). Its estimated coefficient consistently had a positive and significant effect in the packer piece rate equations, but not in the cleaner equations. The quadratic term was never significant.

We also included mean total per capita household income from other workers in the worker's household (MHHPC) on the assumption that workers from poorer households would be more highly motivated, in which case the expected sign on MHHPC would be negative. Instead, the estimated coefficient was significant and positive in the equation explaining the piece rate received by packers, and was otherwise insignificant. The significant result may be spurious, but it could mean that workers from families where income from other workers was higher tended to earn more because of a greater family work ethic or other family characteristic

[18] Piece rate equilibrium requires the maximization of firm profits and worker utility. If there are workers with different productivity levels and if firms are willing to hire the lower-productivity workers only at a lower piece rate, equilibrium requires that the piece rate earnings of all employed workers are greater than their opportunity cost.

[19] Though the characteristics of each worker are exogenous, the mean characteristic of a firm's workers is the result of firm and worker choices and is probably not independent of the piece rate that is paid. We do not have appropriate instruments for these variables.

[20] In the equation for packers, only the coefficient on MAGE2 is significant and it is positive. If the marginally significant negative coefficient on MAGE is considered significant, the net effect of work force mean age is not substantial in this equation. See also Table

correlated with productivity.

Two experience variables were used: mean years in the piece rate task at which the worker was working when interviewed, i.e. cleaner or packer (MEXPERT), and mean years with the same firm (MTENURE).[21] Mean task experience (MEXPERT) was rarely significant, but the mean years that a shed's workers had been employed with the firm (MTENURE) was always positive and significant, while its quadratic term was negative and significant.[22] When the tenure variable was omitted from the equation, the experience variable became only slightly more significant.

A worker's longer tenure could equally well signal that the worker had been willing to sacrifice income in order to remain with a firm that she liked, as that the firm was willing to pay more for workers that it valued. However, the positive sign on MTENURE suggested that tenure was likely to be an indicator of worker skills that were important in this type of work, such as manual dexterity and speed, ability to concentrate, and motivation. These abilities were observable to the employer over time. Additionally, however, a firm's decision to rehire workers was also potentially influenced by the manager's trust in a worker. Most managers expressed concern about wanting to avoid "troublemakers" and having a preference for workers that they already knew. The processing sheds were vulnerable to work stoppages for higher piece rates or other conditions that did occur occasionally, as well as to worker absenteeism, so firms may have been willing to pay a higher rate to retain trusted workers. Since both trust and productivity factors were likely to be combined in TENURE, it is impossible in this model to distinguish their separate effects.

The standard human capital variables had relatively weak effects. The relatively weak effects could be caused by our failure to specifically include indicators of worker productivity like manual dexterity, eyesight, and endurance. Since these characteristics were not measurable in any practical way for the purposes of this

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[21] Mean years in the industry (MEXPERI) was tried, but it had the same sign as mean years in the task (MEXPERT) and was never significant.

[22] Over the range of actual sample variation, an increase in the average tenure of firm workers was first associated with an increase in the piece rate and then with a decline. The firm whose workers had the shortest tenure (1.2 years) had an estimated piece rate about 3.5 pesos lower than a firm whose workers had the optimum tenure (4.1 years). However, the firm whose workers that had the longest tenure (7.3 years) had the lowest piece rate, about 4 pesos lower than a firm with the optimum tenure. Longer average tenure could reflect a firm's ability to screen workers and establish conditions that will retain higher productivity workers over time. However, very long tenure could also indicate that a firm had a largely "captive" labor force because of geographical or institutional reasons.

study, this represents another potential source of bias. Not having this kind of information also makes it impossible to sort out some of the competing labor demand and supply reasons for why TENURE and other variables are significant. That said, we believe TENURE helps to capture some of these unobservable characteristics, making it less likely that we have an important omitted variables problem. It is more likely that the relatively weak effects of the observed human capital variables is attributable to the possibility that the savings that firms achieve by hiring more productive workers is small. Nonetheless, the regressions show that firms did pay somewhat higher piece rates when they had a work force with a higher average level of observable skills or experience.

