INFORMATION, EMPLOYER SIZE, TRAINING, AND WAGE GROWTH

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INTRODUCTION

Researchers have demonstrated that larger firms provide more on-the-job training than smaller firms [Barron, Black, and Loewenstein, 1987; 1989]. It is surprising, therefore, that wage growth does not appear to be greater in larger firms [Schiller, 1982; Keeley, 1984]. In this paper we investigate this puzzle.

Our central hypothesis is that larger firms possess more information about the skills workers obtain from on-the-job training they sponsor. Because other firms cannot evaluate these skills accurately, the larger firm does not have to increase the wages of the workers they train to match their increased productivity. This information advantage converts this general training to firm-specific training; the firm is willing, as a result, to absorb a higher proportion of the investment cost.

THE MODEL

To develop this asymmetric information argument formally, we consider two firms that provide general training, equally useful to all employers, but under different levels of uncertainty.[2] Within this context we examine the variations in levels of training and wages with uncertainty (or conversely, information) about worker productivity. To emphasize the problem at hand, we assume a two-period model, in which all training is provided in the first period and all the gains from training are reflected in the second-period production function. All values are implicitly discounted to present values. The firm, as characterized, utilizes one variable input, labor, upon which it makes expenditures to change the production function in the second period. Hence, expected profits are:

$$E(\pi) = \mathrm{E}[p_q^{\,0}\, g(x) + p_q^{\,1}\, f(x, z) - w_0 x - k_0 x - w_1 x]. \tag{1}$$

The above symbols are defined in Table 1.

Table 1
Definitions of Symbols

p_q^0	=	the price of output in the first period.
p_q^1	=	the price of output in the second period.
$g(x)$	=	the initial production function.
$f(x,z)$	=	the production function after training.
w_0	=	the first period wage.
w_1	=	the present value of the second period wage.
x	=	the number of workers employed and trained.
z	=	a random variable affecting output.
k	=	the average training cost per worker.

Following the Becker [1962] tradition all firms are assumed to be risk neutral. The production functions are traditionally neoclassical: $f_x > 0$, $g_x > 0$, $f_{xx} < 0$, $g_{xx} < 0$. The expected value of z is $E(z) = \Omega$ and $f_x(x, z)$ is concave in z: $f_{xz} > 0$, $f_{xzz} < 0$. The necessary and sufficient conditions for a maximum of (1) are

(2) $$E[p_q^0 g_x(x^*) + p_q^1 f_x(x^*, z)] = w_0 + k_0 + w_1, \text{ and}$$

(3) $$D = E[p_q^0 g_{xx}(x^*) + p_q^1 f_{xx}(x^*, z)] < 0,$$

where x^* is the profit maximizing level of x.

For simplicity, we suppose the firm with better knowledge of the benefits of training has perfect knowledge, so that its second-period production function is $f(x,\Omega)$. Our assumption that f_x is concave in z implies that for the profit-maximizing employment, x^*, of the uncertain firm,

(4) $$p_q^0 g_x(x^*) + p_q^1 f_x(x^*, \Omega) \geq E[p_q^0 g_x(x^*) + p_q^1 f_x(x^*, z)].$$

Since at x^* the value of the marginal product of a trained worker under certainty is greater than the expected value of the marginal product of a trained worker under uncertainty, the firm facing the expected value of the random variable z will not choose x^* to maximize profits. Rather, it will choose x to satisfy the following necessary condition for profit maximization:

(5) $$p_q^0 g_x(\hat{x}) + p_q^1 f_x(\hat{x}, \Omega) = w_0 + k_0 + w_1,$$

where $\hat{x}$ is the profit-maximizing level of employment under certainty in its second-period production function. This implies that $\hat{x} > x^*$ because $g_x(x)$ and $f_x(x,\Omega)$ are monotonically decreasing functions of x. Thus, the firm facing certainty will choose a higher level of employment. If both firms face uncertainty, it can be shown that the one with the riskier distribution of z will invest less in on-the-job training (OJT) [Rothschild and Stiglitz, 1970].

Assume that training is technically general, that the skills produced by OJT are equally useful in all firms, though asymmetric information generates rents for the firm facing Ω. Since the employer's information about its workers is somewhat proprietary — in the sense that the worker cannot easily, or credibly, provide this information to other employers — general training turns out to be somewhat firm-specific [Bishop, 1990; Katz and Ziderman, 1990]. The worker's increased productivity in the firm that provides the training is imperfectly signalled to other firms (alternatively, the current firm has an advantage in assessing the productivity enhancing effects of OJT), so that OJT raises the expected value of productivity in other firms less than in the current firm.

