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THE DETERMINANTS OF EMPLOYEE PRODUCTIVITY AND EARNINGS: SOME NEW EVIDENCE

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ABSTRACT

This paper uses data from a nationwide sample of firms on employee wages and characteristics to reexamine the determinants of employee productivity and earnings. The data include several measures of job experience, training, and both worker and firm characteristics as well as subjective employer productivity ratings and earnings of workers. Given observations on the same individual at different points in time, we can consider both levels and changes in earnings and productivity, with various firm- and job-specific effects eliminated from the latter.

The results show that: 1) Both previous experience and tenure in the current job have significant, positive effects on wages and productivity. Previous experience effects are found primarily on levels of wages and productivity while tenure affects occur for both current levels and changes. 2) Hours of training are positively related to productivity and wage growth but generally not to levels of either. 3) Among demographic characteristics, we find productivity growth and current productivity levels to be slightly higher for females while their wages are significantly lower. Other determinants of earnings and productivity ratings (e.g., such as various types of incentive pay and the fraction unionized) are considered here as well.

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I. Introduction

In recent years, a series of studies have been done which empirically examine the determinants of (as well as the relationship between) worker productivity and earnings. Several strands have appeared within this literature. For instance, Medoff and Abraham (1980, 1981) have challenged the traditional "human capital" interpretation of the experience-earnings effect (i.e., that experience raises wages because it enhances productivity), using performance ratings of professional and managerial employees from the files of two large companies.[1] In fact, they find no positive effects of experience on within-grade performance. But using different data, other authors (e.g., Brown (1983), Maranto and Rodgers (1984)) have found more positive effects of experience.[2]

More generally, the links between productivity and earnings and/or the determinants of each have been examined by others as well (e.g., Frank (1984), Klein et. al. (1987), Weiss (1988)).[3] The effects of pay incentives on worker output and earnings have also received attention, (e.g., Seiler (1984), Lazear (1986), Weiss (1987), Brown (1987)), though we have seen little direct evidence on output effects of incentives.[4]

One reason for some of the conflicting results in the papers cited above is that almost every one is based on a unique sample of workers, making results from each very difficult to generalize. Of course, this primarily reflects the fact that measures of employee productivity are generally not available for most employees and, when available, they are generally quite specific to a given set of workers.

In this paper, I use data from a nationwide survey of firms on employee wages, characteristics and performance to reexamine the determinants of productivity and earnings. The data are from the Employment Opportunity Pilot

Project (EOPP) Survey of Firms in 1980 and 1982.[5] This survey of about 3400 firms (in 1982) includes a lengthy set of questions on the wages and characteristics of the last worker hired by each firm. In particular, one set of questions gauges subjective employer productivity scores (on a 0-100 scale) at different points in time for this most recent employee. These scores will be used as our measures of employee performance. In this study I consider the determinants of both productivity and wages between and within firms.

We will present estimates of wage equations in which a variety of experience measures (for both past experience and tenure on the current job) as well as productivity scores are used as explanatory variables. To deal with the problem firm-specific factors in the subjective productivity measures, we estimate some wage-change equations using data for different points in time on each worker. We also estimate productivity score equations (in both levels and changes) to measure the extent to which determinants of wages and of productivity are the same. Other factors which presumably influence both wages and productivity, such as hours spent in training and the presence of pay incentive schemes, also will be considered, as will be a variety of demographic and firm-level characteristics. By estimating wage and productivity equations in both levels and changes and as functions of a broad range of determinants, this paper will build on previous work by John Barron, John Bishop and others which considered some of these same issues.[6]

The results of this paper can be briefly summarized here. We find that both previous experience and tenure have significant positive effects on wages and productivity. The previous experience effects are mostly observed on levels of wages and productivity, and are strongest for experience that has some application to the current job. The effects of job tenure, on the other hand, can be seen on both current levels and changes of wages and

productivity. We also find hours of training to be positively related to both wage and productivity growth but generally not to levels of either. Finally, we find perceived productivity growth (as well as current productivity levels) to be a bit higher for female than for male employees even though their wages are significantly lower. The effects of pay incentive schemes and various firm characteristics (such as unionism) are noted as well.

The rest of the paper is laid out as follows: Section II describes the data and equations estimated in greater detail, while Section III presents the results of estimated wage and productivity equations. Section IV contains the conclusion and implications of this work.

II. Data and Equations

The EOPP Survey of firms in 1980 and 1982 was administered in 28 local areas that were sites for the EOPP experiments in the late 1970's. The sites are heavily concentrated in the South and mid-West, and about half are SMSA's. Large and/or low-wage firms were oversampled within each site.

The 1982 survey, which we use below, asked two general types of questions of employers: one type covering firm-wide characteristics (e.g., number of employees, fraction unionized, number of vacancies, etc.) and the other covering the last worker hired during or before the previous year.[7] Among the latter questions in the 1982 Survey were the occupation, sex, age and years of education of the worker, as well as his or her wages - both starting and current (or most recent if the employee was no longer with the firm). If some sort of incentive scheme was used as part of the pay package, the type of scheme (e.g., commission, tips, piece rate, etc.) was noted as well.

In addition, employers were asked to score that employee's productivity on a scale from 0 to 100, where the former would reflect no productivity and the latter the maximum feasible output on the job. The question was asked for different points in the employee's tenure at the firm: the first two weeks, the third through twelfth weeks, and currently/most recently. Separate questions were asked for "typical" employees on the same job so that relative comparisons could be made within the firm.