Moreover, the econometric evidence was reinforced by statements from managers who indicated a preference for workers that produced more and higher quality output, were more trustworthy, and demonstrated greater ability to get along with coworkers and management. Several managers showed us lists that documented workers' characteristics and indicated that they used these lists when hiring. Finally, eight sheds paid piece rates for cleaners that were internally differentiated by the level of individual worker productivity and three sheds paid such differentiated rates for packers.[23] This differentiation was explicit confirmation that worker productivity mattered for these firms.[24] Each of these findings is contrary to the frequent assumption in the economic literature that worker characteristics do not matter when piece rates are used.[25]

Firm-controlled productivity increasing factors. We expected that firm investments in technology, improved plant organization, or the ability to process grapes that were in better condition would raise worker productivity. Further, so long as workers were aware of firm-influenced productivity differences, such higher productivity should lead to lower, not higher piece rates. To the extent that firms possessed improved technology that allowed their workers to achieve higher productivity or were better organized and could provide

[23] In these cases, our piece rate series utilizes the base (lowest) piece rate. A dummy variable, included to test whether the use of differentiated piece rates affected the base piece rate, was statistically insignificant.

[24] Plants that paid differentiated piece rates were larger and had larger fixed costs or offered better fringe benefits. When piece rates were differentiated, the highest piece rate within a shed averaged about 25% more than the lowest or base piece rate, though one firm offered a proportionately much higher maximum piece rate.

[25] For example, Fuller (1968) states "The typical employment relation in seasonal agriculture is utterly barren.... Since the great majority of the work is done at piece rates, neither the contractor nor the farmer hires *people as individuals*, [neither]... is much concerned whether a hundred boxes of tomatoes are picked by two workers or by ten, so long as they get picked. In a similar way, there is little concern whether those who are picking today are the same as those who picked yesterday or last week or last year, so long as there are enough hands to get today's job done on time." (italics in original)

a constant flow of good quality grapes to workers, allowing workers to process more boxes per time period, the firm should pay a lower piece rate. This follows from the assumption that each worker should earn an income consonant with her opportunity cost in equilibrium.[26] If a firm's characteristics allow its workers to produce more output, *ceteris paribus*, worker competition for the jobs at the firm should cause the piece rate to decline until its workers' incomes are equal to what they would earn elsewhere.

As a simple example, assume that the average firm offers the average worker conditions under which she achieves productivity q^a. The firm pays piece rate, p^a, so that the worker earns an income $y^a = p^a q^a$, which, in equilibrium, is assumed equal to her opportunity cost, including any required premium for the extra effort and/or risk inherent in piece rate employment (Stiglitz 1974, Pencavel 1977, Lazear 1990). If another firm offers conditions under which an average worker can achieve higher than average productivity, $q' = \beta q^a$, $\beta > 1$, that firm should be able to hire the worker at a piece rate equal to $p' = p^a/\beta$, which again yields an income equal to y^a. The firm's piece rate saving is the incentive given for its productivity-increasing investments.

We tested this hypothesis using several variables. First, plant organization was expected to influence productivity via the steadiness of grape flow to workers. We used data on the variability in the total number of boxes of grapes processed in the three days immediately prior to our survey to indicate the firm's ability to organize a steady flow of grapes to its workers. Variability was measured as the ratio of the maximum number of grapes processed in one day relative to the minimum number of grapes processed in one day (RATIOP). A high ratio, indicating poorer organization, was expected to be associated with a lower piece rate, and this was indeed the result. The coefficient on RATIOP was negative and significant in each of the regressions for cleaners and packers. Data on the day to day variation in total shed output for only three days of production appears to have captured a significant aspect of shed operation.[27]

[26] Workers who decide to work in a specific shed should determine that piece rate work provides them with an income that is higher than they could earn in wage employment and also that, among packing sheds, the shed chosen offers the highest income.

[27] There is an important difference between technology or grape condition and plant organization in terms of the tradeoff between the resulting higher productivity and associated lower piece rate. Better technology and better grape condition allowed workers to achieve higher productivity with no greater expenditure of effort than the workers would have expended to achieve a lower productivity in an average firm. In contrast, improved plant organization allowed workers to process additional grapes by providing them with a steadier flow of raw material, avoiding periods with nothing to process, but the provision of more grapes also required workers to make a greater effort. So long as workers strongly preferred higher income to enforced "rest" while at work, workers should have been willing to accept a lower piece rate to have a more regular supply of grapes, though the tradeoff should be less than proportional to the

As an alternative measure of plant organization, we asked managers and workers how long workers had stood at their positions each day without working for lack of grapes and used the mean time reported by workers as an alternative indicator of the flow of grapes (WAIT). The estimated coefficient had the expected sign, but was significant in only the equation for cleaners.

We also collected data on grape condition (amount of disease and damage) during the three days for which we obtained productivity data, expecting that grape condition would influence worker productivity. However, managers could not provide us with an independent index of grape condition and we had to abandon this variable.

Finally, we developed an index of firm technology based on each firm's use of several technologies that were thought to directly affect worker productivity and/or demonstrate the firm's concern for achieving higher productivity (SUMTECH).[28] A higher index was expected to be associated with lower piece rates. The coefficient was always negative and significant in each of the regressions for cleaner piece rate. It had the expected sign, but was not significant for packer piece rates. This is consistent with the fact that these technologies affect cleaners much more than they affect packers.

