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Authors
Rubin, D. Kate
Perloff, Jeffrey M

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by

D. Kate Rubin
Jeffrey M. Perloff

California Agricultural Experiment Station
Giannini Foundation of Agricultural Economics
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D. Kate Rubin*
Jeffrey M. Perloff**

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* Graduate Student, Department of Agricultural and Resource Economics, University of California Berkeley and Law Clerk to Harry Pregerson, U. S. Court of Appeals for the Ninth Circuit.

** Professor, Department of Agricultural and Resource Economics, University of California, Berkeley

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Who Works for Piece Rates and Why

Whether a hired agricultural worker has a piece rate or a time rate job is not random. The probability the worker is paid by the piece is a function of the worker's demographic characteristics (especially age) and the wage differential between piece-rate and time-rate jobs. Using a simultaneous equations model, we show that wages and age-earnings profiles substantially differ between workers in piece-rate and time-rate jobs and that the probability of working in piece rate varies significantly with age.

Piece-rate contracts provide workers with incentives to work harder and faster in a given period than under time-rate contracts. Under a piece-rate contract, individuals who are willing to work very hard or who are highly skilled are rewarded for their higher productivity.

The portion of the earnings differential due to differences in the characteristics of the contract, of the worker, or both are captured in our model. Our results are consistent with the widely-held belief that younger workers choose more effort-intensive, piece-rate jobs in order to gain higher earnings. Somewhat more surprising, however, is our finding that older workers also select piece-rate employment.

In our model, the choice of contract and earnings are jointly determined. The choice of type of payment contract depends on both *earnings* and *nonearnings* effects. Worker who can earn relatively more in piece-rate than time-rate work are more likely to choose piece rate, all else the same. Other factors also influence this choice such as psychic and physical costs and greater income uncertainty in piece-rate work.

In the next section, we discuss how a worker's choice of payment contract varies with age. In the second section, the estimating model is described. The data source and some summary statistics are reported in the third section. In the fourth section, the estimation results are discussed for the earnings equations and the contract choice equation. In the next section, the estimated model is used to conduct several simulations. We simulate the probability of working in piece rate as a function of age and decompose that probability in earnings and nonearnings effects of age.

Age and the Choice of Contract

The type of compensation contract offered by an employer determines the characteristics of job applicants, the intensity of the work effort, and the level of earnings. If a worker has a choice, the worker chooses the contract with the highest return taking into account both monetary and psychic rewards and costs.

Typically, piece-rate contracts offer higher compensation in exchange for greater effort. Piece-rate workers are rewarded for working harder and faster. They bear greater income risk from averse weather conditions and other factors. Workers unsure of their own abilities bear greater income risks on piece-rate jobs.

The relationship between age and contract choice is complex. All else the same, we would expect younger workers who can work harder and longer to choose piece-rate work. On the other hand, due to their limited experience, younger workers may have fewer skills.

Middle-age or older workers are more likely to have families, which may affect their attitudes towards taking relatively risky piece-rate employment. For example, an individual with a working spouse may be more inclined to take risks; whereas another without a working spouse and many children may be unwilling to do so. Good workers who remain with one farm for a while may be rewarded with relatively high-paying, low-risk time-rate jobs. To the extent that piece-rate work leads to greater physical strain and stress, it may be less attractive to prime-age workers who hope to sustain a life-time career in agricultural labor.

Because they are less productive, very old and very young workers may prefer time-rate employment where earnings do not depend on productivity. On the other hand, time-rate employers may fire relatively unproductive workers. Thus, the old and the young may be restricted to working in piece-rate where they are unlikely to be fired for working slowly.

Because there are many offsetting effects for each age group, theoretical considerations alone cannot predict the shape of the age-earnings profile. In our empirical work, we decompose the effect of age on contract choice into two categories: *earnings* and *nonearnings* effects. Because the age-earnings profile differs between piece rate and time rate, the relative earnings in piece rate varies with age. When the relative earnings in piece rate are high, all else the same, the worker is more likely to want to work in piece rate. There are other psychic and physical costs and benefits of working in piece rate that influence the worker's decision as to which type of contract to choose. These other factors include job stress, relative risks, and the ability to work with other family members.