A few different measures of employee experience are also available in these data. One question asked how many months of previous experience the employee had that has some application to the current job. Presumably, this question gauges occupation and/or industry-specific experience. From the question on the employee's age and years of education, we can also calculate a standard measure of total labor market experience (i.e., age minus years of education minus 6). Finally, tenure within the firm was specifically asked from those employees who were no longer with the firm. For those still present, tenure can be calculated from the date of hiring and the survey date.

In addition to the tenure measures, several questions were asked about the amount of time explicitly invested in training by the new employee. Total hours of formal and informal training provided by management, supervisors, or trained personnel as well as informal training provided by co-workers are the ones used below.

With all of these data, we are able to estimate equations of the following form:

$$1) \quad \ln (W^s_{ij}),\ PS^s_{ij} = a_s + b\tilde{X}_{ij} + c_s\tilde{X}^2_{ij} + d_sY_{ij} + f_s\tilde{Z}_j + \varepsilon^s_{ij}$$

$$2) \quad \ln (W^c_{ij}),\ PS^c_{ij} = a_c + b_c\tilde{X}'_{ij} + c_c\hat{X}'^2_{ij}\ d_cY_{ij} + f_c\tilde{Z}_j + \varepsilon^c_{ij}$$

where W^s_{ij} and W^c_{ij} are starting and current (or most recent) wages of employee i at firm j; PS^s_{ij} and PS^c_{ij} are starting (first two weeks) and current (or most recent) productivity score; the $\tilde{X}_{ij}$ are the previous experience and training measures while the $\tilde{X}'_{ij}$ include these as well as job tenure; the Y_{ij} are other individual-specific measures, such as education, sex, and occupation (as well as dummies for the use of the various incentive schemes); while the Z_j are firm-wide characteristics, such as site and industry dummies, fraction unionized and plant and firm size. Comparisons of coefficients from equations 1) and 2) thus indicate the extent to which the determinants of earnings and productivity are comparable.

In addition to estimating equations 1) and 2) as indicated, we can also add the PS_{ij} as independent variables to the appropriate ln (W_{ij}) equations. Comparisons of coefficients on the X_{ij} or X'_{ij} estimated with and without the PS_{ij} indicate the extent to which returns to training, experience, tenure, etc. reflect returns to productivity. Comparisons of the coefficients on the PS_{ij} with those from simple wage equations containing these variables similarly show us the extent to which "human capital" variables account for observed productivity of individual workers.

Of course, a major concern in all of this involves the subjective nature of the PS_{ij}. If the managers at each firm have different notions about what a particular productivity score means in terms of employee performance, these firm-specific effects may be correlated with various regressors and thus may cause biased coefficient estimates (see footnote 7) in the wage equations). Job-specific factors in these evaluations (<u>within</u> 1-digit occupation and 2-digit industry) would cause similar problems.

Fortunately, the multiple observations per worker and firm on wages and productivity scores enable us to estimate difference equations in which these firm-specific factors are eliminated. Assuming that $a_c = a_s$, $b_c = b_s$, etc., first-difference equations could be estimated in which all time-invariant characteristics of workers and firms are omitted as regressors, leaving only tenure (as the difference in experience) and training as time-varying factors.

However, the assumption of equal intercepts and coefficients may not hold. For the productivity-score equations in particular, various worker, job or firm characteristics may be associated with differences in employee learning and therefore in productivity-growth, or in employer evaluations of such growth. If nothing else, employee learning or changes in employer evaluations over time would cause different intercepts between the PS^s and PS^c equations.

Therefore, we will present estimates of change equations below in which intercepts and time-invariant regressors are both omitted and included, with specification tests done for the validity of each. There are also other well-known problems with change equations if independent variables are measured with error, as subjective productivity scores might well be.[8] In this case, differencing compounds the relative magnitude of the error and causes downward-biased estimates (e.g., Freeman (1984)). Because of this possibility, we consider results from equations in levels as well as those in changes below.

Another issue which frequently arises in estimating productivity differentials among employees is that of sample selection, since those hired do not represent a random sample of worker attributes and the selection criteria are likely correlated with the determinants of productivity (Brown, 1982). This is somewhat less of a problem for a sample of workers at many

firms than for those at one firm, since the former contain a more random sample of employee charactheristics. Furthermore, comparisons of wage and productivity equations ought not to be greatly plagued by this problem, since similar selection criteria are operating in both cases.

A final issue here involves the fact that both starting and current wages are observed in different years for different workers, since the most recently hired worker before August 1981 might have been hired in earlier years or may have left the firm before 1982.[9] Since the early 1980's were years of high inflation as well as minimum wage increases,[10] annual wage increases due to these factors might cause upward biases in the estimated wage effects of tenure. Accordingly, we include controls for CPI and minimum wage levels and changes based on the starting and current/most recent years in all of the equations estimated below.[11]

III. Results

In Table 1 we present means and standard deviations for the wages and characteristics of the "last worker hired" by firms in the 1982 survey.

The results confirm the relatively low-wage nature of the sample, with starting wages in 1980-81 of about $5.00 an hour. Most workers are high school graduates employed in clerical, sales, and service occupations.