Overall, three variables were used to characterize processing firm-controlled productivity-increasing characteristics. The coefficients on each of these variables had the expected sign and two were always significant. These results supported the hypothesis that firm investments that raised worker output were reflected in lower, not higher piece rates. This is an important finding because the expected effect on productivity from individual firm characteristics could well pose a case where information asymmetry could be an important barrier to an efficient market. Workers could easily ascertain the piece rates paid by different firms, but the effect of firm characteristics on a worker's productivity should have been harder to predict. Firms that had made investments that led to higher worker productivity should have wanted to advertise that information in order to convince workers that they should accept a lower piece rate, while firms that had not should have wanted to hide the fact. The evidence here suggests that workers were both aware of the

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increase in productivity that this permitted.

[28] These technologies included a mechanical box distributor to move grapes along the processing line, an electrical staple gun to tack box

importance of firm-influenced productivity differences and able to obtain information about what firms actually provide. We later discuss possible mechanisms by which this success was achieved.

Firm Services--Fringe Benefits

Most processing sheds provided workers with some combination of fringe benefits that included meals, snacks, transportation to and from work, child care, interest-free loans, and higher quality bathrooms. Sheds also provided different quality work environments in terms of worker treatment by supervisors and managers. According to the theory of equalizing wage differentials, sheds that provide more and better fringe benefits and/or a better work environment should pay lower piece rates. We expected the same would occur for piece rates. [29]

Using workers' evaluations of the fringe benefits provided by the firm in which they worked, we created an index of fringe benefits (FRINGE).[30] As expected, the coefficient on FRINGE was always negative and it was significant in half the regressions. The partial correlation between the individual fringe benefits and the piece rates paid was also negative for nearly all of the fringe benefits, with the more expensive benefits such as lunch, childcare and bathrooms having the strongest negative correlations. See Table 7. These results provide additional empirical support for a theory of piece rate equalizing differences. Few prior empirical studies have been able to evaluate the link between fringe benefits and the wages or piece rates paid because of a lack of appropriate data.

We also asked workers why they had chosen to work in the shed where they were interviewed. Although a large number of reasons were given, many workers referred to the good working conditions of the plant. We utilized the percentage of workers in each plant that mentioned good working conditions as an index of working

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tops to boxes, a computer, and a fax machine.

[29] Theoretically, a firm notes that workers have a demand for certain amenities that the firm can profitably provide. When piece rates are used, a firm "sells" amenities to workers through an implicit reduction in the piece rate. Because many fringe benefits have a quasi-public good quality, i.e., bathrooms, firms with a larger number of workers should have a cost advantage over smaller firms in the provision of such benefits. Similarly, firms that have a longer operating season can defray the costs of fixed assets over a larger number of boxes of fruit, thus decreasing the piece rate reduction per box. Finally, workers that have higher total incomes are likely to have a higher demand for fringe benefits, to the extent that the latter are income elastic. *Cet. par*., sheds that provide fringe benefits will attract workers that place a higher value on such services, irrespective of those workers' productivity.

[30] Services were ranked on a scale from 0 to 5, with 0 assigned when the service was not offered and 1-5 representing the ranking from "bad" to "good." The aggregate index was a weighted sum of each shed's workers' mean evaluations of all services. The largest weights were placed on meals, transportation and bathroom quality (which interviews suggested were very important to most workers)

conditions (MCOND). Though far from an objective metric of working conditions, we thought we might find an inverse relationship with the piece rate if the compensating wage differential effect were strong. [31]

MCOND was also included as a possible indicator of the fair-wage effort hypothesis put forth by Akerlof and Yellen (1990) whereby workers will withdraw effort if they think they are not being paid what they consider to be a fair wage. Workers who do not appreciate the working conditions may be less willing to work hard, and thus the firm would pay them less (according to our hypothesis on the piece rate-productivity effect).

The coefficient on MCOND was consistently positive and significant in the regressions for both types of piece rates. The result indicates some evidence for the fair-wage effort hypothesis and rejects the compensating wage differential argument. However, this variable has not only the problem of being a poor measure of objective conditions (and thus a poor indicator for testing the CWD argument), but since the firm should determine the piece rate taking into account its working conditions, endogeneity is an issue. We do not see it as an important effect, but felt it worthwhile mentioning. Including it did not substantially change the estimated coefficients of other variables.