In the theoretical literature, three key points about employer decisions are raised. First, employers choose the type of wage contract depending on the relative cost of monitoring workers and the trade-off between the greater output under piece rate and the lower quality (Pencavel; Roumasset and Uy). There should be few differences across employers here because our sample is restricted to harvest workers and we control for crop.

Second, when the skill distribution of the firm's work force is highly variable or unknown, piece-rate contracts shift the risk of low or variable productivity from the employer to the worker (Stiglitz, 1976). We partially control for these factors by examining a fairly homogeneous work force in a single county in California. Nonetheless, to the degree that attitudes towards risk are related to age, this factor will be reflected in our estimated nonearnings age effect.

Third, different wage contracts may be offered to induce workers to reveal private information as to how quickly tasks can be performed (Gibbons, 1985). So far as we can determine, this factor is not an important consideration for the workers and jobs we are examining.

The Estimating Model

We estimate a system of contract choice and earnings equations, where we take account of sample selection in the earnings estimates.[1] The logarithm of daily earnings in piece-rate, w_p, and time-rate, w_t, employment are functions of observed individual demographic characteristics and crop, X, and unobserved individual differences, η_p and η_t:

$$w_p = \beta_p X + \eta_p, \tag{1}$$

$$w_t = \beta_t X + \eta_t. \tag{2}$$

A worker's relative monetary benefit, B, from piece-rate work is defined as the logarithmic earnings differential:[2]

$$B = w_p - w_t \approx \beta_p X - \beta_t X. \tag{3}$$

The relative psychic and physical disutility, D, from piece-rate work (e. g., from greater effort) and income risk is not observed. This disutility,

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[1] Formally, our model is analogous to the union wage models in Lee (1976), Perloff and Sickles (1987), and Perloff (1991); the education model in Willis and Rosen (1979); and the migration model in Robinson and Tomes (1982).

[2] The right-hand-side approximation of the earnings differential is based on an unconditional estimate in the terminology of Gyourko and Tracy (1988). The unconditional differential does not include selection effects and represents only the varying returns to the worker's observed characteristics in piece-rate and time-rate work. The conditional differential takes into account both the selectivity bias and varying returns to the worker's unobserved characteristics. Both the unconditional and conditional wage differential are reported in the next section.

$$D = \gamma Z + \varepsilon, \tag{4}$$

is assumed to vary with a worker's observed characteristics, X, and with unobserved characteristics, ε.

If the monetary benefit, B, from working a piece-rate job exceeds the relative disutility from such work, D, the worker chooses a piece-rate job (I = 1), and, otherwise, the worker takes time-rate employment (I = 0):[3]

$$I = 1 \quad \text{if } B > D,$$

and (5)

$$I = 0 \quad \text{if } B \leq D.$$

Because we assume that the disturbance terms (η_p, η_t, ε) are jointly normally distributed, equation (5) can be estimated using probit. By substituting for B and D in equation (5), using the other equations, we obtain a reduced-form contract choice equation:

$$I = 1 \quad \text{if } \beta_p X - \beta_t X - \gamma Z - \varepsilon > 0,$$

and (6)

$$I = 0 \quad \text{if } \beta_p X - \beta_t X - \gamma Z - \varepsilon \leq 0.$$

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[3] More generally, one might prefer to model job choice as the outcome of decisions by both workers and employers. Because our data set only has information on worker characteristics, we are forced to focus on only worker decisions.

Equation (6) can be estimated using maximum-likelihood probit, where the exogenous right-hand-side variables are the union of those included in X and Z.

Following Heckman (1979) and others, we can estimate the earnings equations (1) and (2) taking account of possible sample selection by either using a maximum-likelihood technique to estimate the contract equation (6) and the wage equations simultaneously or by estimating (6) and including an extra term (Mills ratio) based on equation (6) in the wage equations.[4] Were we to use ordinary least squares to estimate the wage equations, (1) and (2), the results would be biased if workers do not randomly choose to work in piece-rate or time-rate jobs. That is, the unobserved individual disturbance terms in the wage equations, η_p and η_t, are not normally distributed if we examine data for only those workers observed working for a given contract.