For the uncertain firm we have

$$p_q^0 g_x(x^*) = w_0 + k_0 \quad \text{and} \quad E[p_q f_x(x^*, z)] = w_1. \tag{6}$$

We, therefore, obtain the traditional Becker result for general training, in which the first-period wage is less than the worker's value of marginal product without training; the wage during training is equal to the value of the worker's marginal product minus the costs of training. Furthermore, the present value of second-period wages is equal to the expected present value of the second-period value of the marginal product.

For the firm facing certainty, on the other hand,

$$p_q^0 g_x(\hat{x}) < w_0 + k_0 \quad \text{and} \quad p_q^1 \cdot f_x(\hat{x}, \Omega) > w_1 = E[p_q f_x(x^*, z)] \tag{7}$$

This result is essentially what we would expect for the case of firm-specific OJT. The first inequality shows that the wage during training exceeds the value of the worker's marginal product, net of training costs. The second shows that in the post-training period the wage is less than the value of the worker's higher second-period marginal product. Rather, the wage in the second period is determined by what a worker is worth to outsiders, which is the expected value of the worker's marginal product.

In sum, in the firm with better information about the productivity enhancing effects of OJT, the relationship between productivity growth and wages is qualitatively identical to the traditional pattern associated with specific capital investments. Thus, productivity growth exceeds wage growth in the larger, better informed firm, more so than in the smaller, more poorly informed firm: workers in smaller firms bear the full costs of training and reap all of the returns to it, so that wages in small firms better track marginal product (net of training costs).[3]

It is important to recognize that superior knowledge generates some firm-specific rents, associated with OJT, that may be lost if the employee quits or is fired. This creates an incentive for larger firms to share some of the costs of otherwise perfectly general training. Essentially, asymmetric information among firms generates specificity of training benefits, even with completely general training. Such specificity leads to not only higher levels of training in the "informed" firm, but to productivity growth that exceeds wage growth. In addition, these factors can lead to identical or flatter wage profiles for firms that provide greater volumes of OJT — a result seemingly inconsistent with traditional theory, but, as we shall see, consistent with our empirical evidence.

EMPIRICAL TESTS

These theoretical predictions are evaluated empirically using the employer files from the second wave (1982) of the Equal Employment Opportunities Pilot Project (EOPP) conducted between February and July 1982. The EOPP employer survey is a national stratified sample of employers (drawn from approximately 30 survey sites) who participated in the EOPP — designed to test the effects of a combination of an intensive job search program and a work and training program. In addition to information about their firms, employers were questioned about the personal characteristics and job performance of their last hired employee. These responses, combined with establishment information, form our database; the unit of analysis is the individual employee, with at most one observation per employer.

The hypothesis that large employers bear a higher percentage of the cost of OJT at any level, or that a higher percentage of training in large firms tends to be firm-specific, is first investigated by looking at how productivity and wage growth differ for large and small employers. Our expectation is that (for a given volume of OJT) the effect of worker productivity growth on wages should be weaker in larger firms. Since the data set contains information not only on training and wage growth, but also on productivity growth, the EOPP is well-suited to investigate this question. Employers were asked both wage and productivity questions about the last new employee hired by the company prior to August 1981, regardless of whether they still employed that person. The more productivity growth exceeds wage growth, for a given volume of OJT, the lower is the proportion of the training costs borne by the worker. Hence, by regressing wage growth on a measure of productivity growth and allowing the effect to differ by employer size, we can indirectly test the proposition that larger employers pay for a greater percentage of the training investments (the coefficient of the interaction of productivity growth and employer size is predicted to be negative if this hypothesis is true).

We further investigate this hypothesis by looking at the differential effect of minimum wages on wage growth in firms of different size. If larger employers are willing to bear a greater share of the costs of OJT, then minimum wage restrictions on the ability of workers to finance their training through wage reductions will have less of an adverse impact on wage growth in larger firms. Essentially, we test this hypothesis with the same regressions, but allow the effect of employer size to vary with whether the worker is directly affected by the minimum wage. Employer size is interacted with a dummy variable indicating whether or not the individual is paid $3.35, the minimum wage at the time of the survey [Bishop, 1990]. The interaction effect is predicted to be positive. In other words, the negative effect of employer size on wage growth is predicted to be less negative for minimum wage workers.