As for productivity scores, we find the mean for initial productivity to be close to 50 on the 0-to-100 scale, while current productivity is substantially higher. The average experience level of about eight years indicates that the average worker here is in his or her mid-twenties in age. About one-quarter of total experience is considered "applicable" by managers, and tenure on the job averages slightly less than a year. Over 70% of these

Table 1

Means (Standard Deviations) for Wages and Characteristics of "Last Worker Hired"

Starting Wage	5.02	Experience:	
	(2.72)	Yrs. in Labor Mkt.	8.718
Current Wage	5.88		(9.099)
	(3.15)	Yrs. in Applicable Job	2.505
			(4.489)
Productivity Score:			
First 2 weeks	52.72	Yrs. of Tenure	.938
	(25.47)	Hrs. of Training:	(.578)
Currently	79.85	Formal	8.672
	(17.68)		(38.659)
Education:		Informal	43.760
High School	.784		(72.823)
College	.083	Coworker	36.914
Occupations:			(126.279)
Prof./Tech.	.043		
Management	.038		
Clerical	.189		
Sales	.154		
Crafts	.004		
Operatives	.020		
Laborer	.002		
Service	.189		
Missing	.356		
Sex:			
Male	.57		
Female	.43		
Fraction Unionized:	.11		
Still With Firm:	.720		
Use of Incentive Pay:	.110		

Notes: "Current" wage and productivity score listed for individuals who are no longer with the firm are those in effect at the time of separation from the firm.

workers are still with their firms. Thus, we are primarily capturing young workers very early in their tenure profiles in this sample.[12] This rather non-representative nature of the sample must be kept in mind as results are interpreted below.

We also find that the average worker in the sample is reported to have over 50 hours of training, though most of it is considered informal. The fraction of workers covered by the various incentive schemes is also quite low.

Equations for Wage and Productivity Levels

In Table 2 we present present of log (wage) equations, with Table 2a containing estimates for starting wages and Table 2b containing those for current/most recent wages. Experience, tenure, and training variables all appear in quadratic form, with tenure appearing only in the current wage equation. For both wage measures, we present specifications in which the personal characteristics and the productivity scores first appear separately and then together. In addition to the experience/training variables, the personal characteristics include dummies for sex, education and 1-digit occupation. Dummies for the presence of incentive pay are also included. Firm characteristics include 2-digit industry, fraction unionized, plant and firm size,[13] and site dummmies. Finally, each equation includes CPI and minimum wage level variables for either the starting or current/most recent year.

The results in Column 1 for each wage equation show effects that are widely consistent with those in the literature. Of particular interest here are the large estimated effects of the experience measures. We find that each year of applicable experience adds over 4% to the employee's wages, while general experience adds about 1% per year. The first year of job tenure adds

Table 2a

Starting Wage: Log (Wage) Equations

	Starting Wage			
	1	2	3	4
Experience	.0095	-	-	.0094
	(.0027)			(.0027)
Exp.^{2}	-.0002	-	-	-.0002
	(.0001)			(.0001)
Applicable Exp.	.0424	-	-	.0407
	(.0046)			(.0046)
App. Exp.^{2}	-.0010	-	-	-.0009
	(.0002)			(.0002)
Tenure	-	-	-	-
Tenure^2	-	-	-	-
Hrs. Training:				
Formal	.0682	-	-	.0811
	(.0528)			(.0530)
Formal^2	-.0002	-	-	-.0002
	(.0002)			(.0002)
Informal	-.0156	-	-	-.0067
	(.0229)			(.0232)
Informal^2	.0000	-	-	.0000
	(.0000)			(.0000)
CoWorker	.0246	-	-	.0294
	(.0267)			(.0267)
CoWorker^2	-.0000	-	-	-.0000
	(.0000)			(.0000)
Productivity				
First 2 weeks	-	.1756	.1934	.0868
		(.0466)	(.0363)	(.03581)
Current	-	-	-	-
Male	.197	-	.207	.196
	(.022)		(.023)	(.022)
Education:				
HS	.132	-	.142	.130
	(.027)		(.028)	(.027)
C	.286	-	.292	.282
	(.042)		(.045)	(.042)
Fraction Union	.0034	-	.0036	.0034
	(.0003)		(.0003)	(.0003)
ln(Plant Size)	.003	-	.007	.004
	(.007)		(.008)	(.007)
Incentive Pay	.050	-	.057	.053
	(.028)		(.030)	(.028)
R^2	.520	.021	.435	.522

Note: Sample size is 1169. All equations except those in col. 2 also include firm size, site, 2-digit industry, and 1-digit occupation dummies. Controls for CPI and minimum wage levels (in logs) for the relevant year appear in all equations. Coefficients on training and productivity are multiplied by 100.

Table 2b

Current Wage: Log (Wage) Equations

	Current Wage			
	1	2	3	4
Experience	.0110	–	–	.0109
	(.0028)			(.0028)
Exp.^{2}	-.0002	–	–	-.0002
	(.0001)			(.0001)
Applicable Exp.	.0411	–	–	.0406
	(.0047)			(.0047)
App. Exp.^{2}	-.0010	–	–	-.0010
	(.0002)			(.0002)
Tenure	.1101	–	–	.0984
	(.0579)			(.0585)
Tenure^2	-.0214	–	–	-.0185
	(.0183)			(.0184)
Hrs. Training:				
Formal	.1493	–	–	.1596
	(.0543)			(.0544)
Formal^2	-.0005	–	–	-.0004
	(.0002)			(.0002)
Informal	.0179	–	–	.0203
	(.0235)			(.0236)
Informal^2	-.0000	–	–	-.0000
	(.0000)			(.0000)
CoWorker	.0122	–	–	.0140
	(.0274)			(.0274)
CoWorker^2	-.0000	–	–	-.0000
	(.0000)			(.0000)
Productivity				
First 2 wks	–	–	–	–
Current	–	.2260	.1555	.0783
	–	(.0722)	(.0570)	(.0537)
Male	.207	–	.225	.209
	(.022)		(.024)	(.022)
Education:				
HS	.143	–	.153	.141
	(.027)		(.029)	(.027)
C	.282	–	.292	.280
	(.043)		(.046)	(.043)
Fraction Union	.0033	–	.0035	.0033
	(.0003)		(.0004)	(.0003)
ln(Plant Size)	.004	–	.006	.004
	(.007)		(.008)	(.007)
Incentive Pay:	.155	–	.171	.160
	(.029)		(.031)	(.029)
R^2	.528	.017	.438	.529