Given consistent estimates of the wage equations, (1) and (2), a consistent estimate of the logarithmic earnings differential (monetary benefit from piece rate work) is $\hat{B} = \beta_p X - \beta_t X$. That is, although we observe a worker's earnings under only one type of contract, we can use the estimated equations to estimate the potential

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[4] Heckman's two-step consistent estimator is

$$w_p = \beta_{pX} + \rho\sigma\frac{\phi}{\Phi} \qquad \text{if } I = 1,$$

and

$$w_t = \beta_{tX} + \rho\sigma\frac{\phi}{1 - \Phi} \qquad \text{if } I = 0,$$

where Φ is the normal distribution, ϕ is the density, ρ is the correlation, and σ is the standard deviation from the reduced-form probit.

logarithmic earnings differential. By substituting this estimate of B into equation (5), we can estimate the structural probit equation for contract choice.

The predetermined and exogenous variables in X that affect contract choice are age and age squared (to allow for nonlinear effects), gender (reflecting physical differences on productivity and health and possible discrimination), whether the worker was born in Mexican (to capture willingness to work hard at relatively unpleasant work and information about the availability of different types of jobs), and how long the worker has lived in this county (as a proxy for information about job choices). In addition, the work status equation also includes B, the logarithmic earnings differential between piece-rate and time-rate work.

The logarithmic earnings are a function of age, age squared, years of formal education, education squared, gender (to capture productivity differences and possible discrimination), whether one is Mexican born (as a proxy for how hard one is willing to work and possible discrimination), and crop (field crops, grapes, nuts, or citrus). Earnings differentials across crops represent compensation for relatively difficult or dangerous work.[5]

Thus, there are three identifying restrictions. First, the variable measuring how long a worker has resided in his or her current county appears only in the contract choice equation. This "time in location" variable is a proxy for the worker's job contacts, which affects a worker's ability to find a piece-rate or time-rate job, but do not

[5] We assume that these differentials are fully compensating so that workers choose between crops randomly, or, at least, there is no sample selection bias resulting from their choice.

affect wages directly. Second, a worker's experience (age - education - 6) affects earnings directly, but not the worker's choice of contract. Third, crop type determines earnings but is unrelated to a worker's choice of contract type.

The Data

The data used in this study are from a 1981 survey of workers employed in agriculture in Tulare County, California.[6] We use all 282 harvest workers in the sample for whom we have complete information on the relevant variables.

The characteristics and earnings of time-rate and piece-rate workers are summarized in Table 1. Over 60 percent of the farmworkers in the sample reported that they received piece-rate compensation on their current or most recent job. The workers in the sample ranged in age from 16 to 76 years, with piece-rate workers having a slightly higher mean age and larger standard deviation. Most of these workers were men born in Mexico.

The method of compensation varied by crop. Two-thirds of the hourly workers harvested grapes. The rest worked in roughly equal proportions in field crops, nuts, and citrus. Two-thirds of the piece rate workers harvested citrus; nearly 20 percent, grapes; 12 percent, nuts; and less than 2 percent, field crops.

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[6] See Mines and Kearney for details. We are very grateful to Richard Mines for permission to use this data set. The data were collected using "snowball" sampling. That is, although the initial group of workers surveyed were chosen randomly, those workers identified a pool of other workers from whom the remaining sample were drawn.

The mean daily earnings for piece-rate workers was $37.63, compared to $34.95 for hourly-rate workers and $37.30 for all workers taken together. Daily piece-rate earnings are more variable than hourly-rate earnings (with respective standard deviations of $17.97 and $5.77).

Estimation Results

A three-step procedure was used to estimate this model. First, we estimated a reduced-form contract choice equation, where the right-hand side variables include all the exogenous and predetermined variables (in X and Z) in the system. Second, conditional on the contract choice equation, the earnings equations were estimated using Heckman's method to avoid sample selection bias. Third, the structural contract equation was estimated using a consistent estimate of B based on the consistently estimated earnings equations.

Earnings Equations

The first two steps can be combined into a single step, however, if one can estimate the contract-type equation and the earnings equations simultaneously using a maximum-likelihood approach. The maximum-likelihood estimators are more efficient than those from Heckman's two-step method, although both methods give consistent estimates. The maximum-likelihood estimated model did not converge for the time-rate earnings equation, so we report the maximum-likelihood estimates for the piece-rate equation and the two-step estimates for the time-rate equation. The two-step estimation for time-rate workers' earnings and the maximum-likelihood estimation for piece-rate workers' earnings are reported in Table 2.[7]

In both earnings equations, the coefficients on age and age squared are statistically significantly different than zero using a 0.05 criterion. In the piece-rate equation, earnings rise with age until one is 38.5 years old and then decrease. In the time-rate equation, earnings do not decrease until a worker is 39.5. All else the same, a 38.5 year old would earn 10.7 percent more than a 25 year old in piece rate and 6.1 percent more in time rate.

