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Piece Rate Vs. Time Rate: The Effect of Incentives on Earnings
Author(s): Eric Seiler
Source: *The Review of Economics and Statistics*, Vol. 66, No. 3 (Aug., 1984), pp. 363-376
Published by: The MIT Press
Stable URL: http://www.jstor.org/stable/1924992
Accessed: 06-04-2018 10:30 UTC

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The Review *of* Economics *and* Statistics

VOL. LXVI | AUGUST 1984 | NUMBER 3

PIECE RATE VS. TIME RATE: THE EFFECT OF INCENTIVES ON EARNINGS

Eric Seiler*

Abstract—This paper examines the effect of piece rates on employee earnings and the impact of incentives on the earnings of over 100,000 employees in 500 firms within two industries. Two incentive effects are observed. First, incentive workers' earnings are more disperse than identical time workers' earnings within both firms and occupations. Second, incentive workers receive an earnings premium of 14%, in part to compensate for the greater variation in their income, and partially as a result of an incentive-effort effect.

THE existence of alternative methods of wage payment facilitates the study of the relationship between individual motivation, compensation, and productivity. Piece-rate and incentive wage payment plans are designed to induce additional employee effort, increase production and, as a result, compensation.

Previous studies[1] of incentive schemes provide relatively unambiguous evidence of wage premiums to piece-rate workers, often as high as 20%, and demonstrate productivity gains in incentive firms approaching 40%.[2] For instance, Pencavel (1977) found a 7% incentive wage premium in a study of 183 male punch-press operators in Chicago, controlling for schooling, experience, race, and union status. Additionally, the dispersion of wages, captured by the standard deviation of the natural log of hourly earnings, is significantly larger for incentive workers.[3]

The current study seeks to evaluate the incentive-earnings relationship on a much larger scale by studying the impact of incentives on the earnings of over 100,000 employees in 500 firms within two U.S. manufacturing industries.

The central thesis is that there is a significant relationship between incentive remuneration and the mean dispersion of individual earnings. Greater dispersion in incentive worker income is the result of fluctuations in individual output per hour while an incentive wage premium is partially a direct incentive-effort effect and partially a compensating differential for the risk of variation in income.

The paper is divided into four sections. Section I examines the extent of various incentive payment systems in the United States. Both the current extent of piecework and changes over time are reviewed. In section II, a model is constructed that isolates the special qualities of an incentive employment contract and analyzes the effects of incentives on remuneration. Section III examines these hypotheses within two "four digit" industries. Within certain data imposed limitations, the incentive-dispersion effect and the incentive wage premium are calculated. In section IV, the results are summarized and suggestions for future research are offered.

I. The Extent of Incentive Payment

An accurate assessment of the extent of incentive wage payments is difficult to make. The benchmark figure in most labor economics textbooks is that 30% of workers in manufacturing receive their basic wages, at least in part, in the form of piece-rate, bonus or commission earnings.[4]

Received for publication May 12, 1982. Revision accepted for publication November 3, 1983.

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I would like to thank Richard Freeman, Lawrence Summers, Bert Bernheim, David Ellwood, Darcy Bradbury, and David Yermack for their continued support and valuable suggestions. Additionally, many participants of the March 2, 1979 National Bureau of Economic Research Conference on Alternative Modes of Compensating Workers offered valuable contributions. Research for this project was funded in part by Grant No. 79-2-7 from the Alfred P. Sloan Foundation and in part by the NBER's research program in Labor Studies.

[1] See Marriott (1957), Mangum (1962), Bush (1974), Cox (1971), Pencavel (1977), and Kennedy (1945) among others.

[2] Mangum (1962), p. 84.

[3] σ in $W_i = .188$; σ in $W_t = .107$.

[4] This is based on 1945 B.L.S. surveys of 56 manufacturing

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Wholesale and retail trade have incentive[5] proportions of 5% and 10%, respectively. Few, if any, public employees or clerical workers are compensated on an incentive basis. Finally, the 1959 Census of Agriculture estimates that 23% of farm labor is compensated on the basis of incentive payment.[6]

The accuracy of these measures and comparability of statistics within broad industrial groups is suspect. A more disaggregate estimate of the extent of incentives is provided by the Bureau of Labor Statistics (B.L.S.) in the Industry Wage Surveys, which cover one-third of the 14.5 million production and related workers in the United States.

Table 1, column (1), presents a compilation of the percentage of incentive workers per industry gathered from 33 Industry Wage Surveys of the period 1972–1976. Overall, slightly more than 25% of the 4.5 million production workers are covered by some type of incentive system. One striking feature is the tremendous variation in the percentage of incentives between industries, even at the "two-digit" level. For example, the extent of incentives in meat-packing (18%) greatly exceeds that of prepared meat (6%); also pressed and blown glass (32%) has over twice as much incentive payment as glass containers (13%). In column (2), piece-rates are shown to be the most common form of incentive payment, rather than bonuses or commissions, especially in those industries that are over 50% incentive.[7]

A comparison of column (3) with column (1) demonstrates the almost universal decline in reliance on incentive compensation over a time period of 5 to 11 years, depending on the industry chosen. This decline is quantified in column (4) in terms of compound percentage change per year. Only two industries, footwear and basic iron and steel, have increases in the percentage of incentive workers. Because of the large size of basic iron and steel (over 400,000 production workers) this increase is sufficient to hold the average reduction in the reliance on incentives in all selected industries to 2% over the 10-year period. The increase in basic iron and steel is mostly due to the increased coverage of the basic collective bargaining agreement of the United Steelworkers of America (Bush, 1974, p. 75). Overall, the recent data indicate a steady decline in the extent of incentive compensation in U.S. manufacturing. While the data do not indicate the cause of the decline, the decrease may be due to a greater reliance on time methods in newer establishments, the closing of some older incentive establishments, and an actual change in the method of compensation for some workers (Cox, 1971, p. 53).

II. Theoretical Examination of the Effects of Incentive Payments on Earnings

Consider two classes of workers: incentive workers, whose earnings are dependent on individual output and time workers, whose earnings are solely a function of hours worked. While retention and promotion decisions and long-term salary profiles may depend on individual performance, the day-to-day hourly earnings of time workers are independent of their own output and effort. Furthermore time workers' incomes are insensitive to the vagaries of the production process and short-run fluctuations of demand.