In another experiment, we regress starting wages on employer size, OJT, and the interaction of employer size and OJT to evaluate directly our prediction that larger employers bear a higher percentage of the costs of OJT. A negative coefficient on OJT reflects worker investments in OJT, and a positive interaction effect indicates that the worker's share in the costs of OJT is lower in larger establishments.

Table 2 provides definitions for the variables used in the empirical analysis; Table 3 reports both summary statistics for key variables and the regression results. A number of the variables used in the analysis require some discussion.

For our analysis, it might be preferable to use firm size rather than establishment size, but the EOPP does not provide such information. Nevertheless, we expect that establishment size (*LSIZE*) adequately captures the employer size effects we are investigating because (1) there is evidence of greater intra-firm mobility at larger establishments *per se* [Idson, 1989]; (2) 72 percent of the establishments in the sample are single-plant firms; and (3) plant and firm size tend to be strongly positively correlated [Miller, 1978].[4] Although the data limitations do not allow us explicitly to analyze firm size effects *per se*, we partly control for firm size by including a dummy variable, indicating the plant in question is part of a multi-plant firm.

Our measure of on-the-job training (*TRAIN*) is the number of hours of OJT received by the employee through both formal and informal training. We add the number of hours of formal training programs "...such as self-paced learning programs or training done by specially trained personnel..", and the number of hours spent by management, line supervisors and nonsupervisory co-workers providing informal training. Although OJT may take place at a number of different points in time during the worker's tenure with a firm, the OJT information available in the EOPP applies only to the first three months of employment. Since OJT is likely to continue beyond the first three months, our OJT measure will likely underestimate the actual volume of OJT workers receive from the firm, though to the extent that early OJT is positively correlated with future OJT, it is a reasonable proxy for actual OJT.

The measure of worker productivity in the EOPP is based on the statement: "Please rate your employee on a productivity scale of zero to 100, where 100 equals the maximum productivity rating any of your employees (in this person's position) can attain and 0 is absolutely no productivity by your employee." Productivity growth (*PG*) is calculated as the difference in worker productivity during the first three months of employment with the company and worker productivity either at the time of the survey or when the worker departs from the company. Wage growth (*WAGEGR*) is calculated as the difference in the logs of the starting hourly wage rate and the hourly wage rate at the time of the survey or when the worker left the company. Note that (1) both the productivity and wage growth measures correspond to the same time period for a given worker, and (2) we control for tenure to take into account variation in these measures over different time periods for different workers. Finally, to control for whether or not the worker separated from the firm prior to the time of the survey, we include a dummy variable (*STAY*), indicating whether the worker left the company prior to the survey.

TABLE 2
Definitions of Variables
Employment Opportunities Pilot Project (Wave II, 1982)

Variable	Definition
WAGEGR	Percentage hourly wage growth computed as the difference in the logarithms of the starting wage for the worker and his or her current wage (or if no longer with the firm, the wage at separation).
LSTWAGE	Natural logarithm of the hourly wage when hired by the company.
LSIZE	Natural logarithm of the size of the plant where the individual is (was) employed, measured by the total number of employees at the plant in December, 1982.
MULTIP	Dummy=1 if the establishment is part of a multi-plant firm.
PG	Employee productivity growth over a two-year period, computed as the difference in the individual's average productivity during the first three months of work and current productivity (or at time of separation).
TRAIN	Hours of on-the-job training received by the individual during the first three months of employment (calculated as the sum of hours of formal training, informal training by management and line supervisors, and informal training by nonsupervisory co-workers).
WM	Dummy = 1 if the respondent has a wage equal to the minimum in 1982 ($3.35).
AGE	Age of the employee when hired by the firm.
EXPER	Years of experience in jobs with some application to the position prior to starting at the company.
TENURE	Years employed with the company (either at time of survey or when the employee separated from the company).
FEMALE	Dummy = 1 if female, = 0 if males.
VOCTRN	Dummy = 1 if employee had vocational training prior to employment by the firm, = 0 otherwise.
STAY	Dummy=1 if employee was still with the company at the time of the survey.

