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ABSTRACT

Using information on time costs of training and gains in wages attributable to training, rates of return on training investments were compared. The range of estimates based on several data sets generally exceeds the magnitude of rates of return usually observed for schooling investments. It is not clear, however, that the difference represents underinvestment in job training. Two methods were used to estimate total annual costs of job training in the U.S. economy for 1958, 1976, and 1987. The "direct" calculation uses information on time spent in training and on wages. For 1976, costs so calculated amounted to 11.2 percent of Total Employment Compensation, which is about half of the costs of school education. In the "indirect" method, training costs were estimated from wage functions fitted to Michigan's Panel Study of Income Dynamics data. In 1976 the direct estimate amounted to between 65 percent and 80 percent of the indirect estimate based on the wage profile. The result provides strong support for the human capital interpretation of wage profiles. The estimates indicate a slower growth of training than of school expenditures in the past decades. Substitution of schooling for job training is a likely cause. (Twenty-eight references and five tables are included.) (Author/NLA)

JOB TRAINING: COSTS, RETURNS, AND WAGE PROFILES

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PREFACE

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Abstract

Using information on time costs of training and gains in wages attributable to training, I computed rates of return on training investments. The range of estimates based on several data sets generally exceeds the magnitudes of rates of return usually observed for schooling investments. It is not clear, however, that the difference represents underinvestment in job training.

Two methods were used to estimate total annual costs of job training in the U.S. economy, for 1958, 1976, and 1987. The "direct" calculation uses information on time spent in training and on wages. For 1976, costs so calculated amounted to 11.2% of Total Employee Compensation, which is about half of the costs of school education. In the "indirect" method, training costs were estimated from wage functions fitted to PSID data. In 1976 the direct estimate amounted to between 65% and 80% of the indirect estimate based on the wage profile. This result represents strong support for the human capital interpretation of wage profiles.

The estimates indicate a slower growth of training than of school expenditures in the past decades. Substitution of schooling for job training is a likely cause.

1. Introduction: Background

The emergence of job training as an observable—albeit still a fragmentary one—has the potential of filling some important gaps in the empirical analyses of human capital investments and of related wage structures. It enables us to pursue questions which were not amenable to research in the past. Thus, while a vast literature, accumulated over several decades, contains a wealth of findings on volumes and on profitability rates of educational investments, corresponding estimates of job training investment could not be constructed. Instead, growth of earnings over working age, known as the "experience wage profiles," was assumed to reflect returns on workers' investments in the labor market, especially in job training. Indeed, a first (and last) indirect estimate of on-the-job training costs by schooling level and in the aggregate was obtained using this interpretation nearly three decades ago (Mincer, 1962).

Job training was used as a latent variable not only in analyzing shapes of wage profiles but also in the study of labor mobility, or turnover. In particular, turnover and slopes of wage profiles were linked in a hypothesis according to which training affects both: On the assumption that some degree of firm specificity usually attaches to on-the-job training, we may conjecture that, on average, the more training a worker receives, the more it tends to be specific to the firm. Consequently, with more training the worker's wage profile is steeper and turnover slower. This "duality hypothesis" was proposed in a paper coauthored with Jovanovic in 1981. In the absence of empirical data on job training or learning, the duality hypothesis provides insights into labor market behavior, as was shown in that paper as well as in a more recent study (with Higuchi, 1988). The latter compares wage structures and labor turnover in Japan with those in the U.S. The negative relation between slopes of wage profiles and labor turnover is shown to hold across industrial sectors within each country. Much larger investments in job training in Japan were adduced to generate both the steeper Japanese wage profiles and the much stronger attachment to the firm in Japan.

As usual, the absence of direct information leads to a proliferation of theories. Thus, the lack of direct evidence on job training stimulated the development of alternative theories that attempt to explain upward slopes of wage profiles as devices to economize on costs of supervision (Becker and Stigler, 1974; Lazear, 1979), or turnover (Salop and Salop, 1976), or as consequences of job sorting or job matching of new hires (Jovanovic, 1979).

The recent growth of information on job training in several data sets has led to empirical studies of the effects of training on wage growth.[1] In my own work, information available in the University of Michigan's Panel Study of Income Dynamics (PSID) was brought to bear on the duality hypothesis. Job training magnitudes were explored as a factor in wage growth and in labor mobility in a National Bureau of Economic Research (NBER) Working Paper (1988): Using information on timing and duration of job training among PSID men, I found negative effects of training on turnover and positive effects on wage growth in the firm and over longer periods transcending tenure in one firm. The positive correlation between general and specific training which explains these results also explains the apparent paradox that, despite wage gains in moving, frequent movers' wages grow less in the long run than those of less frequent movers.