The first hypothesis is that incentive workers exhibit greater variation in earnings as a result of variation in their effort and output. Formally, introduce a random variable θ, with mean equal to 1 and variance of σ_θ^2. This variable explicitly introduces factors beyond the control of a worker into the production function. Let e denote individual effort yielding a production function:

$$X = X(e, \theta). \tag{1}$$

With a multiplicative production specification, the wages of incentive workers and time workers are

$$W_{incentive} = P \cdot e \cdot \theta; \qquad W_{time} = T \tag{2}$$

where P is a linear piece-rate and T is the rate of compensation per hour. Since P and T are not measured in comparable units, some transformation of P, denoted $t(P)$ which is measured in dollars per item per hour, must exist such that competitive market forces yield $\overline{W} = \overline{t(P)} = \overline{T}$. A log normal earnings distribution yields the follow-

industries. Similar magnitudes were found in 8 non-manufacturing industries.

[5] Cox (1971), p. 54, proportion incentive.

[6] U.S. Commerce Department, Census of Agriculture, Volume II, 1959, p. 304.

[7] The major exception is basic iron and steel which employs group bonuses in addition to a guaranteed hourly additive.

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TABLE 1.—THE EXTENT OF INCENTIVE PAYMENT IN SELECTED U.S. MANUFACTURING INDUSTRIES

Industry	(1) % Incentive 1972–1976	(2) % Piece-rate Only 1972–1976	(3) % Incentive 1963–1968	(4) Compound Percentage Change per Year
Meat packing (1963–74)	18	4	30	−4.54
Prepared meat (1963–74)	6	3	8	−2.58
Flour (1967–72)	1	—	2	−12.94
Candy (1965–75)	11	5	25	−7.88
Cigars (1967–72)	45	45	57	−4.62
Synthetic & cotton textiles (1965–75)	28	28	31	−1.01
Wool textiles (1966–75)	21	14	23	−1.00
Textile dyeing (1965–76)	10	6	11	−0.86
Women's hosiery (1967–73)	62	62	70	−2.00
Men's hosiery (1967–73)	58	57	65	−1.88
Children's hosiery (1967–73)	65	65	70	−1.28
Men's & boys' suits & coats (1967–76)	73	71	74	−0.15
Men's & boys' shirts (1964–74)	75	72	81	−0.77
Work clothing (1968–72)	80	80	82	−0.62
Household furniture (1965–74)	17	7	18	−0.63
Corrugated boxes (1964–76)	25	6	36	−2.99
Paperboard containers (1964–70)	12	3.5	16	−4.68
Industrial chemicals (1965–71)	1	—	5	−23.53
Synthetic fibers (1966–76)	2	1	8	−12.94
Paints (1965–76)	0	0	1	—
Fertilizers (1966–71)	0.5	—	1	−12.94
Misc. Plastic (1964–74)	5	3	13	−9.11
Leather tanning (1968–73)	44	35	53	−3.65
Footwear (1968–75)	74	73	70	+0.82
Glass containers (1964–75)	13	1	38	−9.29
Pressed & blown glass (1964–75)	32	7	36	−1.06
Structural clay (1964–75)	22	16	28	−2.17
Basic iron & steel (1967–72)	79	—	66	+3.66
Iron & steel foundries (1967–73)	22	11	24	−1.44
Fabricated structural steel	8	3	—	—
Machinery–non electrical (1966–75)	12	5	17	−3.80
Motor vehicles (1963–73)	1	—	2	−6.70
Motor vehicle parts (1963–74)	27	16	31	−1.25

ing decomposition of variance in compensation:

$$\operatorname{var}(\ln W_i) - \operatorname{var}(\ln W_t) = \operatorname{var}(\ln\theta) + \operatorname{var}(\ln e) + 2\cdot\operatorname{cov}\{\ln(e)\ln(\theta)\}. \quad (3)$$

If the right-hand side of (3) is positive the variance of incentive workers' earnings will exceed that of time workers. While $\operatorname{var}(\ln(\theta)) \geq 0$, and $\operatorname{var}(\ln(e)) \geq 0$ the sign of the covariance term is ambiguous.

On one hand, it is possible that individuals adjust their effort systematically in an inverse relationship to fluctuations in risk. Thus $2\cdot\operatorname{cov}\{\ln(\theta)\ln(e)\}$ could offset any variance in earnings. This occurs when piece workers withhold effort, especially in periods of high potential output, to avoid a downward adjustment of the piece-rate.[8] Increased effort may also be employed to compensate for potentially low compensation in difficult periods. Often, peer pressure results in the withholding of effort to protect less productive employees. Conversely, peer pressure may operate to encourage employees who would normally shirk responsibility.

On the other hand, for many workers, effort decisions are independent of risk with 2 ·

[8] See Mangum (1962), p. 176; Kennedy (1945), p. 118 and section IV.

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$\text{cov}\{\ln(e)\ln(\theta)\} = 0$, and for some $2 \cdot \text{cov}\{\ln(e)\ln(\theta)\}$ is positive. The latter is true for individuals who work especially hard when the opportunity for gain per unit of effort is greatest. It is unlikely that intentional effort adjustments systematically compensate for variation due to risk for all incentive workers. Additionally, many effort decisions are reached a priori and could not be used to compensate for adverse states of nature. It is doubtful that the covariance between risk and effort compensates for both $\text{var}(\ln(e)) > 0$ and $\text{var}(\ln(\theta)) > 0$; thus $\text{var}(\ln w_i) > \text{var}(\ln w_t)$.

It should be noted that this analysis assumes that prospective employees can choose either compensation system, given their occupational choice. Obviously this is only true where employers have chosen to offer both systems of payment. It should not be assumed that employer payment system choice will vary solely with $\text{var}(\ln \theta)$. The choice of payment system depends on the employer's relative risk aversion, the technology of the industry, including the ability to accurately monitor output, and historical institutional factors.