Facilitation of off-season work

Most workers sought employment in the slack season. Some firms made a specific effort to provide their workers with employment during the slack season. We included a variable for the mean number of days of off-season employment obtained by a firm's workers (MOTHEM) in the expectation that a firm's ability/willingness to provide such employment could induce workers to accept a lower piece rate during the packing season. However, MOTHEM could also be an indicator of unobserved worker quality, with better workers gaining more work during the year. If so, these workers should have received a higher piece rate during the packing season. The coefficient on MOTHEM was positive and significant in the equations for cleaner piece rates, providing some support for the latter hypothesis.

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and the smallest weight on first aid, which was deemed unimportant by most workers.

[31] The appropriate approach would have been to ask workers to evaluate the working conditions of the firm in which they worked. We did not, believing that asking such a question, particularly if it directly referred to the firm's management, might make workers and management uncomfortable. Having asked workers why they chose to work in the firm, we attempted to adapt their answers to get at the same issue. Despite the unexpected econometric result, we included it here in order to be forthcoming. Including it did not substantially change the estimated coefficients of other variables. If working conditions are measured inappropriately, or if other important plant characteristics are not included as independent variables, we may have an omitted variables problem for plant

Relative impact of independent variables on the piece rate

To assess the impact of each independent variable on the piece rates paid, we multiplied the estimated coefficient (β_i) of each variable by its sample standard error (σ_i). The resulting statistic provided an approximate indicator of the effect of "equally likely" movements in the different independent variables on the piece rates paid.[32] We evaluated only variables having a statistically significant coefficient. Since there was some variation in the magnitude of the estimated coefficients across equations, we used an average of the estimated coefficients. The results (see Tables 8a and 8b) were broadly consistent with our expectations that stronger effects would come from firm-controlled productivity-increasing factors, location factors, and equalizing difference factors, with weaker effects from worker-controlled productivity-increasing factors.

For cleaners, the five most important variables included two that reflected location (AVDIST and REG2), two that reflected firm-controlled productivity-related characteristics (SUMTECH and RATIOP) and one that reflected annual duration of employment (SEASON). Fringe benefits, another equalizing difference, was important in explaining the variation in the piece rates received by workers, but not those paid by firms. Several variables reflecting observable aspects of worker human capital characteristics had small net effects.

The results for packers were similar with one exception. Mean per capita income from other family workers (MHHPC) had by far the largest estimated effect of any variable. We discount its importance because this variable was marginally significant in only one equation and its sign changed in the equations for cleaner piece rates. The five next most important variables for packers included three that reflected location (AVEDIST, REG2 and REG3), one that reflected firm-controlled productivity factors (RATIOP) and one that reflected annual duration of employment (SEASON). Fringe benefits (FRINGE) and firm size (MAXBOX) had small effects, as did whether the firm deducted taxes from worker payments (TAX).

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characteristics.

[32] We utilize this measure instead of estimated elasticities because the latter say nothing about the variation of the independent variable within the sample. This approach assumes that movements of one standard deviation are approximately equally likely to occur for all variables.

Mechanisms for Dealing with Imperfect Information

The efficient operation of the packing shed labor market depended importantly on the ability of workers and sheds to obtain reliable information about numerous characteristics of the other which were not easily observable. Our econometric results suggest that workers and firms managed to deal fairly effectively with this problem. What mechanisms were used? First, we heard from many workers that they exchanged information about firms in an informal, but purposeful manner, particularly during the off season. The seasonal nature of work allowed workers time to discuss the characteristics of different sheds with close friends and kin, make decisions about where they would like to work and seek employment in that shed. Firms usually started recruiting in October or November, two to three months before the packing season began. Numerous workers changed firms from year to year, though changes were instigated by managers as well as by workers.[33]

Second, most shed managers knew the characteristics of many potential workers because of previous employment experience. Some managers maintained detailed lists enumerating the qualities of past employees. When additional, unknown workers were required, firms preferred to recruit by word of mouth, asking existing employees to recruit new workers. This recruiting approach probably provided managers with better information about the quality of potential workers and also increased the likelihood that potential workers would have good knowledge of the particular combination of pecuniary and non-pecuniary attributes offered by the firm.[34] Allowing workers to interact with friends and kin also tended to create a working environment that the workers valued.

At the beginning of the packing season we were surprised to find that several plants had not established the piece rate to be paid, although they had been operating more than a week. Workers in these plants indicated that they expected the piece rate would be within a given range, but were not greatly concerned. Managers in these plants indicated that they still did not have sufficient information about grape prices and labor market conditions to set the piece rate. Clearly, managers had some scope to assess the quality of their work force

[33] Ninety percent of the labor force interviewed had packing shed experience prior to 1992. Annual turnover varied greatly by firm, from 20% to 80%.

before setting the piece rate. Similarly, that workers began work without fixing the piece rate confirms that other firm characteristics were important in their choice of shed and that there was some level of understanding between many workers and management. Workers did not feel that their employment options were limited. Most workers interviewed at the beginning of the season indicated that they felt they could quit and immediately obtain another job.