Another effect of job training which has been observed is the reduction in the incidence of unemployment among workers who receive training. This is a corollary of the reduced turnover, as close to half of firm separations involve unemployment. Finally, there are two important observations bearing on the determinants of job training: (1) Workers with more years of schooling are more likely to engage in job training,[2] and (2) more training is provided in industries in which technological progress is faster.[3]

The potential significance of these initial research accomplishments is of a high order: (1) They indicate that human capital analyses of labor market behavior based on proxies for post-school training hold up when direct measures of such training are used. (2) The documented link between training, schooling, and technological change directs attention to the sources of demand for human capital and to its role in economic growth.

As we reach better, empirically based insights into the effects and determinants of job training, it is necessary to return to a task that I attempted in an indirect fashion in 1962: to estimate the extent and profitability of private sector job training, this time based on direct, albeit imperfect information.

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[1] See section 2 below.

[2] All studies described in section 2 found this positive relation. See also the data in the Time Use Study shown in Table 3.

[3] See Lillard and Tan (1986) and Mincer (1989).

Although precise estimates cannot be hoped for, given the quality of current data and the conceptual complexities, orders or ranges of magnitude are feasible, and should yield insights into important issues.

This is the primary purpose of the present study. At a time when concern is raised about the quality of the American workforce and statements about underinvestment in human capital abound in public rhetoric, an attempt at comprehensive estimates of volumes of investment and of their profitability is a prerequisite for public discussion. Another objective of this paper is to compare the directly estimated magnitudes of training investments with indirect estimates obtained from wage profiles, as was done in the 1962 study. Such comparisons can help in gauging how much of the growth (slope) in the wage profile is attributable to observable training processes. If the magnitude is significant, a link between the direct and indirect estimates can be used to infer changes in training investments over time.

2. Data Sources and Related Literature

Direct information on the incidence, timing, and duration of job training is available in several data sets. The information represents responses, mainly from household surveys, to questions about formal or informal job training or learning in the firm or outside the firm during the preceding year. The questions are phrased differently in the various surveys, both in detail and in degree of subjectivity. Nevertheless, the elicited information makes possible qualitative and quantitative estimates from which a degree of consensus may emerge.

The available data on job training suffer from poverty amidst plenty. Table 1 indicates both the proliferation and the shortcomings of the data. Although concentrating on one consistent source of data would provide single-valued results, I attempt in addition to draw on results based on various data sets to gauge a degree of robustness, if any.

Table 1
Information on Job Training[1]

Data Set	Coverage	Incidence	Duration of Spells	Duration in Hours
CPS	1983 survey All workers Cross-section	During current job	Not available	Not available
PSID	Question on current job asked in 1976, 1978, 1985 All males	Dates estimated within current job	In months	In a separate 1976 survey
NLS Previous Young Cohort	A number of periods Young males	Variable survey periods	Not available	Not available
NLS New Young Cohort	A number of periods Young males	Over 3 years	In weeks	Not available
EOPP	Young male new hires at low wages 1980-1982	Within 3 months after hire	Within 3 months	Available, incompletely

[1] Available and utilized in the references. More information and broader coverage may exist in the data sets.

The PSID, an annual survey of about 5,000 households, provides usable information on job training for about 1,200 male heads of households in 1976, 1978, and 1985. The information covers the length of time of training required during the current job, as well as its learning contents in 1976.[4]

[4] One question asked was: "On a job like yours, how long would it take the average new person to become fully trained and qualified?" This question followed another about training prior to the current job, therefore intending to measure training attached to the current job. Another usable question was whether the current job provides "learning which could help in promotion or getting a better job."

Information on intensity (hours per week) of training is available in a supplementary time study of PSID workers by Duncan and Stafford (1980). The PSID data have been analyzed by Duncan and Hoffman (1978), Brown (1988), Gronau (1982), and Mincer (1988a).

The National Longitudinal Samples (NLS) surveys covering several thousand households conducted at Ohio State University contain annual or biannual information on job training for two cohorts of young men (aged 14 to 24 in 1968, and in 1979), and for mature men (aged 45 to 59 in 1968). The new (1979) cohort of young men contains information on the duration of a spell of training. In-house training reported in the 1968 cohorts has been studied by Lillard and Tan (1986). The new young cohort has been analyzed by Parsons (1986) and Lynch (1988).

The Current Population Survey of the U.S. Census, the largest periodic sample of US households, contains the incidence of training in its March '83 survey. The data have been analyzed by Lillard and Tan (1986).

Finally, the 1982 EOPP (Equal Opportunity Pilot Project) is the only survey of employers (about 2,000 in 31 areas). It provides information on hours of training of new hires during the first three months on the job. These data have been described and analyzed by Lillard and Tan (1986), and Barron, Black, and Lowenstein (1989) and reanalyzed by Holzer (1989).