The second hypothesis is that there exists a direct positive effect of incentive payments on the compensation of employees. Two separate factors lead to this conclusion. Under the assumption that workers are risk averse, $\text{var}(\ln W_i) > \text{var}(\ln W_t)$ implies that $w_i > w_t$. This is similar to a compensating differentials model where the unfavorable condition is the existence of risk. Employee risk aversion, even combined with a risk neutral employer implies a wage premium for a group characterized by greater variance in earnings.

The second factor is independent of the dispersion hypothesis and is the effect often attributed to incentive schemes. The pecuniary effect of incentive implies $e_i > e_t$ which would directly yield $w_i > w_t$, which can be formally[9] shown as follows: assume identical utility functions with constant relative risk aversion and constant elasticity of marginal utility of income. The expected utility for workers by method of wage payment can be defined as

$$E(U_i) = E\left\{(W_i)^a (e_m - e_i)^b (\sigma_\theta^2)^{-c}\right\}$$

and

$$E(U_t) = E\left\{(W_t)^a (e_m - e_t)^b\right\} \quad (4)$$

where e_m is the maximum bound on human effort and e_t is the numeraire. From (2) substitutes for W_i and W_t are obtained, yielding

$$E(U_i) = p^a E(\theta^a) e_i^a (e_m - e_i)^b (\sigma_\theta^2)^{-c}$$

and

$$E(U_t) = T^a (e_m - 1)^b. \quad (5)$$

Incentive workers will choose a level of effort that maximizes their expected utility. Setting $\partial E(U_i)/\partial e_i = 0$ in (5) yields $e_i = (a/(a+b)) \cdot e_m$.

The incentive wage premium is found by setting $E(U_i) = E(U_t)$ in (4). A logarithmic transformation with algebraic manipulation yields

$$\ln(W_i) - \ln(W_t) = (c/a)\ln(\sigma_\theta^2) + (b/a) \times \{\ln(e_m - 1) - \ln(e_m - e_i)\}. \quad (6)$$

It is easy to see the effect of effort on earnings. If $e_i > e_t$ then $e_i > 1$ and $(b/a)\{\ln(e_m - 1) - \ln(e_m - e_i)\} > 0$. Thus the partial effect of increased effort due to incentives is a positive earnings premium.

Finally, the model decomposes the incentive-earnings effect into its two expected components, a compensating differential for risk $(c/a) \cdot \ln(\sigma_\theta^2)$ and the effort effect.

III. The Effects of Incentive Payments on Employee Compensation

A. Description of the Data Set

Two separate Industry Wage survey data sets provided by the Bureau of Labor Statistics are used to investigate the hypotheses. The surveys chosen based on availability and the presence of a substantial incentive paid segment are (1) Footwear, April 1975, and (2) Men's and Boys' Suits and Coats, April 1976. Within each industry information is provided on an individual and firm-by-firm basis. For all production workers within the scope of the Bureau of Labor Statistics survey,[10]

[9] Of course, this is a simplified model which assumes all incentive systems to be homogeneous. Van Dusen Kennedy had isolated 25 major forms of incentive plans by 1945, including those with bonuses, minimum guarantees, and maximum ceilings. In each case, the wage specification in (2) must be altered to reflect the idiosyncracies of the specific plan.

[10] Summaries and tabulations of these studies are found in B.L.S., bulletins, 1946 and 1962, respectively. In each case, the Bureau studies over 70% of the eligible firms containing over

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data exist on individual hourly earnings, method of wage payment, sex, detailed occupation, and a numerical code for the firm.

The second segment of the data set includes characteristics that are common to all members of a given firm. Those used in this analysis include geographic region, community size, firm size, major product produced by the firm, method of production, proportion of supervisory personnel employed by the firm, and union status. A firm is considered to be unionized if labor-management contracts cover a majority of its production workers. Little distortion occurs here since in unionized firms, union contracts usually apply to all production workers (Freeman, 1980, p. 23). The type of incentive scheme, whether individual or group, is provided for each firm. In the two industries to be studied, almost every incentive-paid worker is compensated on the basis of individual piecework. Table 2 lists the means and standard deviations of the important variables in the analysis; in each industry, the information is provided for the entire sample and then for the incentive-paid workers and the time-paid workers separately.

In both industries, the great majority of workers are paid on an incentive basis. It is possible that the earnings effects of incentive payments operate differently in predominantly incentive industries as opposed to predominantly time-paid industries. If so, the generality of conclusions from this data must be limited.

The greatest strengths of this data set are the large number of observations and the detailed disaggregation of occupations. Since all analysis occurs within two specific industries, both four-digit industries under the Standard Industrial Classification coding system, the usual loss of information stemming from the blunt aggregation of records into two-digit industry dummies does not occur. Moreover, since the occupation classifications are industry specific they are far more detailed than is usually the case.

There are two important limitations in the data set. First, the traditional human capital and demographic variables such as schooling, experience,

80% of eligible workers. There is a sample selection bias favoring large firms. Controlling for the number of production workers per firm should help account for this bias.

TABLE 2.—SELECTED VARIABLE MEANS AND (STANDARD DEVIATIONS) FROM B.L.S. INDUSTRY WAGE SURVEYS: FOOTWEAR AND MEN'S & BOYS' SUITS & COATS

Variable	Footwear			Men's and Boy's Suits and Coats		
	Full	Incentive	Time	Full	Incentive	Time
(1) Proportion of Incentive Workers	0.74 (0.44)	—	—	0.82 (0.38)	—	—
(2) Number of Production Workers per Firm	428.0 (344.1)	423.2 (312.7)	431.0 (422.1)	652.0 (841.2)	675.9 (742.9)	444.2 (772.5)
(3) Proportion Male	0.33 (0.47)	0.29 (0.45)	0.43 (0.49)	0.21 (0.41)	0.16 (0.36)	0.42 (0.47)
(4) Proportion Unionized	0.47 (0.50)	0.49 (0.50)	0.40 (0.49)	0.80 (0.40)	0.81 (0.37)	0.73 (0.44)
(5) Proportion Urban[a]	0.41 (0.49)	0.37 (0.48)	0.52 (0.50)	0.76 (0.43)	0.76 (0.42)	0.76 (0.42)
(6) Proportion of Supervisory Personnel[b]	0.07 (0.04)	0.06 (0.04)	0.07 (0.04)	0.07 (0.05)	0.07 (0.04)	0.02 (0.15)
(7) Proportion of Workers Covered by Minimum and Maximum Rates of Compensation[c]	0.38 (0.49)	0.39 (0.49)	0.37 (0.48)	0.36 (0.48)	0.38 (0.49)	0.27 (0.44)
Number of Production Workers	79,425	58,691	20,734	42,252	34,651	7,601
Number of Firms		306			228	

[a]Urban is defined as falling within a standard metropolitan statistical area.
[b]Non-production, non-clerical employees.
[c]This variable is on a firm-by-firm basis.