Several managers indicated that they offered their best packing shed workers off-season employment to help retain such workers during the packing season. Such workers should also have obtained information through such work about the condition of the grapes that they (and others) were to process. With this information, they should also have been better able to determine what was an acceptable piece rate in that firm, and perhaps even to communicate it to other potential workers.[35]

Conclusions

As noted previously, our model suffers from endogeneity issues and perhaps omitted variables. As we have no way to correct for these problems with the existing data, caution is warranted when interpreting the estimated coefficients. Nonetheless, the qualitative results are theoretically plausible and generally consistent with impressions that we gained while carrying out the survey regarding how the labor market functioned. The results show that piece rate variation was systematically related to worker and employer characteristics and suggest that, rather than representing inefficiency, piece rate variation played an important economic function of allowing specific workers to be allocated among specific firms given heterogeneity of both workers and firms.

Labor and management appeared to possess significant information about the value of different types of firm and labor characteristics. Firm work forces varied greatly in terms of mean worker characteristics and these differences were related systematically to the piece rates paid. In turn, workers demonstrated a willingness to work in firms in which the piece rate was low if employment in those firms offered other advantages. Such advantages included a longer work season, better technology or organization that enabled workers to achieve higher productivity, attractive fringe benefits, firm proximity to workers' homes, and even the offer of illegal,

[34] Recruiting labor in this traditional and somewhat paternalistic way was evidence of a system in which personal ties often played an important role in the work relationship. It was unclear whether such ties favored or hindered work efficiency.

tax-free pay. Geographic variations in labor supply and demand also affected piece rates. Overall, analysis of these labor market transactions suggested a greater complexity and sophistication of operation than is commonly assumed in most discussions of rural labor markets in developing countries.

Our results explained a larger proportion of the variation in observed piece rates than is generally explained in research on the variation in wages across firms. We suspect this occurred because our micro data set provided information on a greater number of linked worker and firm characteristics than are usually available in such studies. Although a considerable amount of the variation in piece rates remains unexplained, the unexplained component might decline further if additional data were sought on currently "unobservable" worker and firm characteristics.

Since the reasons used to explain piece rate differentials are similar to those that have been advanced to explain wage differentials, our results are broadly relevant to that literature as well.
Note, however, that the effect of piece rate differentials on worker incomes (and firm cost) is a function of worker productivity, which is not the case for wages. If worker productivity varies greatly, as it did in the table grape packing sheds studied, more productive workers will pay more than less productive workers for a specific firm benefit when piece rates are used. Differentiated piece rates can avoid this problem. If piece rates are not differentiated, the use of a piece rate deduction to recover the costs of, say, fringe benefits, appears less efficient and equitable than use of a wage deduction since the value of fringe benefits consumed is not likely to be strongly correlated with individual worker productivity. This consequence of piece rate payment could make it more difficult for firms and workers to "agree" on the exchange of a service for a reduction in the piece rate and thus impede the provision of such services, relative to industries in which wages are paid.

Piece rate differentials that are explained by differences in firm technology or organization are particularly interesting in light of the fact that firm factors were traditionally not included in studies of wage determination.[36] In the last decade, however, an increasing number of empirical wage studies have incorporated firm characteristics as determinants, often with the goal of trying to understand one aspect of unexplained

[35] If the grapes were expected to require less work to process, the piece rate should have been reduced.
[36] See Groshen (1991) and Willis (1986). Groshen wrote, "Labor supply factors dominate current empirical research on wage

differences across firms (e.g., differences by size, percent female). Except for Abowd (1993, 1994), the data were not sufficiently disaggregated to permit explanation of detailed firm-related differences. Groshen also found that even when controlling for human capital, occupation, and industry, significant establishment differentials remained, and concluded that "these results signal a need for research on whether intra-industry variations in plant-wide quality of employment (e.g., location, personnel policies, environmental factors) could explain establishment wage differentials." In this paper, we have been able to show that those kinds of specific firm-related factors are significant determinants of pay. It is likely that such micro data would also work well in determining the impact of specific firm factors on wage differences.

Human capital variables have long been known to be important determinants of wages, but they have been considered irrelevant to the setting of piece rates. This study shows that not only is the determination of piece rates highly dependent on market labor supply and demand factors, it is also dependent on the characteristics of workers. These piece rate differentials are notable because they were not expected to exist. That is, although it is widely known that piece rate workers are heterogeneous, it is broadly accepted that variations in worker "quality" are automatically and *fully* handled by use of a piece rate. As shown in this paper, however, this is only part of the story. More productive workers have higher average products *per unit of output* achieved, not only per unit of time worked, provided that more productive workers save on the use of complementary factors. That is, labor's share of the value added in each unit of output rises as innate worker productivity rises and this is reflected in a rising piece rate.