Turning to the central results in Table 3, we see that wage growth is significantly lower in larger firms.[5] In addition, both productivity growth and OJT independently act to increase wage growth (clearly OJT reflects a number of factors in addition to measured productivity growth) and minimum wages significantly reduce wage growth (consistent with the findings of earlier researchers).[6]

Of key interest for testing our hypothesis is the differential effect of wage growth on productivity growth in establishments of different size. As predicted by the

TABLE 3
Employer Size Effects on Wage Growth and Starting Wages

	Mean (Std. Dev.)	Wage Growth	Starting Wages
LSIZEx100	2.89	-0.663[c]	1.538[b]
	(1.44)	(0.413)	(0.695)
PGx100	15.57	0.161[a]	
	(19.33)	(0.041)	
PGxLSIZEx1000		-0.265[b]	
		(0.131)	
WMx10	0.14	-0.907[a]	
	(0.35)	(0.264)	
WMxLSIZEx10		0.165[b]	
		(0.082)	
TRAINx1000	81.68	0.119[b]	-0.299[a]
	(123.20)	(0.060)	(0.121)
TRAINxLSIZEx1000		0.013	0.142[a]
		(0.020)	(0.040)
MULTIPx100	0.28	-0.110	5.787[a]
	(0.45)	(0.902)	(1.831)
EDUCx10	12.53	0.319[c]	0.531[a]
	(1.71)	(0.179)	(0.046)
$EDUC^2$x100		-0.129[c]	
		(0.068)	
AGEx100	27.09	0.433[c]	3.497[a]
	(9.26)	(0.235)	(0.478)
AGE^2x1000		-0.596[c]	-0.470[a]
		(0.334)	(0.068)
EXPERx100	3.69	-0.324[c]	0.503[a]
	(7.97)	(0.172)	(0.035)
$EXPER^2$x1000		0.056	-1.224[a]
		(0.045)	(0.091)
TENUREx10	1.30	0.325[a]	
	(1.27)	(0.032)	
FEMALEx10	0.45	-0.179[b]	-2.760[a]
	(0.50)	(0.075)	(0.152)
VOCTRNx100	0.29	-0.333	1.121[a]
	(0.45)	(0.827)	(0.168)
TEMPx10	0.10	-0.135	-0.476[b]
	(0.30)	(0.124)	(0.248)
STAYx10	0.73	0.190[b]	-0.229
	(0.44)	(0.091)	(0.170)
Constant		-0.151	0.256[a]
		(0.119)	(0.085)
R^2		0.1493	0.4075

All regressions are estimated by ordinary least squares (parameter estimates are rescaled as indicated, descriptive statistics are not). The dependent variable in the wage growth regression (WAGEGR) is the difference between the logs of the starting wage and the wage at the time of the survey (or when the employee separated from the company). The dependent variable in the starting wage regression (LSTWAGE) is the log of the wage received by the employee at the start of his/her employment with the company. Parameter estimates are listed with standard errors in parentheses. $N = 1{,}822$; a. Significant at the 1 percent level; b. Significant at the 5 percent level; c. Significant at the 10 percent level.

theory, we find a negative (and significant, albeit small) interaction effect of size and productivity growth, which indicates that the effect of the latter on wage growth is lower in larger firms — a finding consistent with the observation that larger employers bear a higher percentage of the costs of OJT.[7] In addition, the positive interaction effect of minimum wages and establishment size (*WM* x *LSIZE*) indicates that the adverse effect of the minimum wage on wage growth is somewhat attenuated in larger firms. This is consistent, once again, with the observation that larger employers pay a higher fraction of the costs of OJT: the minimum wage does not act as strongly in larger firms as it does in smaller firms to inhibit the financing of training investments.

We can obtain further insight into the magnitudes of the effects with some simple calculations. Using the estimated wage growth regression equation, we see that the effect of productivity growth on wage growth is given by

$$\partial \textit{Wage Growth}/\partial PG = 0.00161 - 0.000265 LSIZE,$$

so that a change in (log) employer size from one standard deviation below the mean to one standard deviation above the mean will reduce the positive effect of productivity growth on wage growth by approximately 53 percent. Similarly, we can look at how the relationship between employer size and wage growth differs for workers who are constrained by the minimum wage and those who are not; the effect of employer size on wage growth is given by

$$\partial \textit{Wage Growth}/\partial LSIZE = -0.00663 - 0.000265 PG + 0.0165 WM + 0.000013 TRAIN.$$

At mean productivity growth of 15.57 and mean OJT of 81.68, employer size has a negative effect on wage growth for workers unconstrained by the minimum wage (*WM*=0), yet for those constrained by the minimum (*WM*=1) the effect is small but positive. In other words, among minimum-wage workers, there is a positive differential employer size effect on wage growth; but for workers unconstrained by the minimum wage, employer size has a significant (albeit small) negative effect on wage growth.