Note: Sample size is 1320. All equations except those in col. 2 also include firm size, site, 2-digit industry, and 1-digit occupation dummies, Controls for CPI and minimum wage levels (in logs) for the relevant year appear in all equations. Coefficients on training and productivity are multiplied by 100.

about 9% to current wage, though the large quadratic term ensures that these increases decline in subsequent years. Even so, these large tenure effects no doubt reflect the concentration of most of our sample on the steep, early part of the profile.

The effects of formal training are much larger than those for informal training by either management or coworkers. The former are positive and significant in the equations for current wages and are marginally significant in those for starting wages, while effects for other kinds of training are not. These results are consistent with our notions of workers bearing at least some costs of training. Quite strikingly, we find large effects of incentive schemes on pay, which are also much larger for current than for starting wages.[14] Finally, we find the usual positive effects of unionism, education and being male (the latter being worth about 20%) on both wage rates.

In Cols. 2 of Table 2 we find the coefficients from simple equations of wages on productivity scores, while in cols. 3 we have added all controls except those for experience and training. These results show positive and significant effects of productivity scores, with a 100-point increase (i.e., from the lowest to highest possible productivity) raising wages by 18% to 23%. On the other hand, a standard-deviation rise in initial productivity raises wages by only about 15% of a standard deviation across firms, and current productivity shows similar results.[15]

The inclusion of the various controls in Col. 3 has virtually no effect on the initial productivity coefficient and a fairly small effect on the current productivity coefficient. The coefficients on the controls themselves are also not greatly changed. But when the experience and training variables are added in Col. 4, the magnitudes of the productivity score effects are

dramatically reduced. In particular, the effect on starting wages is reduced to about half of its previous size and that on current wages to about a third of its previous size. This suggests that experience and training are strongly correlated with perceived productivity, and may account for much of the observed effect of productivity on wages across firms. On the other hand, the experience and training effects themselves are not much changed by inclusion of the productivity scores. The tenure coefficient in the current wage equation is reduced by the greatest amount, and the reduction is only about 13% of the original one. These results suggest that experience and training have important non-productivity related effects on wages as well.

Table 3 provides additional evidence on the determinants of perceived productivity. In this table we have estimated coefficients of productivity score equations. The results show significant, positive effects of applicable previous experience on productivity scores, though the effect is much larger for initial than for current productivity. A standard-deviation rise in such experience raises one's productivity score in the first two weeks by about .35 of a standard deviation and one's current score by about .20.

For the latter, however, we find an even larger effect of tenure in the firm. A one year rise in tenure raises the productivity score by 23 points, and a standard deviation rise in tenure raises the current productivity score by about three-fourths of a standard deviation.

These sizable effects of previous experience and tenure on productivity therefore stand in sharp contrast to the results of Medoff and Abraham, who found negative effects of experience on productivity within grade. The differences in results between these studies might reflect the much wider range of firms and occupations that are represented in these data relative to theirs (which considered only professional/managerial employees at two

Table 3

Productivity Score Equations

	First 2 Weeks	Current
Experience	.171	.110
	(.225)	(.156)
Exp.^{2}	-.001	-.002
	(.006)	(.004)
Applicable Exp.	2.073	.749
	(.375)	(.261)
App. Exp.^{2}	-.056	-.018
	(.015)	(.011)
Tenure	-	23.334
		(2.868)
Tenure^2	-	-5.818
		(.943)
Hrs. Training:		
Formal	-.148	-.069
	(.043)	(.030)
Formal^2	.001	.000
	(.000)	(.000)
Informal	-.103	-.026
	(.019)	(.013)
Informal^2	.000	.000
	(.000)	(.000)
CoWorker	-.056	-.026
	(.022)	(.015)
CoWorker^2	.000	.000
	(.000)	(.000)
Male	1.371	-2.759
	(1.775)	(1.234)
Education:		
HS	1.491	2.842
	(2.191)	(1.526)
C	4.510	3.066
	(3.457)	(2.404)
Fraction Union	.034	.016
	(.026)	(.018)
ln(Plant Size)	-1.050	.833
	(.571)	(.406)
Incentive Pay:	-3.247	-5.622
	(2.316)	(1.610)
R^2	.155	.155

Note: Controls are same as in cols. 1, 3, and 4 of Tables 2a, b.

firms), as well as the within-grade focus of their work. However, the evidence here supports Medoff and Abraham in suggesting that experience and tenure also have some effects on wages which are not productivity-related. The large observed effects of the objective experience measures on both subjective productivity scores and wages, as well as the observed effects of these scores on wages, also enable us to have some confidence that the productivity score levels are meaningful as measures of worker performance.[16]

On the other hand, we find generally negative effects of hours of training on productivity scores, though they are much less negative for current than for initial productivity. This suggests at least the possibility that, conditional on being hired, the returns to training are higher for the firm's less initially-productive workers, who therefore receive more of it. Alternatively, these negative effects might reflect downward biases caused by the correlation of firm- or-job-specific factors in subjective productivity scores with these training variables.[17] The incentive pay variables also show generally negative effects, which might have similar interpretations.