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determination even though they explain less than half of observed wage variation." Willis points out that human capital factors were predominant because data on workers was easily available.

Table 1

Piece Rates Paid Per Firm: All Regions, Santa Maria, and Buin/Paine

Variables	N	Mean	Std. Dev.	Minimum	Maximum
All Regions					
Weighted Piece Rate Embalaje-Gross/Net	39	19.7	4.2	14.4	28.8
Weighted Piece Rate Limpieza-Gross/Net	42	53.6	11.5	35.0	76.6
Buin/Paine					
Weighted Piece Rate Embalaje-Gross/Net	19	19.5	4.6	14.5	28.8
Weighted Piece Rate Limpieza-Gross/Net	22	60.7	9.5	43.2	76.6
Santa Maria					
Weighted Piece Rate Embalaje-Gross/Net	18	20.4	3.7	14.4	28.2
Weighted Piece Rate Limpieza-Gross/Net	18	46.1	8.0	35.9	68.6

Table 2a

Firm Characteristics: All Regions

Variables	N	Mean	Std. Dev.	Min.	Max.
Years of operation	42	9.2	5.9	1.0	30.0
Max. no. of boxes processed per day 1991	41	2951	2265	534	11,000
Total packers and cleaners employed in firm	41	49.0	34.7	10.0	185.0
Days in operation/season 1991	42	72.9	26.8	20.0	118.0
No. of boxes processed/season 1991 (‘000)	42	122.3	172.8	10.0	800.0
No. hectares planted to fruit by firm	42	131.3	257.3	0.0	1250.0
If process fruit from other growers	42	0.36	0.5	0.0	1.0
If have a box distributor	42	0.19	0.4	0.0	1.0
If have a computer	42	0.66	0.5	0.0	1.0

Table 2b					
Mean Worker Characteristics by Firm					
Variables	N	Mean of Means	Standard Deviation	Minimum Mean	Maximum Mean
Mean age	42	30.2	4.3	20.8	38.1
Mean schooling	42	8.2	1.2	5.4	10.8
Mean tenure	42	3.3	1.4	1.2	7.3
Mean experience in task	42	5.2	2.3	1.8	10.5
Mean distance traveled to work (km)	42	6.2	5.1	0.6	31.2
Percent married or living with partner	42	0.54	0.2	0.0	0.9
Mean hours/day worked by packers	39	10.3	2.2	7.4	15.9
Mean hours/day worked by cleaners	42	9.6	2.1	6.5	14.6
Mean packer hourly productivity	39	19.2	7.0	9.3	33.3
Mean cleaner hourly productivity	42	5.5	1.8	1.7	9.6

Table 3					
Effects of Piece Rate Adjustments on Piece Rate Variation					
Piece Rate Adjustment	N	Mean	Standard Deviation	Minima	Maxima
Firm cost: packers	39	19.7	4.2	14.4	28.8
Worker net: packers (g*ross PR discounted 12%)*	39	18.4	4.3	12.7	28.8
Worker net: packers (g*ross PR discounted 20%)*	39	17.5	4.5	11.5	28.8
Firm cost: cleaners	42	53.6	11.5	35.0	76.6
Worker net: cleaners *(gross PR discounted 12%)*	42	50.1	11.8	30.8	75.2
Worker net: cleaners *(gross PR discounted 20%)*	42	47.7	12.5	28.0	75.2

TABLE 4	
Variable	Definition of Variables Used in Regressions
TAX	Dummy for accounting method (1=If the firm deducts)
AVDIST	Average distance traveled by workers to firm
AVTIME	Mean hours worked per day at firm
MAGE	Mean age of workers in firm
MAXBOX	Maximum number of boxes processable per day by firm
MEXPERT	Mean years of experience in task
MHHPC	Mean per capita household income not including worker income
MMARST	Proportion of workers in firm that are married
MOTHEM	Mean days workers are employed during the rest of the year
MSCH	Mean number of years of schooling
MTENURE	Mean years of tenure of workers in firm
MCOND	% of workers in firm who chose firm for working conditions
MOTHEM	Mean number of days workers employed during the off-season
PRPF	Weighted packer piece rate (8 kg)—firm cost
PRPW12	Weighted packer piece rate (8 kg)—worker net (withholding discounted 12%)
PRCF	Weighted cleaner piece rate (8 kg)-- firm cost
PRCW12	Weighted cleaner piece rate (8 kg)-- worker net (withholding discounted 12%)
RATIOP	Ratio of minimum to maximum total grapes processed by day
REG2	Dummy for Buin-Paine region
REG3	Dummy for Lontue region
SEASON	Firm season length in 1991 in days
FRINGE	Index of services--increasing in quantity and quality
SUMTECH	Index of firm technology
WAIT	Average daily time inactive waiting for grapes to process