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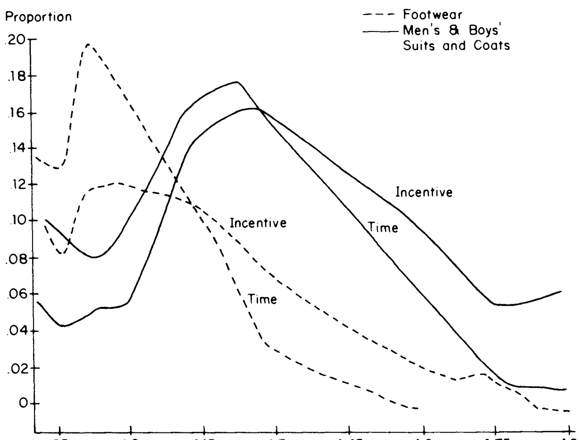
age and race are omitted. This makes it difficult to isolate the causation of earnings effects, as discussed below. Second, many employees are not covered by a detailed occupational group. Instead, they are lumped into a large diverse occupational group. This nonspecified group constitutes 61% of the sample in footwear and 23% in men's and boys' suits and coats. Subsequent analysis will be performed with and without inclusion of the unspecified occupational group. When the results are sensitive to this omission both will be reported.

B. *Initial Analysis of the Earnings Hypothesis*

The frequency distributions of log hourly earnings are plotted in figure 1. Dotted lines denote footwear, solid lines designate men's and boys' suits and coats. In both industries, the dual hypothesis is visually confirmed: the distributions of the wages of incentive groups are flatter, implying higher dispersion, and their means are higher. In footwear, these effects are quite pronounced, with the bulk of time-rated workers compensated within a more narrow and lower range. In men's and boys' suits and coats, the differences are much less noticeable as the incentive-paid workers exhibit only a slightly more disparate earnings profile than the time-compensated employees.

The substantial overlapping of the distributions supports the compensating differential segment of the earnings effect. If the two distributions were distinct, the hypothesis that $W_i > W_t$ in part to compensate for $\text{var}(W_i) > \text{var}(W_t)$ would be weakened. The overlap in the frequency distributions demonstrates that both the effort effect and the compensation effect could account for the incentive earnings effect.

FIGURE 1.—FREQUENCY DISTRIBUTIONS OF EARNINGS BY METHOD OF WAGE PAYMENT



While the comparison of means is relatively unambiguous, quantitative comparison of dispersion requires the choice of an appropriate metric to describe inequality. Several statistics can be used to analyze the extent of income inequality.[11] These include the coefficient of variation in earnings, the Gini coefficient, the standard deviation of the logarithm of earnings, and earnings' quartiles. Each of these statistics weights variance differently depending on its location in the distribution. In this work, the standard deviation of the natural log of earnings is used. Since the standard deviation of the natural logarithm weights differences in the lower end of the income distribution more heavily than those in the upper end, it is likely to underestimate the inequality between incentive and time compensation. This is due to minimum wage laws and to minimum guarantees present in many incentive wage plans, which decrease dispersion in the lower end of the distribution.

Table 3 supports the visual results found in figure 1. First, in terms of dispersion, $\text{var}(W_i) > \text{var}(W_t)$ in both industries. The differences in the standard deviation of log earnings are 0.72 and 0.22 in footwear and men's and boys' suits and coats. The greater difference in footwear is consistent with the graphical analysis.

The differences in mean log earnings for the two industries are 0.122 and 0.141, respectively. These differences approximate the percentage incentive earnings premium in each sample. Additionally, the differences in dollar/hour earnings are 0.41 and 0.57, respectively, certainly a meaningful differential in compensation. In footwear, for example, the difference in favor of incentive workers is \$16.00 per week and over \$800.00 per year. Thus, at the aggregate level the data confirm the theoretical hypothesis of section II.

C. *Analyzing the Incentive Effect—Specification Issues and Selection Bias*

The central methodological problem is isolating the observed dispersion and earnings effects directly due to the method of wage payment from

[11] See Atkinson (1970) and a discussion by Freeman (1980).

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TABLE 3.—COMPARISON OF MEAN AND STANDARD DEVIATION OF LN HOURLY EARNINGS AMONG PRODUCTION WORKERS BY INDUSTRY

	Footwear			Men's & Boys' Suits & Coats		
	Observations	Mean ln Earnings	Standard Deviation ln Earnings	Observations	Mean ln Earnings	Standard Deviation ln Earnings
1. Incentive	58,691	1.096	0.272	34,651	1.369	0.304
2. Time	20,734	0.974	0.200	7,601	1.228	0.282
3. Differences		0.122	0.072		0.141	0.022
4. t-ratio for means		68.31[a]	—		38.91[a]	—
5. F-ratio for standard deviation		—	1.85[a]		—	1.16[a]

Source: B.L.S. Industry Wage Surveys.
[a] Significant at the 1% level.

those due to other factors related to payment systems.

Omitted factor bias is a potential problem in the B.L.S. data since most human capital variables are absent. These include age, education, experience, job tenure, and race. The magnitude of the bias depends on the correlation between incentive payment and the missing factors and on the relative importance of the missing factors in explaining wage differentials. In the Pencavel study, the inclusion of schooling, experience, job tenure, race, and union status in the regression analysis reduced the gross piece rate wage premium of 8.8% to a controlled effect of 7%, a relatively small reduction. A similar reduction in the Industry Wage Survey sample still would yield incentive earnings effects of 9.7% and 11.2% in footwear and men's clothing, instead of the observed 12.2% and 14.1% earnings' premiums.