A few other observed effects are worth mentioning as well. There is a positive, insignificant effect for male workers (relative to females) on initial productivity which becomes negative and significant for current productivity. Employer perceptions of their female employees thus seem to rise significantly with time on the job, to the point that they may be perceived more positively than their male counterparts. Of course, both the initial positive effect and the current negative effect of being male are very small, reflecting small fractions of a standard-deviation change in productivity. Much more important is the contrast between the essentially comparable productivity scores and the much lower wages of women. While other factors (such as expected turnover differences) might conceivably explain the

wage effect, they are unlikely to be of sufficient magnitude to fully explain the difference.[18] The argument that sex differentials in wages reflect discrimination thus becomes more compelling.

Finally, we note positive but generally small and insignificant effects of unionism and worker education on their productivity scores. It is, however, noteworthy that the positive union effects become significant (though they remain much smaller than wage effects in percentage terms) when the experience and training variables are omitted from the productivity score equations.[19]

Equations for Wage and Productivity Changes

As noted above, there are some fairly serious questions about the validity or meaning of these results. Variation in jobs within the 1-digit occupation and 2-digit industry categories for which we control may render some comparisons meaningless and might account for a few of the anomalous results above, particularly for incentive pay. Variation in firm-specific factors affecting subjective employer evaluations might create biases in either direction in the coefficients of Tables 2 and 3, depending on their correlations with individual regressors. Any measurement error in the productivity scores would also cause downward biases in the magnitude of the coefficients on these variables in Table 2, which might explain their relatively small magnitudes and their small effects on other included variables.

To deal with the problem of firm- and job-specific factors in productivity-score measures, we estimate wage-change and productivity-change equations and present these results in Tables 4 and 5 respectively. As noted above, differences in estimated effects for current wages and productivity

relative to their starting values may eliminate the justification for using a strict first-difference approach and may therefore imply the use of intercepts and time-invariant regressors in these equations. Accordingly, we present estimates in Tables 4 and 5 of equations containing intercepts. Only the time-varying regressors (i.e., tenure and hours of training) are included in the first few specifications of the wage change equation, while eventually the others are added as well. Changes in productivity scores are also used as regressors in Table 4 and as dependent variables in Table 5. The first-difference versions of the wage equations do, however, appear in the Appendix.

The results of Table 4 show that tenure and training both have significant, positive effects on wage growth.[20] As before, the effects of formal training are larger than those of informal training, while both types of training by management have more positive effects than time spent with coworkers. Interestingly, training explains little of the tenure effect on wage growth. We also find that wage growth is positively affected by incentive pay schemes. On the other hand, previous experience bears no relationship to wage growth.

When changes in productivity scores are added to the wage change equations, we again find positive and significant effects, with the magnitudes somewhat smaller than they were in comparable wage level equations. However, the presence of change in experience (i.e., tenure) in these equations lowers the magnitude of the productivity effect by a much smaller amount than did experience in the wage level equations. In this case, tenure and training hours account for 10-15% each of the magnitude of the productivity effect, while all other controls account for little more. Conversely, productivity changes account for about 10% of the estimated tenure effects on wage changes.

Table 4

Wage Change Equations: With Intercept and Fixed Characteristics

	1	2	3	4	5	6	7
Intercept	.040	.026	-.023	.070	.030	.020	-.027
	(.016)	(.016)	(.023)	(.011)	(.016)	(.016)	(.023)
Change in Productivity	-	-	-	.0822	.0738	.0649	.0707
				(.0179)	(.0179)	(.0181)	(.0182)
Experience	-	-	.0016	-	-	-	.0016
			(.0013)				(.0013)
Exp.^{2}	-	-	-.0000	-	-	-	-.0000
			(.0000)				(.0000)
Applicable Exp.	-	-	-.0014	-	-	-	-.0004
			(.0022)				(.0022)
App. Exp.^{2}	-	-	.0000	-	-	-	.0000
			(.0001)				(.0000)
Tenure	.1191	.1216	.1237	-	.1073	.1115	.1141
	(.0272)	(.0270)	(.0268)		(.0272)	(.0270)	(.0267)
Tenure^2	-.0241	-.0257	-.0256	-	-.0220	-.0239	-.0242
	(.0087)	(.0086)	(.0085)		(.0087)	(.0086)	(.0085)
Hrs. Training:							
Formal	-	.1024	.0756	-	-	.0979	.0700
		(.0261)	(.0259)			(.0260)	(.0258)
Formal^2	-	-.0002	-.0002	-	-	-.0002	-.0001
		(.0001)	(.0001)			(.0001)	(.0001)
Informal	-	.0332	.0339	-	-	.0276	.0286
		(.0113)	(.0102)			(.0113)	(.0112)
Informal^2	-	-.0000	-.0000	-	-	-.0000	-.0000
		(.0000)	(.0000)			(.0000)	(.0000)
CoWorker	-	-.0138	-.0121	-	-	-.0173	-.0145
		(.0138)	(.0131)			(.0132)	(.0130)
CoWorker^2	-	.0000	.0000	-	-	.0000	.0000
		(.0000)	(.0000)			(.0000)	(.0000)
Male	-	-	.007	-	-	-	.010
			(.011)				(.010)
Education:							
HS	-	-	.013	-	-	-	.012
			(.013)				(.013)
C	-	-	-.005	-	-	-	-.004
			(.021)				(.020)
Fraction Union	-	-	-.000	-	-	-	-.000
			(.000)				(.000)
ln(Plant Size)	-	-	.002	-	-	-	.001
			(.004)				(.004)
Incentive Pay	-	-	.104	-	-	-	.106
			(.014)				(.014)
R^2	.116	.143	.202	.116	.129	.152	.212