In my work with the PSID (1988a), I compared year-by-year wage growth of workers in the 1976 firm in periods with training with workers and periods without training. The effect of a year with training on wage growth in the 1976 job was 4.4%, using the 1968-82 annual PSID surveys. No other variables had much of an effect on wage growth, except for a small negative effect of prior experience.

The effect of training on wage growth was greater (9.5%) at younger ages (working age 12 years or less) than at older ages (3.6%). The difference reflects greater intensity of training among young workers, as is shown in the Duncan and Stafford (1980) time study (see Table 3).

The findings that wage growth decelerates with age because training does, and that no other variable appears to affect individual wage growth, indicate the importance of job training or learning in producing the typical upward sloping and decelerating wage profiles over working lives.

The same conclusion is reached in a study by H. Rosen (1982). Using the 1976 PSID data, Rosen divided the sample into two groups: workers who received training during the year and those who did not. (Cross-sectional) wage profiles were steep and concave in the first group, and very flat in the second. This suggests, once again, the importance of job training or learning in creating the typical shapes of wage profiles.

As with the PSID, all the studies based on other data sets found positive and significant effects of training on wages and on wage growth.

Barron, Black, and Lowenstein (1989) use the EOPP survey of over 2,000 employers located in 31 areas across the country. They measure training in hours spent in training by new hires and by their supervisors and co-workers during the first three months of employment in the firm. The mean training hours were 151 in the three months. They report that in a two-year period, training raised wages by 15%, or 7.5% per year. It will be recalled that a year of training in the PSID raised wages of young workers, whose average age was about the same as the new hires in the EOPP, by 9.5%, and by 3.6% for workers who, on average, were 15 years older, and who had correspondingly smaller intensity (hours per week) of training. This is also consistent with the 9% effect per year found by Brown (1988) for new hires who had no previous training.

Holzer's (1989) reanalysis of the EOPP data yields a smaller wage growth effect of 4.7%. Lynch (1988) uses the new young cohort of the NLS. Here information is available on all training spells of recent male entrants into the labor force during the 3-year period 1980 to 1983. She finds that wages of young workers with job training during the year rose by 11%, while an additional year of tenure without training increased wages by 4%, the net effect is therefore 7%.

Lillard and Tan (1986) also find significant effects of training on wages in the CPS and in the 1963-1980 young cohort of the NLS. In the CPS (their Table 4.1), company training raises wages by

11.8%; in the NLS (their Table 4.5), job training raises wages of young workers by 10.8% initially, but the effect declines subsequently.

In sum, estimated effects of an additional year with training appear to range from 4.4% in the PSID for all new hires to 9% for young workers in the PSID, 7% for the new young cohort in the NLS, and 11% for the previous young cohort in the NLS. The 12% "effect" for CPS men is a cross-sectional finding that trainees have higher wages than non-trainees, but it takes no account of the pretraining wage. It is not included in the profitability analysis in Table 2.

Table 2
Rates of Return on Investments in Job Training

Data Set	$\dot{w}$	k	r^1	r(workers)		Average Tenure	Upper Limit of r(employers)[5]
				d=12%	d=4%		
PSID[1], All Males	4.4	.15	29.3	12.8	23.5	8	23.6
EOPP[2] Young New Hires	4.7	.20	23.5	8.7	18.5	3	10.8
NLS_1[3], New Young Cohort	7.0	.22	31.8	16.0	26.5	3	17.4
NLS_2[4], Previous Young Cohort	10.8	.25	43.2	26.0	37.5	4	25.9

[1] Based on Mincer (1988a); k from Duncan and Stafford (1980).
[2] Based on Holzer (1988).
[3] Based on Lynch (1989).
[4] Based on Lillard and Tan (1986); k from Duncan and Stafford.
[5] $r = r^1 [1 - (1/1 + r^1)^T]$

In Table 2, $r^1 = \frac{\dot{w}}{k}$; $r = \frac{\dot{w}}{k}(1-d)-d$; *d = depreciation rate.*

3. Profitability of Job Training Investments

Table 2 presents the rates of return on investments in job training. Prima facie, these estimates of effects of a year with training on wage growth (column 1) are comparable to effects of an additional year of schooling at the average level of schooling. Yet, viewed as measures of profitability, or as rates of return on the cost of job training (column 3), these numbers appear to be much too large.

The reason is that job training is not a full-time (full-year) activity. If it takes 25% of worktime during an average week of a year with training, the rates of return on worker opportunity costs are four times higher than the estimated rates of wage growth.