Self-selection bias on the part of the firm and/or the individual is also a potential problem. This bias could affect the hypothesis by systematically varying the distribution of an omitted explanatory variable between the two wage payment systems, or it could operate by changing the risk aversion or effort level mix between the two groups.

First, consider the selection bias on the part of the firm. It is unlikely that a firm would want to hire a highly motivated or unusually able individual on an incentive basis. Since such an individual's productivity is high without incentives, the firm would unnecessarily reward the high production on a piece-rate basis that it would costlessly enjoy on a time-rate basis. Thus, it is difficult to explain the incentive-earnings effect with the argument that firms merely choose "better" workers for employment on an incentive basis.

The firm may contribute to the greater dispersion of earnings among piece-rate employees through its selection process. When a risk-averse firm is unsure of an individual's actual productive capacity, it is more likely to hire that individual on an incentive basis. This is the converse of the risk-spreading argument employed in the basic model. It is therefore possible that the observed difference in dispersion is due to the selection, by the firm, of individuals with a more diverse productivity capacity.

Selection bias on the part of the individual poses difficult problems as well. An individual who is inherently hard-working is better off under an incentive scheme even though the incentive has little or no effect on his productivity. The empirical significance of individual self-selection will be examined by comparing the incentive earnings effect at different levels of aggregation. Some support for a self-selection hypothesis would exist if the incentive-earnings effect falls as aggregation decreases. Hard-working individuals will seek out industries, occupations, firms and, finally, specific tasks within a firm, which reward their excess effort. Successive dummy controls should pick up an increasing share of the incentive-earnings effect if the self-selection view is valid.

It is reasonable to assume that both self-selection and incentive-earnings effects occur simultaneously for many individuals. Inherently hard-working individuals who choose work partially on the basis of the form of remuneration are likely to feel a pecuniary incentive effect and ad-

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just their efforts accordingly. It would be unrealistic to assume that the bulk of an observed incentive-earnings effect was the function of self-selection on the part of the individuals.

Individual self-selection is unlikely to be a major factor in increasing the dispersion of incentive workers' wages. Individuals with low or variable expected productivity are more likely to prefer time payment, all else equal. Therefore, while self-selection on the part of individuals might explain a higher mean earnings for incentive workers, it is unlikely to explain a distribution that has a greater variance.

The final specification issue concerns the appropriateness of cross-section earnings dispersion as the proxy for the relative riskiness of different jobs. The true measure of individual earnings variation is more accurately captured by the average time series dispersion across individuals. The lack of time series data precludes the use of such a specification in this study. The proxy that is used, cross-section dispersion, is a function of individual time series dispersion, the dispersion in individual ability and the covariance between these two types of variation. An argument in favor of the cross-section proxy is that the relevant compensating differential is that faced by the marginal worker. Consider a new employee unsure of how his own abilities will interact with the production process of the firm. Furthermore, he does not know if he will have competent supervision or materials that are easy to work with. For such an employee the perceived risk is well proxied by the existing dispersion of earnings in the firm. Finally, since new employees are more likely to have relatively short planning horizons, critiques of this proxy based on a permanent income view are less worrisome.

D. *Regression Analysis of Dispersion*

Multiple regression analysis separates the variance in log earnings explained by the measured characteristics from the variation due to the residual. Variance can be created between the effects of the measured characteristics in two ways. First, if incentive workers had different characteristics than time workers, the variance and covariance of the characteristics would vary between the two samples which could result in different variances for W_i and W_t. Secondly, incentive systems could alter the effect that the measured characteristics have on the earnings of workers, thus affecting the variance. Additionally, incentive payments could alter the variance due to the residual. A complete exposition of the following method of dispersion analysis is presented by Freeman (1980) and is partially outlined here. Initially, separate earnings equations are estimated in the form:

$$\ln W^i = \hat{a}^i + \sum_T \hat{b}_j^i X_j^i + \hat{e}^i \quad (7)$$

$$\ln W^t = \hat{a}^t + \sum_T \hat{b}_j^t X_j^t + \hat{e}^t \quad (8)$$

where X_j is the j^{th} measured determinant of earnings with coefficient $\hat{b}_j$. Let i and t act as superscripts for the incentive and time sectors, respectively. If the variance in earnings stems from the greater risk borne by incentive workers, as this hypothesis asserts, most of the differential variation should be found in the residual.

Table 4 presents the results for both industries. The first two columns list the mean and standard deviations of the explanatory variables for incentive and time workers for each industry. The dependent variable in each case is the log of hourly earnings. As expected, most of the difference in dispersion is found in the residual as measured by the standard error of estimate.

It is then possible to examine whether the difference in dispersion is due to heterogeneity by estimating the variance that would exist if incentive workers had the characteristics of time workers, and conversely. This can be done by substituting the variance/covariance of the X's of one group for those of the other. Formally, the difference in variation of earnings due to the difference in the characteristics of the samples is shown by

$$\sum_j (\hat{b}_j)^2 \left(\sigma^2(X_j^i) - \sigma^2(X_j^t)\right) + \sum_j \sum_k \hat{b}_j \hat{b}_k \sigma\left(X_j^i X_k^i\right) - \sigma\left(X_j^t X_k^t\right) \quad (9)$$

with the $\hat{b}$'s taken consistently from either (7) or (8).