Note: Sample size is 1169. Controls are same as in Table 2 and 3, except that the CPI and minimum wage variables now reflect changes (i.e., log(1 + % change) rather than levels. Dependent variable is log(current/starting wage).

We also note that the intercepts in many of these equations are significant, while the time-invariant regressors of Cols. 3 and 7 are mildly significant as well.[21] But as these are not significant in all cases, we consider the results of first-difference wage equations in the Appendix as well. While the magnitudes of most effects are larger in these equations, the qualitative results are very similar. Productivity changes now account for about 14% of the wage change-tenure effect.

In Table 5, we once again find significant and positive effects of tenure on productivity score changes.[22] The magnitudes are somewhat smaller than were the comparable ones in Table 3, but they remain quite large.[23] But in contrast to the earlier productivity score equations, we now find that both formal and informal training also have significant positive effects on productivity changes, even after controlling for job tenure. As was suggested before, female employees show significantly higher productivity growth than do males, though there is no significant growth in their relative wages. The large and significantly positive intercepts in all of the equations suggest a rise in employer evaluations of their employee's performance over time, even after controlling for tenure.

In sum, the estimates of wage-change and productivity-change equations reinforce our earlier findings that tenure raises both productivity and earnings, though it also has effects on earnings which are independent of productivity. We also find that hours of training contribute significantly to wage and productivity growth, even if they are not related to the levels of either; and that sex differences in wages are not reflected in productivity levels or growth.

Before concluding, we note again that the presence of measurement error in the subjective ratings may mean that wage change equations compound any downward biases that existed in the estimated productivity score coefficients

Table 5

Productivity Change Equations:
With Intercepts and Fixed Characteristics

	1	2	3
Intercept	16.000	12.510	6.639
	(2.438)	(2.458)	(3.709)
Experience	-	-	-.028
			(.213)
Exp.^{2}	-	-	-.000
			(.000)
Applicable Exp.	-	-	-1.344
			(.360)
App. Exp.^{2}	-	-	.639
			(.015)
Tenure	17.035	16.333	14.625
	(4.067)	(4.005)	(3.957)
Tenure^2	-4.092	-3.998	-3.177
	(1.339)	(1.318)	(1.302)
Hrs. Training:			
Formal	-	7.295	8.143
		(4.226)	(4.193)
Formal^2	-	-.031	-.036
		(.013)	(.013)
Informal	-	8.671	7.636
		(1.824)	(1.813)
Informal^2	-	-.011	-.010
		(.003)	(.003)
CoWorker	-	5.266	3.201
		(2.139)	(2.112)
CoWorker^2	-	-.006	-.004
		(.002)	(.002)
Male	-	-	-4.163
			(1.703)
Education:			
HS	-	-	1.532
			(2.105)
C	-	-	-1.531
			(3.358)
Fraction Union	-	-	-.016
			(.025)
ln(Plant Size)	-	-	1.820
			(.560)
Incentive Pay	-	-	-2.406
			(2.222)
R^2	.023	.062	.126

Note: Controls are same as in previous tables. Dependent variable is the difference between productivity scores currently and those of first two weeks.

of wage level equations. The estimates of Tables 4 and 5 might therefore be viewed as lower bounds to the true effects of productivity on wages and on the wage-tenure relationship. Furthermore, the similarities between productivity effects on wages and experience in equations for levels and these for changes again suggest that the subjective productivity scores used in the analysis here are meaningful as measures of worker performance.

IV. Conclusion

This paper uses data from a nationwide sample of firms on employee wages and characteristics to reexamine the determinants of employee productivity and earnings. Productivity is measured by subjective productivity ratings of recently hired workers by their employers. The primary determinants of productivity and earnings that we consider are employee experience and tenure, hours of training, pay incentive schemes, and various demographics characteristics of workers. Wage and productivity score equations are estimated in changes as well as levels to eliminate job- and firm-specific factors in these productivity scores.

The results show that both previous experience and current job tenure have positive and significant effects on wages and productivity. These results appear in levels of wages and productivity for previous experience and in both current levels and changes of wages and productivity for job tenure. A good deal of the wage-productivity relationship is accounted for by experience, and the effects are largest for experience that has some application to the current job. On the other hand, experience and tenure have additional effects on wages which appear to be independent of their productivity-enhancing effects.

We also find that hours spent in training have positive effects on both wage and productivity changes, though productivity levels suggest that less initially productive workers may receive more hours of training than do their counterparts, within firms. The various pay incentive schemes, which generally have large positive effects on wage levels and changes, do not have similar positive effects on productivity levels or changes.

Finally, we find various other effects of individual and firm characteristics. In particular, female employees show greater productivity growth then do male employees, and their current productivity levels are slightly higher as well. These results for females and males stand in sharp contrast to their relative wage levels, which are significantly higher for men. The evidence that higher wages for male workers reflect discrimination is therefore strengthened. We also find positive effects of unionism on productivity scores of workers, though in percentage terms these effects are much smaller than are the effects of unionism on wages.