Years of formal education and its square are statistically significant in the time-rate earnings equation but not in the piece-rate equation. In time rate, earnings only rise up to 7.4 years of formal education. There are no statistically significant crop differentials (where the base crop is citrus fruit). Nor are there statistically significant gender or place of origin effects.

In the piece-rate equation, the test that the squared correlation of the disturbance in the earnings regression and in the selection criterion, ρ^2, equals zero is very strongly rejected. The Heckman test statistic for sample selection bias for the time-rate equation (a t-test that the coefficient on the sample selection adjustment term is zero) is -0.073. Based on the strong results for the piece-rate equation, we conclude

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[7] These equations were estimated using William Greene's Limdep 5.1. Not surprisingly, the two-step estimates of the piece-rate earnings equation are close to that of the maximum-likelihood estimates. The only difference is that the coefficients on two of the crop dummies were statistically significantly different from zero at the 0.05 level in the two-step estimates.

that failure to take into account potential sample selection would lead to bias in estimated earnings equations.

Contract Choice

Using the estimated earnings equations, we calculated the logarithmic earnings differential, $\hat{B}$, for each worker. We use the estimated equations to calculate B, because, for any given worker, earnings are only observed for one of the two contracts. The logarithmic earnings differential is included in the structural contract choice equation (where the variable = 1 if the worker is employed on a piece-rate job). These probit estimates are reported in Table 3.[8] The various pseudo-R^2 measures range from 0.19 to 0.31. Seventy-nine percent of the observations are correctly predicted by the estimated equation.

Age and the logarithmic earnings differential have asymptotically statistically significant effects on the contract type at the 0.05 level. Gender, place of birth, and time in location do not have statistically significant effects.

Age is included on the right-hand-side of this equation directly and is reflected through the logarithmic earnings differential, B. The *nonearnings* effect of age (the effect of the age variable directly) on contract choice is nonlinear. The probability of working in piece rate falls with age until one is 34 years old and then rises. Thus, holding all other variables constant, very young and very old workers have a higher probability of working in piece rate than do prime-age workers. This nonmonetary

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[8] The equation was estimated using Kenneth J. White's Shazam 6.2.

effect reflects the increased or decreased disutility of harder work in piece-rate as a function of age, attitudes towards risk bearing that are related to age, and so forth.

Age has an indirect effect on contract choice through the logarithmic earnings differential, B. That is, because earnings in both piece-rate and time-rate vary with age, age affects contract choice indirectly through its effect on relative earnings under the two types of contracts. This *earnings* effect captures the monetary difference or productivity differences associated with age.

Simulation Results

We can use the estimated equations to simulate how contract choice varies with age. First, we examine how the probability of working in piece rate varies with age. Second, we decompose the effect of age on this probability into earnings and nonearnings effects.

Probability of Working in Piece Rate as a Function of Age

Contract choice varies substantially with age as shown in the first two columns of Table 4. The predicted probability of working in piece-rate is close to the actual pattern (the column labeled "piece rate"). We also calculated the probability of working in piece-rate holding all variables except age at their average levels (the column labeled "marginal probability"). The marginal probabilities, which show the pure effect of age, are U-shaped with respect to age. The lowest probability occurs at age 34.

In Table 4, we report both the unconditional logarithmic earnings differential, B, and the conditional differential. Both show how much higher piece-rate earnings are than time-rate earnings as a percentage. The unconditional differential, B, is based on only the estimated β coefficients. The conditional logarithmic earnings differential, reflects both the effect of various demographic characteristics (through the estimate β coefficients) and the sample selection effect.[9]

Based on the unconditional differentials in Table 4, one might infer that, for all age groups, the average worker has higher daily earnings in time-rate employment. Based on the conditional differentials, which adjust for sample selection, however, the average worker has higher earnings in piece rate for all but the oldest age groups.