TABLE 5a Cleaner Piece Rates

Dependent Variables: n=42	Estimated Coefficients (with t statstics in parentheses)							
	PRCF		PRCW12		PRCF		PRCW12	
TAX	3.85*	(1.69)	0.98	(0.42)	4.23*	(1.85)	1.55	(0.67)
REG2	5.91*	(1.79)	7.21**	(2.15)	9.85***	(3.28)	9.96***	(3.27)
REG3	-11.12	(1.50)	-8.84	(1.18)	-3.60	(0.52)	-3.34	(0.47)
AVDIST	1.45***	(2.93)	1.77***	(3.51)	1.67***	(3.88)	2.01***	(4.52)
MAXBOX x100	0.06	(0.95)	0.01	(0.12)				
SEASON	-0.17***	(2.89)	-0.18***	(3.05)	-0.11**	(2.00)	-0.14**	(2.42)
MOTHEM	0.05*	(1.88)	0.07**	(2.34)	0.03	(1.00)	0.05*	(1.69)
RATIOP	-11.87**	(2.28)	-12.30**	(2.32)	-13.72***	(2.72)	-14.98***	(2.94)
SUMTECH	-2.87**	(2.41)	-2.75**	(2.35)	-1.55	(1.60)	-2.07**	(2.10)
WAIT	-0.04*	(1.65)	-0.04	(1.49)				
MAGE	7.93***	(2.73)	3.49	(1.18)	6.65**	(2.19)	3.68	(1.19)
MAGE2	-0.14***	(2.96)	-0.07	(1.49)	-0.11**	(2.20)	-0.06	(1.23)
MSCH	5.27	(0.57)	3.97	(0.42)				
MSCH2	-0.43	(0.76)	-0.32	(0.55)				
MMARST	-1.20	(0.22)	5.71	(1.05)				
MTENURE	9.65***	(2.82)	7.07**	(2.03)	9.83***	(2.90)	9.02***	(2.61)
MTENURE2	-1.17***	(3.03)	-0.82**	(2.08)	-1.07***	(2.72)	-0.96**	(2.38)
MEXPERT	-4.51*	(1.86)	0.05	(0.02)	-2.30	(1.00)	1.01	(0.43)
MEXPERT2	0.41**	(1.97)	0.07	(0.33)	0.21	(1.05)	-0.04	(0.21)
MHHPC x10	-0.03	(0.72)	-0.05	(1.14)				
FRINGE	-1.05	(0.34)	-3.06	(0.96)	-2.53	(0.96)	-4.97*	(1.84)
MCOND	13.22**	(2.06)	5.58	(0.86)	11.10*	(1.83)	6.79	(1.10)
CONSTANT	-66.25	(1.12)	-8.02	(0.13)	-53.91	(1.16)	-16.21	(0.34)
R^2	.81		.82		.78		.78	
R^2 adjusted	.60		.61		.63		.64	
F Stat & Critical Value at 1%	F(22,19) = 8.38 > 2.86		F(22,19) = 8.60 > 2.86		F(16,25) = 9.05 > 3.18		F(16.25) = 9.31 > 3.18	