A few caveats must be kept in mind as these results are reviewed. The exact nature and meaning of the subjective productivity score variable remain questionable, and this unusual sample of young and inexperienced workers must be noted as well. Still, the results here strongly suggest that wages are affected by a wide range of both productivity- and non-productivity-related factors, including discrimination and unionism. The potential for training to raise both wages and productivity is also documented. More study of these links between productivity and earnings as well as the determinants of each is certainly warranted.

FOOTNOTES

[1]The seminal piece in the literature which stresses the productivity-enhancing effect of experience is Mincer (1974). But more recent theoretical formulations stress that profit-maximizing firms may choose earnings profiles that are steeper than productivity profiles with respect to experience (e.g., Lazear (1979)).

A somewhat different question has recently been raised about whether the returns to job tenure really reflect differences in "match quality" across people and jobs as opposed to a return to tenure for people on the same jobs (Abraham and Farber, 1987). If, in fact, those with longer tenure have higher quality matches, we would expect to see higher productivity among those with longer tenure.

[2]Maranto and Rodgers find that the experience of government officials in monitoring firm compliance with minimum wage laws raises their productivity in uncovering violations. Brown finds that most of the wage-tenure profile is explained by the time which individuals report that it takes for them to complete training and become fully productive on their jobs.

[3]Frank analyzes the distributions of sales and earnings among automobile dealers and realtors, finding a narrower spread in the latter than the former. Klein et. al. and Weiss use data on output for production workers at a large firm to analyze the effects of gender and high school graduation on observed output and quits. Another strand of this literature analyzes the union effect on productivity and compares it with the wage effect. This growing literature is summarized in Freeman and Medoff (1984).

[4]Lazear and Brown present theoretical arguments on firm choice between straight time and incentive pay, and Brown provides empirical evidence as well. Seiler and Weiss provide evidence that individual incentives (relative to straight time pay or group incentives) raises the variance of earnings across individual workers and infer effort/output effects from this.

[5]The 1982 wave of the survey was developed at the National Center for Research on Vocational Education and administered by Gallup, Inc.

[6]These papers include Barron et. al. (1986), Barron and Lowenstein (1986), and Bishop (1987, 1988). Results are discussed below where relevant.

[7]The question calls for the last employee hired on or before August 1981. Approximately 20 workers in this sample were, in fact, hired during 1982. Frequencies of workers hired in 1979, 1980, and 1981 were 99, 206, and 1110.

[8]The point that subjective performance ratings are characterized by a fair amount of randomness is made in Hunter (1983).

[9]Of those who are no longer with the firm, 19 left in 1980, 167 left in 1981, and about 190 left in 1982. All who are still with the firm report wages for 1982.

[10]CPI levels (using 1967 as the base year) were 217.4, 246.8, 272.4, and 289.1 respectively for the years 1979-82. Minimum wages set by the Federal government were $2.90 in 1979, 3.10 in 1980, and 3.35 in 1981.

[11]The coefficients on the log(CPI) levels and changes are significantly less than one in most wage level and change equations. The data thus reject deflating as a means for dealing with nominal wage adjustment. The use of year-level or year-change dummies in the appropriate equations instead of CPI and minimum wage variables led to fairly comparable results with regards to the effects of experience and productivity on wages.

[12]The youthfulness and low experience levels of the sample reflect not only its focus on low-wage firms but also the fact that a sample of last-hired workers will overrepresent high turnover, low duration workers and jobs within firms. This must be kept in mind as results are interpreted below.

[13]Plant size actually refers to company employment levels within the site, for which exact magnitudes were gauged in the survey. Total company employment (i.e., both within and outside the site) was then gauged using a set of categories i.e., 1-100, 100-250, 250-500, 500-2000, and 2000+. We use the continuous within-site measure and well as dummy variables from total firm employment.

[14]Since we focus here on wage levels rather than variances, these results are a bit different from those of Seiler and Weiss (see footnote 5) who find higher variances when using individual level incentives. It is, however, quite plausible that the means and variances of worker compensation are positively correlated.

[15]These magnitudes are roughly similar to those found by Bishop (1987) with these data. He focused on relative wage and productivity differences between employees within firms, using a relatively small sample of workers with vocational education (in addition to the "last worker hired") about whom questions were asked in the EOPP Survey.

[16]It is, of course, possible that the correlations between wages and productivity scores are explained by a tendency of supervisors to rate higher wage employees with higher scores, thereby rationalizing the higher wages which they receive anyway. The experience-productivity effects might also be explained by a positive age-bias in scoring, as suggested by Rothe (1949).

[17]The case for negative selection into training is somewhat weakened by the positive correlations between hours of training and levels of education

observed for these workers, though correlations with previous experience were negative. Both results are consistent with those observed by Mincer (1988) and Lillard and Tan (1986). Since the estimated performance effects are within 1-digit occuption, positive correlations with education and negative ones with productivity are not implausible.

[18]The presence of sex differentials in wages that are not observed in productivity has been noted by Klein et. al. (1987). Differential quitting behavior between males and females has been noted by Viscusi (1980) and Matzen (1986). However, the differentials calculated here already control for currently observed tenure as well as training. It is thus unlikely that expected tenure differentials could fully explain the observed wage effect.