The last column of Table 3 reports complementary evidence on the sharing of OJT costs, focusing on the differential effects of training on starting wages in establishments of different size. In addition, as expected, we also see that after controlling for individual attributes higher levels of OJT costs are associated with lower starting wages in larger establishments. This is precisely what the Becker [1962] model of human capital investment predicts, i.e., workers pay for at least some portion of their OJT by initially accepting lower wages. For the purposes at hand, however, our interest is in the significantly positive estimated coefficient on the interaction term (*TRAIN* x *LSIZE*). This interaction term shows that the negative influence of OJT on starting wages is significantly less pronounced in larger establishments. As predicted by the theory, this is consistent with the observation that workers in larger establishments pay for a lower percentage of the costs of a given volume of on-the-job training.

CONCLUSIONS

This paper has investigated the implications of differential employer information about worker productivity, and specifically about the productivity-enhancing effects of OJT on wage growth and starting wages. We claim that larger employers possess more accurate information about their workers because of their greater expenditures on screening and their inherent advantage in constructing internal labor markets that allow the larger employer to observe the worker in a number of different jobs over time. As a result, larger employers not only invest more in OJT, but also bear a larger percentage of the costs of any level of OJT since the risk to them is lower than at smaller firms.

Even if OJT develops skills that are technically general in nature, it will in practice still be somewhat firm-specific in the sense that the worker cannot fully signal his enhanced productivity to the market. Hence, information asymmetries (regarding worker productivity) between the worker's current firm and potential alternative employers act to increase the specificity of OJT regardless of the degree to which these skills are technically firm-specific.

Based on data drawn from the second wave of the Employment Opportunities Pilot Project, we find empirical support for the hypotheses that larger establishments have a greater divergence between productivity growth and wage growth, a less adverse effect on wage growth from minimum wages, and a less depressing effect of training costs on starting wages than smaller establishments.

NOTES

We would like to thank Dan Black, David Bloom, Raymond Fishe, Masanori Hashimoto, Philip Robins and the reviewers for helpful comments.

1. For simplicity of exposition we develop this idea for the extreme cases, with one firm facing some uncertainty and the other firm certainty (a more general approach is outlined in an appendix available from the authors upon request).
2. It is also interesting to see the adverse effect of minimum wages on employment. Given the first and second order conditions in Equation (2) and (3), an increase in the initial wage rate w_0 produces, $\partial x^*/\partial w_0 = 1/D < 0$. A mandated increase in first-period wages, therefore, decreases employment.
3. Larger plants are also more likely to be part of multi-plant firms; a simple probit regression of a dummy *MULTIP* = 1 if the establishment is part of a multi-plant firm, on *LSIZE* (log of number of workers at the establishment) yielded an estimated coefficient (standard error) on *LSIZE* of 0.388 (0.017), which is significant at the one percent level.
4. In order to remove outliers, we deleted observations in which wage growth was more than three standard deviations above or below its mean value (the sample mean is 0.0995 with a standard deviation of 0.3646).
5. While our R^2 values seem "low", they are actually higher than the 0.099 value found by Hashimoto [1982] for a sample restricted to young white males, even though our sample includes men and women with unrestricted variations in age, and is therefore more heterogeneous.
6. We have included an interaction of establishment size and OJT (*TRAIN* x *LSIZE*) in the wage growth regression to allow the effect of OJT on wage growth to differ by size across establishments. Our model predicts a negative sign on this term, i.e., if larger employers pay for a higher percentage of OJT, a given volume of OJT should have a weaker effect on wage growth in larger establishments. Yet we see (Table 3) that the effect is essentially zero. While we cannot be sure why the differential

OJT effect is insignificant, one possible explanation might be that OJT in larger establishments is more of an ongoing aspect of the employment relationship than in smaller establishments, so that OJT during the first three months of employment more significantly understates total OJT in larger than in smaller plants. If this supposition is correct, an otherwise negative interaction effect might be biased upward by unobserved higher levels of continuing OJT in larger establishments after the first three months of employment acting to increase the wage growth.

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