As shown in Table 4, the unconditional relative earnings in piece rate first increase and then decrease with age in a bell-shaped pattern. The conditional differential rises, falls, rises, and then falls. The unconditional differential peaks for prime-age workers (36-45 years). The conditional differential has a local peak for workers aged 36 to 45 (a 15 percent higher wages in piece-work than in time-rate work) and a global peak for workers aged 56 to 65 (a 30 percent higher earnings).

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[9] The unconditional differential underestimates piece-rate, but not time-rate, earnings. The average actual earnings of time-rate workers is approximately $34.95 per day. The average of the unconditional estimates is $34.00 and the average of the conditional (sample selection corrected) estimates is $34.03. Actual average piece-rate earnings were $37.64 per day. The average unconditional estimate is $29.83 per day, whereas, the average of the conditional estimates is $42.33.

Direct and Indirect Effects of Age

Both the actual percentage of individuals in each age cohort who work piece-rate and the estimated marginal probabilities of working piece-rate decline and then increase with age. Thus, very old workers in this sample are likely to work in piece rate even though they would earn more in time rate. These workers are either trading higher wages for the flexibility of piece-rate jobs or they are simply unable to obtain employment as hourly-wage workers. That is, according to our model, the nonearnings effect of age is more important for these workers than the earnings effect in choosing to work in piece rate.

Based on the earnings effect alone, we might expect that prime age workers have the highest probability of working in piece rate. That is, young workers who are less experienced and older workers who are less fit than prime-age workers earn relatively more in time-rate jobs where their rate of pay is not directly dependent on the level of productivity. Because young and old workers are relatively likely to work in piece rate, the direct effect of age must dominate the indirect wage effect, especially for the older workers.

Older workers may work in piece rate because they cannot find time rate jobs or because piece-rate employment offers greater opportunity to work part time or with other family members. For example, many family members, including children and the elderly, often work together in a piece-rate job and are paid as a group for their joint output.

The earnings and nonearnings effects of age are illustrated in Figure 1 for a representative male, Mexican-born worker. In calculating each curve in Figure 1, continuous nonage variables are set at their median values and the crop dummies are set at their mean values. The estimated structural probit equation is used to derive these curves. The direct effect curve is the estimated probability of working piece-rate at each age holding the other variables (including the logarithmic earnings differential, B) constant. That is, the nonearnings effect curve is based on the age coefficient. It does not include the indirect effect of age through the logarithmic earnings differential (the coefficient on B).

To calculate the earnings effect of age on the probability of working piece-rate, we hold the nonearnings effect constant by multiplying the age coefficient by the median age, and allow B to vary with age. That is, the earnings effect reflects how the variation of relative earnings with age affects the probability of working in piece rate. As shown in Table 5, the probability of working in piece rate increases with the logarithmic earnings differential in piece rate.

The total effect curve allows age to directly and for B to vary with age. The total effect curve is not the horizontal sum of the direct and indirect curves, because age is held constant for either the earnings or nonearnings effect along the direct and indirect curves.

The nonearnings effect of age on the probability of working in piece rate falls until the mid thirties, rises until the mid sixties, and then hits a plateau. Thus, the nonearnings effect of age is that, holding other variables including B constant, very young and very old workers have a higher probability of working in piece rate.

The earnings effect rises until the mid thirties and then falls. That is, because relative earnings in piece rate peak relative to those in time rate for prime-age workers, the earnings effect of age is that prime-age workers have the highest probability of working in piece rate all else the same.

The total curve rises nearly linearly. That is, the nonearnings effect dominates the earnings effect for older workers. Similar patterns are found for both men and women, those not born in Mexico, and various other demographic groups and across all crops.

Conclusion

Age earnings profiles differ between piece-rate and time-rate work. As a result, workers of different ages choose different contracts. The decision whether to work on a piece-rate job depends on earnings and nonearnings effects of age. The nonearnings effect captures taste factors, such as the disutility from working faster and harder in piece rate, which vary with age. The earnings effect captures the changes in the earnings differential with age.

For the very young and very old, the nonearnings effect of age dominates the earnings effect. Although we have stressed the choice by workers, this result may reflect the unwillingness of time-rate employers to hire less productive older and younger workers. Another possible explanation is that these workers are generally not the prime earners in the household, and may prefer piece-rate jobs, which are more likely to be temporary or part-time. Yet another explanation is that these secondary workers often work with other family members for a piece-rate calculated on their joint harvest output.