* Significant at a = .10. ** Significant at a = .05. *** Significant at a = .01

TABLE 5b Packer Piece Rates

Dependent Variables: n=39	Estimated Coefficients (with t statistics in parentheses)							
	PRPF		PRPW12		PRPF		PRPW12	
TAX	2.75***	(2.90)	1.63*	(1.72)	3.02***	(3.24)	2.26**	(2.42)
REG2	-5.59***	(4.13)	-4.71***	(3.47)	-4.73***	(3.71)	-4.50***	(3.58)
REG3	-9.65***	(3.11)	-8.06***	(2.60)	-9.80***	(4.12)	-8.81***	(3.83)
AVDIST	0.77***	(3.48)	1.02***	(4.59)	0.51***	(3.52)	0.67***	(4.62)
MAXBOX x100	0.09***	(3.06)	0.06*	(1.88)	0.07***	(3.33)	0.04**	(2.00)
SEASON	-0.10***	(3.97)	-0.10***	(5.00)	-0.12***	(5.47)	-0.13***	(5.87)
MOTHEM x 10	-0.01	(0.08)	-0.04	(0.27)				
RATIOP	-11.49***	(4.95)	-12.58***	(5.42)	-9.27***	(4.70)	-10.14***	(5.14)
SUMTECH	-0.31	(0.50)	-0.28	(0.46)				
WAIT	0.01	(0.89)	0.01	(1.17)				
MAGE	-0.70	(0.57)	-2.02	(1.62)				
MAGE2	0.01	(0.66)	0.04*	(1.80)				
MSCH	10.56	(1.70)	16.88***	(2.72)	6.63	(1.21)	10.12*	(1.85)
MSCH2	-0.62	(0.17)	-1.00***	(2.69)	-0.36	(1.12)	-0.57*	(1.84)
MMARST	7.89***	(3.41)	9.28***	(4.00)	5.42**	(2.38)	6.97***	(3.06)
TENURE	4.07***	(2.93)	3.46**	(2.48)	3.33**	(2.21)	2.92*	(1.94)
TENURE2	-0.41**	(2.54)	-0.29*	(1.84)	-0.41**	(2.37)	-0.32*	(1.88)
EXPERT	-1.68	(1.59)	-0.18	(0.17)				
EXPERT2	0.09	(0.91)	-0.03	(0.35)				
MHHPC x 10	0.03	(1.56)	0.04*	(1.89)				
FRINGE	-2.79**	(2.13)	-3.63***	(2.77)	-1.57	(1.34)	-2.02*	(1.74)
MCOND	6.77**	(2.23)	2.34	(0.77)	7.65***	(2.84)	4.79*	(1.78)
CONSTANT	-11.42	(0.37)	-23.27	(0.76)	-8.77	(0.38)	-21.50	(0.94)
R^2	.77		.78		.70		.71	
R^2 adjusted	.45		.47		.52		.54	
F Stat & Critical Value at 1%	F(22,16) = 5.89 > 2.95		F(22,16) = 6.23 > 2.95		F(14,24) = 6.36 > 2.94		F(14,24) = 6.78 > 2.94	

* Significant at a = .05. ** Significant at a = .10. *** Significant at a = .01

Table 6							
Expected marginal daily piece rate income from working in a firm with a longer season							
	Average piece rate, p	Average output per day, q	Average days per season, D	$pq\|_{D=73}$	dp/dD	$pq\|_{D=74}$	$dY/dD\|_{D=73}$
Cleaners	53.6	52	73	2787	-0.160	2779	2172
Packers	19.7	192	73	3782	-0.115	3760	2148

Table 7					
Mean Worker Evaluation of Firm Fringe Benefits					
Fringe Benefit	No. Workers	Mean	Std. Deviation	Correlation with PRPW20	Correlation with PRCW20
Lunch	32	2.9	1.28	-0.90	-0.01
Snack	249	3.4	0.94	0.10	0.00
Snack 2	175	3.1	1.08	0.00	-0.11
Transportation	241	3.2	1.13	-0.02	-0.08
First aid	216	3.3	1.10	0.15	0.01
Child care	31	2.8	1.44	-0.24	-0.35
Loans	26	3.6	0.90	-0.05	-0.11
Bathrooms	386	2.9	1.27	-0.05	-0.26

Table 8a		
Relative Impact of Independent Variables on Cleaner Piece Rates		
Independent variable	Gross piece rates paid by firm	Net piece rates received by worker
AVDIST	4.7	5.8
SUMTECH	-3.2	-2.4
REG2	3.0	3.7
SEASON	-3.0	-3.8
RATIOP	-2.5	-2.6
MCOND	2.2	0
TAX (1 = pay taxes; 0 = do not pay taxes)	2.0	0
MOTHEM	1.9	0
FRINGE	0	-2.6
MAGE (net effect considering quadratic)	0.8	0
MTENURE (net effect considering quadratic)	0.7	0.6
MEXPERT (net effect considering quadratic)	-0.6	0

Table 8b		
Relative Impact of Independent Variables on Packer Piece Rates		
Independent variable	Gross piece rates paid by firm	Net piece rates received by worker
MHHPC	9.2	9.2
SEASON	-2.7	-2.7
RATIOP	-2.0	-2.7
REG2	-2.4	-2.3
AVDIST	1.7	2.2
REG3	-2.1	-1.8
MAGE (net effect considering quadratic)	0	1.6
MMARST	1.5	1.1
TAX (1 = pay taxes; 0 = do not pay taxes)	1.3	1.1
FRINGE	-1.4	-1.0
MSCH (net effect considering quadratic)	0	1.0
MCOND	1.4	1.0
MAXBOX	1.6	0.9
MTENURE (net effect considering quadratic)	0	0.7

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