[19]Unionism here is positively (though weakly) correlated with previous experience (ρ=.07 for applicable and .03 for general experience) and negatively correlated with hours of training (ρ=-.05 for informal training by management and -.03 for that with coworkers). The latter result is consistent with Mincer (1983). When experience and training variables are omitted from productivity score equations, the coefficient (and standard error) on collective bargaining are .053 (.028) and .032 (.019) for initial and current productivity scores respectively. Moving from 0 to 100% unionism would thus raise wages by about 33% (Table 2) and productivity by about 10% initially and 4% currently.

[20]The positive effects of training on both wage and productivity growth have been noted in these data by Barron et. al. (1986) and elsewhere by Mincer (1985) and Lillard and Tan (1986).

[21]The F-value of the entire set of time-invariant regressors is 3.91 ($F_{.05}$ = 1.27) in the wage change equations.

[22]Effects of tenure on changes in productivity scores in these data have been noted by Bishop (1988).

[23]A one standard-deviation change in tenure leads to a change in productivity growth of about .41 of a standard deviation.

REFERENCES

Abraham, Katherine and Henry Farber. "Job Duration, Seniority, and Earnings." American Economic Review, June 1977.

Barron, John et. al. "Job Matching and On-The-Job Training." Unpublished paper, 1986.

Barron, John and Mark Loewenstein. "On Imperfect Evaluation and Earnings Differentials." Economic Inquiry, October 1986.

Bishop, John. "Do Employers Share the Costs and Benefits of General Training?" Unpublished manuscript, 1988.

Bishop, John. "The Recognition and Reward of Employee Performance." Journal of Labor Economics, October 1987.

Brown, Charles. "Estimating the Determinants of Employee Performance." Journal of Human Resources, Spring 1982.

Brown, Charles. "Firm Choice of Method of Pay." Unpublished manuscript, 1987.

Brown, James N. "Are Those Paid More Really No More Productive? Measuring the Relative Importance of Tenure Versus On-The-Job Training in Explaining Wage Growth." Unpublished manuscript, 1983.

Frank, Robert. "Are Workers Paid Their Marginal Products?" American Economic Review, September 1984.

Freeman, Richard. "Longitudinal Analysis of Trade Unionism." Journal of Labor Economics, April 1984.

Freeman, Richard and James Medoff. What Do Unions Do? Basic Books, 1984.

Hunter, John. "A Causal Analysis of Cognitive Ability, Job Knowledge, Job Performance, and Supervisor Ratings." In Performance Measurement and Theory ed. by F. Landy et. al., 1983.

Klein, Roger et. al. "Factors Affecting the Output and Quit Propensities of Production Workers." NBER Working Paper No. 2184, March 1987.

Lazear, Edward. "Salaries and Piece Rates." Journal of Business, 1986.

Lazear, Edward. "Why is There Mandatory Retirement?" Journal of Political Economy, June 1979.

Lillard, Lee and H. Tan. Private Sector Training. Rand Corporation, 1986.

Meitzen, Mark. "Differences in Male and Female Job-Quitting Behavior." Journal of Labor Economics. April, 1986.

Maranto, Cheryl and Robert Rodgers. "A Test of the On-the-Job Training Hypothesis." Journal of Human Resources, Spring 1984.

Medoff, James and Katherine Abraham. "Experience, Performance and Earnings." Quarterly Journal of Economics, 1980.

Medoff, James and Katherine Abraham. "Are Those Paid More Really More Productive? The Case of Experience." Journal of Human Resources, Spring 1981.

Mincer, Jacob. "Job Training, Wage Growth, and Labor Turnover." NBER Working Paper No. 2690, 1988.

Mincer, Jacob. Schooling, Experience and Earnings. National Bureau of Economic Research, 1974.

Mincer, Jacob. "Union Effects: Wages, Turnover and Job Training." NBER Working Paper No. 808, 1983.

Rothe, H.F. "The Relation of Merit Ratings to Length of Service." Personal Psychology, Summer 1949.

Seiler, Eric. "Piece Rate vs. Time Rate: The Effect of Incentives on Earnings." Review of Economics and Statistics, August 1984.

Viscusi, W. Kip. "Sex Differences in Worker Quitting." Review of Economics and Statistics. August, 1980.

Weiss, Andrew. "High School Graduation, Performance and Wages." Journal of Political Economy, August 1988.

Weiss, Andrew. "Incentives and Worker Behavior: Some Evidence." NBER Working Paper No. 2194, March 1987.

Appendix

Wage Change Equations: First Differences

	1	2	3	4	5
Change in Productivity	-	-	.1147	.0789	.0675
			(.0173)	(.0177)	(.0180)
Tenure	.1666	.1528	-	.1411	.1342
	(.0194)	(.0196)		(.0201)	(.0201)
$Tenure^2$	-.0386	-.0351	-	-.0324	-.0308
	(.0065)	(.0065)		(.0066)	(.0066)
Hrs. Training:					
Formal	-	.1038	-	-	.0988
		(.0261)			(.0260)
$Formal^2$	-	-.0002	-	-	-.0002
		(.0001)			(.0001)
Informal	-	.0361	-	-	.0295
		(.0112)			(.0112)
$Informal^2$	-	-.0003	-	-	-.0000
		(.0002)			(.0001)
CoWorker	-	-.0129	-	-	-.0168
		(.0132)			(.0132)
$CoWorker^2$	-	.0000	-	-	.0000
		(.0000)			(.0000)
R^2	.529	.545	.518	.537	.550

Note: Same as Table 4.