These calculations are presented in table 5. Line 1 repeats the observed difference in variation found in table 3. Line 2a provides $(\sigma W_i - \sigma W_t)$ with incentive characteristics, while line 2b provides the same differential assuming the workers exhibit the time characteristics. The results are quite signifi-

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TABLE 4.—REGRESSION ESTIMATES OF THE IMPACT OF INDIVIDUAL CHARACTERISTICS ON LN HOURLY EARNINGS AND THE STANDARD ERROR ESTIMATES AMONG PRODUCTION WORKERS BY METHOD OF PAYMENT

	Footwear				Men's and Boys' Suits and Coats			
	Mean + Standard Deviation		Dependent Variable Log Hourly Earnings		Mean + Standard Deviation		Dependent Variable Log Hourly Earnings	
Explanatory Variables	Incentive	Time	Incentive	Time	Incentive	Time	Incentive	Time
1. Male	0.29	0.43	0.113	0.105	0.16	0.43	0.190	0.166
	(0.45)	(0.49)	(0.03)	(0.002)	(0.36)	(0.49)	(0.005)	(0.006)
2. Union	0.49	0.40	0.042	0.068	0.81	0.74	0.204	0.163
	(0.50)	(0.49)	(0.003)	(0.003)	(0.37)	(0.44)	(0.004)	(0.009)
3. Size of Firm	5.83	5.73	0.017	0.043	6.12	5.41	0.036	0.004
(Log)	(0.66)	(0.82)	(0.002)	(0.002)	(0.89)	(1.19)	(0.002)	(0.004)
4. Proportion of	0.06	0.07	0.491	0.773	0.07	0.08	0.576	0.595
Supervisors in Firm	(0.04)	(0.04)	(0.026)	(0.029)	(0.04)	(0.06)	(0.038)	(0.057)
5. Urban	0.37	0.52	0.061	0.004	0.76	0.76	0.026	0.080
	(0.48)	(0.50)	(0.003)	(0.003)	(0.42)	(0.43)	(0.004)	(0.009)
6. Occupational, Region, Product Dummies			40				35	
R^2			0.230	0.292			0.337	0.401
SEE			0.239	0.169			0.248	0.220

cant. In footwear, the difference in $(\sigma W_i - \sigma W_t)$ drops slightly from that observed in the aggregate (0.072) to either 0.066 or 0.063. In men's clothing, $(\sigma W_i - \sigma W_t)$ rises from an observed 0.022 to either 0.042 or 0.044 after adjustments. In both industries the differences remain substantially the same. Most interesting is that the greater dispersion in the characteristics of time workers was actually masking the incentive dispersion effect in the men's clothing industry.

After controlling for heterogeneity, it is possible to examine whether the incentive effect operates through the measured characteristics or the residual. The magnitude of the incentive effect on variation caused by measured characteristics, controlling for differences in the variance/covariance of the characteristics of the two samples, is found by comparing the variation in earnings explained by the incentive wage equation with incentive characteristics to the variation in earnings explained by the time equation with incentive characteristics, as reported in line 3a. The difference in the standard deviation of log earnings is 0.013 in footwear and 0.038 in men's clothing. Line 3b presents the differences using time characteristics 0.001 and 0.029, respectively. In both industries, the estimated difference due to a difference in the effect of the regression coefficients is larger for the

TABLE 5.—ANALYSIS OF THE EFFECT OF DIFFERENT CHARACTERISTICS ON THE DIFFERENCE IN THE STANDARD DEVIATION OF THE LN OF HOURLY EARNINGS BETWEEN INCENTIVE AND TIME WORKERS

	Footwear	Men's and Boys' Clothing
1. Initial Difference in Standard Deviation	.072	.022
2. Difference after Correcting for Different Characteristics		
(a) Using Incentive Wage Equation	.066	.044
(b) Using Time Wage Equation	.063	.042
3. Difference Due to Different Equations		
(a) Incentive Characteristics as Weights	.013	.038
(b) Time Characteristics as Weights	.001	.029
4. Difference Due to Different Residuals	.070	.028

Notes: line 1: See table 3.
line 2: From equation (9).
line 3a: $\Sigma_j(\hat{b}^i)^2\sigma^2(X_j^i) + \Sigma_j\Sigma_k\hat{b}_j^i\hat{b}_k^i\sigma(X_j^iX_k^i) - [\Sigma_j(\hat{b}^t)^2\sigma^2(X_j^i) + \Sigma_j\Sigma_k\hat{b}_j^t\hat{b}_k^t(X_j^iX_k^i)]$.
line 3b: Substitute t for i and i for t in line 3a.
line 4: See table 4.

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incentive characteristics. Overall, these results demonstrate that incentives operate to increase dispersion by augmenting the coefficients of the measured characteristics.

Finally, line 4 isolates the effect of incentives on the residual. In footwear, the impact through the residual dwarfs the effect through measured characteristics, while in men's and boys' clothing they are evenly split. This suggests that the cause of the incentive dispersion effect varies between industries.

E. *Regression Analysis of the Earnings Effect*

In this section a standard earnings function is estimated with the addition of an incentive variable to capture the effect of incentives on earnings.

Let I be a dichotomous variable indicating the existence of incentive payment with coefficient $\hat{b}_1$. Let X_j denote the j^{th} determinant of log earnings (W), with coefficient $\hat{b}_j$, $j = 2, j$, with residual $\hat{e}$. This yields a simple regression equation:

$$\ln W = \hat{a} + b_1 I + \sum_j \hat{b}_j X_j + \hat{e}. \tag{10}$$

Table 6 presents the regression analysis of this equation for footwear and men's and boys' suits and coats. Control variables are employed similar to those used in the preceding analysis of dispersion. For footwear, two separate equations are reported due to the large size of the undifferentiated occupational category. Thus, column (1A) reports regression results for the entire sample, while column (1B) includes only those workers who are in the detailed occupational categories.

The results are as expected, demonstrating a strong incentive earnings effect even with extensive regional, occupational, and production dummy control variables. In the entire sample of footwear production workers, the incentive earnings effect is 14.1%. Within men's and boys' suits and coats, the effect is 15.6%. Both effects are statistically significant. On the whole, the results are insensitive to changes in the specification of dummy control groups, including the deletion of the undifferentiated occupational group as shown in column (1B). As might be expected, the R^2 increases from 0.257 to 0.311, since the sample no longer contains a large, diverse, occupational group. The incentive coefficient in the reduced footwear sample rises to 0.171. This refutes the argument that the incentive

TABLE 6.—REGRESSION ESTIMATES OF THE EFFECT OF INCENTIVE PAYMENTS ON LOG HOURLY EARNINGS

Explanatory Variables	Coefficients (standard errors) and Number of Dummies		
	Footwear		Men's and Boys' Suits and Coats
	(1A)	(1B)[a]	(2)
1. Incentive	.132(.002)	.171(.005)	.145(.003)
2. Union	.047(.002)	.058(.003)	.195(.004)
3. Male	.118(.002)	.134(.004)	.188(.004)
4. Ln (Size)	.027(.001)	.006(.002)	.030(.002)
5. SMSA	.046(.002)	.042(.003)	.027(.004)
6. Proportion of Supervisors	.581(.021)	.348(.034)	.614(.031)
7. Proportion Covered by Minimum and Maximum Rates	.002(.002)	−.004(.005)	.009(.003)
8. Proportion of Men per Firm	.027(.008)	.033(.013)	—
9. Regions	3	3	3
10. Occupations	24	23	24
11. Major Product	13	13	7
12. Method of Production	—	—	4
13. N (Observations)	79,425	30,891	42,252
14. Dependent Variable Log Earnings Mean (S.D.)	1.06(.261)	1.11(.279)	1.34(.305)
15. R^2	.257	.311	.355
16. SEE	.225	.232	.245

[a](1B) excludes all workers not employed in a selected occupation as determined by the B.L.S.