The empirical results in this study also show that a substantial number of prime-age workers do not choose piece-rate contracts even though they stand to benefit considerably in terms of the wage differential. This result contradicts the belief that prime-age workers are most likely to choose piece-rate because they are both experienced and capable enough to reap substantial rewards from this type of payment scheme. In fact, prime-age workers are, as a group, the least likely to work piece-rate as compared to other age groups. For these workers, higher earnings in piece-rate jobs may not compensate for the disutility of more intensive effort, more variable incomes, and possibly a greater risk of injury or a shortened career in farm-work.

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Table 1. Summary Statistics: Piece-Rate and Time-Rate Workers

Variable	Time Rate (n = 107)	Piece Rate (n = 177)
Male (%)	91.43	93.22
Born in Mexico (%)	77.14	89.83
Field Crops (%)	9.52	1.69
Grapes (%)	67.62	19.77
Nuts (%)	12.38	12.43
Citrus (%)	10.48	66.10
Age (years)	31.92	33.76
(standard deviation)	(10.55)	(12.58)
Daily Earnings ($)	34.95	37.63
(standard deviation)	(5.77)	(17.97)

Table 2. Estimated Earnings in Piece-Rate and Time-Rate Jobs

	Piece Rate (177 observations)		Time Rate (105 observations)	
	Coefficients	Asymptotic Standard Errors	Coefficients	Asymptotic Standard Errors
Intercept	7.26*	.37	7.60*	.42
Age	.043*	.017	.022*	.0094
Age^2	-.00056*	.00021	-.00028*	.00011
Education	-.0034	.029	.037*	.016
$Education^2$	.0016	.0025	-.0025	.0014
Male	-.057	.16	.014	.061
Born in Mexico	.033	.12	-.040	.064
Crops	-.20	.38	.057	.42
Grapes	-.14	.12	.065	.37
Nuts	.15	.10	.12	.23
ρ^2	.80*	.13	.016	[a]
Sigma	.44*	.033	.18*	.012
R^2	.21		.13	

[a] The Heckman t-test statistic on the Mills Ratio term is -0.073.

Note: A "*" indicates that the coefficient is statistically significantly different from zero at the 0.05 level.

Table 3. **Probit Equations for Piece-Rate Harvest Work**

	Coefficients	Asymptotic Standard Errors
Intercept	2.08	.78*
Age	-.099	.038*
Age^2	.0015	.00049*
Male	.30	.33
Born in Mexico	.19	.25
Time in location	-.013	.013
Earnings differential (B)	5.13	.70*

Number of observations = 282

Log of likelihood function = -149.92 (-186.17 with constant term only)

Maddala R^2 = .23

Cragg-Uhler R^2= .31

McFadden R^2 = .19 (unadjusted) and .18 (adjusted for degrees of freedom)

Chow R^2 = .27

Percentage of correct predictions = 79

Hensher-Johnson normalized success index = .25

Prediction Success Table

		Actual 0	Actual 1
	0	73	27
Predicted	1	32	150

Table 4. Ratio of Piece-Rate to Time-Rate Earnings, Conditional and Unconditional, by Age Cohort

Age Group	Number	Piece Rate (%)	Predicted probability (%)	Marginal Probability (%)	Unconditional B	Conditional B
16-25	86	63	62	68	-13.4	7.2
26-35	99	58	57	61	-12.0	7.5
36-45	56	66	63	66	-9.6	15.1
46-55	22	64	70	80	-11.4	11.3
56-65	15	80	85	94	-14.0	30.4
66-75	3	100	71	100	-42.1	-15.8
76-85	1	0	28	100	-70.6	-40.2
All	282	63	62	61	-12.6	10.0

Note: B is the ln(earnings) differential.

Table 5. Effect of the Unconditional Log Earnings Differential on the Probability of Working Piece Rate for Harvest Workers

Piece-Rate Earnings as a Percentage of Time-Rate Earnings	Probability of Working Piece Rate
50%	4.3
60	11.5
70	24.6
80	43.0
90	63.2
100	80.3
110	91.4
120	97.0
130	99.2
140	99.8
150	100.0

Figure 1

The Probability of Piece Work as a Function of Age