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effect is correlated with omitted occupational dummies in equation 1A.

Overall, these regressions[12] show that $W_i > W_t$ by nearly 14% in both industries. The belief in the incentive effect would be strengthened if it were larger for those tasks where effort is likely to have a larger effect on output and thus earnings. Therefore, all else equal, it is expected that those occupations that require skill, especially in the form of speed, and those that are not machine paced, are more likely to contain an incentive effect of large magnitude.

This hypothesis is examined by interacting incentive wage payment with occupational categories. Let $\hat{c}_k$ be the coefficient for the k^{th} occupational group and $\hat{d}_k$ be the coefficient of the interaction between incentives and the k^{th} occupation; (10) becomes

$$\ln W = \hat{a} + \hat{b}_1 I + \sum_k \hat{c}_k O_k + \sum_k \hat{d}_k O_k I + \sum_j \hat{b}_j X_j + \hat{e}. \tag{11}$$

The incentive-earnings effect in occupation k is equal to $(\hat{b}_1 + \hat{d}_k)$. Table 7 ranks the occupations of each industry on this basis. In both industries, it appears that the incentive-earnings effect is greatest in those occupations where effort should matter the most.

In footwear, those occupations involving greater skill and relying on manual as opposed to machine labor, enjoy the largest incentive effects. For example, edge setters and trimmers who exhibit a 31% differential are primarily engaged in "shaping and polishing the edge of the sole of the shoe by

[12] Equation (10) uses ln hourly earnings for the individual earnings analysis. Data on fringe benefits exist for each firm, and a ln total compensation variable was constructed for inter-firm analysis. The incentive effect is 0.163 in footwear and 0.135 in clothing, for total compensation.

TABLE 7.—DECOMPOSITION OF INCENTIVE EFFECTS BY OCCUPATIONAL CATEGORIES

Footwear		Men's and Boys' Suits and Coats	
Occupation	% Incentive-Earnings Effect	Occupation	% Incentive-Earnings Effect
1. Edge trimmers and setters	31%	1. Packers	40%
2. Treers	30	2. Underpressers	32
3. Sewers (hand)	29	3. Pressers	32
4. Assemblers for pullover	27	4. Stock clerks	31
5. Cutters whole shoe (hand)	26	5. Sewers, hand	28
6. Repairers	23	6. Basters and collar setters (hand)	26
7. Cutters whole shoe (machine)	23	7. Fitters	25
8. Cutters lining (machine)	21	8. Janitors	25
9. Shankers, vulcanizers sole attachers	21	9. Thread trimmers and basting pullers	19
10. Inseamers, jointers	20	10. Sewing machine operators, coats	16
11. Pulling and lasting machines	18	11. Cutters and markers	16
12. Bottom scourers	18	12. Shapers	13
13. Roughers and rounders	16	13. Sewing machine operators, trousers	12
14. Pasters and skivers	15	14. Work distributors	12
15. Stitchers	13	15. Non-classified	12
16. Thread lasters	13	16. Finishers, hand	12
17. Top stitchers and vampers	13	17. Spreaders	11
18. Heel, seat and toe lasters	13	18. Inspectors	11
19. Sliplast stitchers	13	19. Pairers and turners	11
20. Fancy Stitchers	13	20. Cutters, lining	10
21. Non-classified	13	21. Cutters, cloth	8
22. Heel seat attachers	9	22. Buttonhole and button sewers, hand	8
23. Floor boys, janitors, inspectors, mechanics	9	23. Markers	6
24. Bed machine operators	5	24. Repairman	5
25. Platform cover lasters	−3	25. Tailors	4

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holding it against the hot iron of the edge setting machine."[13] Treers (30%) "clean and finish shoes by removing spots and discolorations and rub uppers with hot irons to smooth wrinkles." Whole shoe cutters, hand (26%), "cut vamps and uppers of shoes from skins or hides with a hand knife."

Those occupations with little incentive differential include heel seat attachers-machine (9%), who "operate a machine to cut out a piece around the outer margin of the heel seat; and nail heels to shoes by machine." Platform cover lasters actually have a negative incentive effect (−3%) for a task consisting of operating a machine to smooth platform covers or wrappers around the platform.

In men's and boys' suits and coats the ranking of the incentive differential yields similar observations. Packers (40%) "place finished garments in shipping containers and seal the containers." Pressers (32%) "perform the final pressing operations by means of hand pressing irons or pressing machines." A sewer, hand (28%), "performs various finishing sewing operations by hand such as stitching edges." There are some exceptions. Janitors, for example, have a relatively large incentive premium (25%) in clothing, though they command only 9% in footwear.

So far the analysis of the incentive earnings effect has controlled for diverse individual and occupational characteristics. A further question can be examined: does the incentive effect operate on individuals, or are certain firms, those predominantly utilizing incentive payments, more likely to remunerate at a higher level?

Let f_k represent the coefficient on the k^{th} firm F. Equation (10) would then resemble:

$$\ln(W) = \hat{a} + \hat{b}_1 I + \sum_j \hat{b}_j X_j + \sum_k \hat{f}_k F + \hat{e}. \quad (12)$$

To avoid the expense of including over 200 firm dummies in the regression estimation, an alternative specification is employed to yield an unbiased estimate of b_1 controlling for the firm effects. The technique consists of subtracting from each individual variable the mean of the firm for that variable:

$$\ln(w_i - \overline{w}) = \hat{a} + \hat{b}_1(I_i - \bar{I}) + \sum_j \hat{b}_j(X_i - \overline{X}) + \hat{e}. \quad (13)$$

In footwear, the coefficient for intra-firm incentive payments is 0.120 (0.003) which closely compares to the coefficient of 0.132 found in the regression results of table 6. For men's clothing, the intra-firm effect is 0.110 (0.004) while the preliminary least squares coefficient is 0.146. Therefore, the magnitude of the incentive-earnings effect is still substantial, even controlling for firm effects.

F. Decomposition of the Incentive-Earnings Effect

The model in section II decomposes the incentive-earnings effect into two parts: a compensating differential due to risk and an effort effect where

$$\ln(W_i) - \ln(W_t) = (c/a)\ln(\sigma_\theta^2) + (b/a) \times \{\ln(e_m - 1) - \ln(e_m - e_i)\}. \quad (14)$$

The decomposition of the earnings premium relies on the use of within-firm variance in earnings as a proxy for the true σ_θ^2 faced by individuals.

Further, in an effort to control for the variance in occupation and ability, etc., that exists within firms, $\ln(\sigma_i^2) - \ln(\sigma_t^2)$ is employed as a proxy for the variance due to risk alone. Thus, to test the effect of risk on earnings, the mean earnings premium for each firm is regressed on the difference in variance for that firm:

$$E(\ln W_i - \ln W_t) = \hat{a} + \hat{b}\left(\ln(\sigma_i^2) - \ln(\sigma_t^2)\right) + \hat{e}. \quad (15)$$

In footwear, only 3.3% of the incentive earnings premium is a result of the greater variance in earnings, while 6.0% of the premium in clothing is explained by the compensating differential hypothesis. In both industries the coefficient of the variance term was significant with the expected sign. The failure of the compensating differential hypothesis to explain a large share of the earnings premium supports a view that much of the premium is due to increased effort by incentive workers. Such a view should be tempered with an understanding that other factors, unrelated to effort, are also captured by the residual.

In each industry, (15) was tested separately for each of 11 occupation subgroups, as shown in table 8. The results are largely consistent with the industry-wide estimations.[14] The major exception is that, in both industries, the premium due to risk ranged from 25% to 50% in some occupational categories. It is possible that the true compensa-

[13] B.L.S. job descriptions are excerpted.

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TABLE 8.—REGRESSION ESTIMATES OF EFFECTS OF EARNINGS VARIATION ON MEAN EARNINGS

	Footwear	Men's and Boys' Suits and Coats
Total Occupations	11	11
$\hat{b} > 0$	11 (7[a])	10 (6[a])
$\hat{b} < 0$	0	1 (0[a])
$0 < \bar{R}^2 \leq 0.1$	7	9
$0.1 < \bar{R}^2 < 0.3$	1	0
$0.3 < \bar{R}^2$	3	2

[a]Significant at the 5% level.

tion due to risk is better captured at decreasing levels of aggregation.

The dominance of the effort earnings hypothesis is consistent with a view that the primary difference between time and incentive payment is the motivational force of incentives which dominates the compensation due to the disutility of risk. Two factors may have reduced the observed compensating differential. First, many firms provide minimum wage guarantees[15] to their employees in both industries. Additionally, the minimum wage laws create a floor for many footwear employees. The impact is a reduction in risk to the worker with a concomitant reduction in compensation for such risk. Second, the inadequacy of cross-section data in capturing variation due to risk may result in the bulk of the differential being found in the residual.

IV. Conclusions and Future Implications

The preceding empirical analysis of two "four-digit" manufacturing industries confirms the theoretical hypothesis that incentive workers experience higher, more dispersed earnings than time workers. The greater dispersion of incentive earnings is observed controlling for heterogeneity in the labor force between the two sectors. A positive incentive-earnings effect of approximately 14% exists both within and between firms, controlling for detailed occupational categories. It is suggested that the incentive-earnings effect is in part a compensating differential for the greater risk borne by piece-rate workers and is in part a pure effort effect.

Since 25% of manufacturing employees receive some form of incentive compensation, the strong incentive-earnings effect suggests that method of wage payment should be included in analyses of earnings whenever possible. Studies of sex and race discrimination as well as the analysis of the union earnings effect could make use of this additional structural parameter.

Ultimately, the greatest potential for incentive data is in the study of determinants of productivity. By its very nature, incentive earnings information yields a measure of individual output. An ideal data set would include both the individual's hourly earnings and a description of his piece-rate or bonus plan. With this information, individual productivity could be compared and analyzed without complete reliance on the qualitative evaluations of supervisory personnel.

[14] A further test of the compensatory differential hypothesis consists of regressing $\ln W_i$ on $\ln \sigma_{ei}^2$ without standardizing for W_i or σ_i^2. In both industries, the coefficient on σ_i^2 is positive and significant in every occupational category.

[15] This information is based on discussions with employers and union officials.

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APPENDIX A

Major Products and Methods of Production	Code
Footwear—Major Products	
Men's Goodyear-welt dress shoes	1
Men's Goodyear-welt work shoes	2
Men's cement-process shoes	3
Women's cement-process, conventional-lasted shoes	4
Women's cement-process, slip-lasted shoes	5
Women's Goodyear-welt shoes	6
Women's Littleway shoes	7
Misses' and Children's cement process, conventional lasted	8
Misses' and Children's Goodyear-welt shoes	9
Misses', Children's and infants' stitchdown shoes	10
Leather footwear with vulcanized sole	11
Leather footwear with injection molded sole	12
Moccasins	13
Other	14
Men's and Boys' Suits and Coats—Major Products	
Men's Suits	1
Men's Separate Tailored Coats	2
Men's Overcoats	3
Boy's Suits	4
Boy's Separate Tailored Coats	5
Boy's Overcoats	6
Uniforms (non-athletic)	7
Suit Vests	8
Other	9
Men's and Boys' Suits and Coats—Method of Production	
Regular shop	1
Regular shop, cutting done elsewhere	2
Regular shop, sewing done elsewhere	3
Cutting shop	4
Contract shop	5

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