Let $k = h/H$, the fraction of work time devoted to job training. Here h is hours of training during the period (week, month, or year) and H average hours of work during the period. Let w_0 be the pretraining and w_1 the posttraining wage. Then the (uncorrected) rate of return on training is $r^1 = (w_1 - w_0) \cdot H/w_0 \cdot h$. Here the numerator is the annual dollar increase in earnings, the return on the investment, while the denominator is the opportunity cost of training. Let $\dot{w} = w_1 - w_0/w_0$ be the percent increase in wages due to training; then the (uncorrected) rate of return is $r^1 = \dot{w}/k$. The first three columns of Table 2 show estimates of $\dot{w}$, k, and r^1 based on the PSID, the EOPP, and the two young cohorts of the NLS.

The r^1 rates appear to be implausibly high. However, they need to be corrected downward, if skills acquired in training depreciate, and if the payoff period is short. The latter factor may be ignored, as the median age of trainees is about 30, so that, without depreciation, and with largely transferable training, the payoff period may exceed 30 years. Depreciation, however, can be substantial, as suggested by Lillard and Tan (1986). For the previous NLS young cohort, they estimate an initial wage gain of 10.8% due to training and a subsequent decline of 1% per year during years since training. This translates[5] into a 12% exponential rate of decline due to depreciation in returns per year.

My attempts to estimate a depreciation rate in the PSID using the Lillard and Tan procedure yielded a barely significant depreciation rate close to 4%. This much smaller figure in the PSID may be due to the broader coverage of all males, compared to younger males in NLS: If training has

[5] Half of the gain vanishes in 5.4 years according to the linear estimate. A depreciation rate (d) of 12% produces a half-life of 5.4 years: d is solved from $(1-d)^t = .5$, where $t = 5.4$.

substantial elements of specificity, mobility would create wage depreciation. Since mobility of young workers exceeds substantially the mobility of older workers, a smaller depreciation rate in the PSID may be reasonable. If the training is largely general, the difference is less plausible. Consequently, I show rates of return corrected for depreciation rates which range from 4% to 12% in columns 4 and 5 of Table 2. To the extent that mobility affects the depreciation rates (d), the higher values of d are applicable to the young groups, and the lower ones to the PSID, which covers all workers.

The estimate of corrected rates of return (r) is obtained as follows: Given the annual depreciation rates (d), equate costs or foregone earnings while training (kw) to the present value of the stream of gains (Δ w) the first year following training,

$$\Delta w \frac{1-d}{1+r} \text{ the next year,}$$

$$\Delta w \left(\frac{1-d}{1+r}\right)^2 \text{ the year after, and so on):}$$

$$kw = \Delta w \left[\frac{1-d}{1+r} + \left(\frac{1-d}{1+r}\right)^2 + \ldots\right] = \Delta w \frac{1-d}{r+d}$$

or

$$\frac{kw}{\Delta w} = \frac{k}{\dot{w}} = \frac{1-d}{r+d}$$

$$\text{It follows that corrected } r = \frac{\dot{w}}{k} \cdot (1-d) - d$$

The rates of return vary widely, depending on the assumed depreciation rates and the data source. On the whole, they exceed the rates usually estimated for schooling investments, especially if the depreciation rates are relatively low.

These figures reflect the profitability of *worker* investments in job training.

The profitability of *employer* investments in training is not necessarily the same, even if r^1, the short-run gain on a dollar invested in training, were the same for employers as for workers. It clearly depends on the trainees' length of stay in the firm as well as on depreciation. Assuming no depreciation and firm tenure of T years, the return on the firm's investment in training is reduced by $[1-(1/1+r^1)^T]$, compared to returns accruing over life-time employment of trainees. Therefore, the rate of return, accruing over T years of tenure is reduced to $r=r^1 [1-(1/1+r^1)^T]$. Column 7 of Table 2 shows estimates of corrected rates of return to employers under these assumptions, given estimated average tenure (T) of trainees. These estimated rates are quite sizable, but they are still overestimates if depreciation (obsolescence) takes place during the trainees' stay in the firm, as is likely. If so, employers' profitability rate may be reduced substantially below the upper limits in column 7 of Table 2. In other words, these upper limits suggest that if depreciation is disregarded, average worker mobility would not produce a strong deterrent to investment in training by firms.

Thus, the question regarding over- or underinvestment in training by employers appears to hinge both on labor mobility and on depreciation rates of such human capital. Underinvestment cannot be diagnosed if both are substantial. Note also that marginal rather than average rates of return (of Table 2) are required for such diagnoses, and the marginal rates are likely to be lower. More research is needed on these factors affecting profitability as well as on proper measures of time and other resources spent in training and on proper econometric estimates of wage gains attributable to training. As to the measures of time and resources, information from much larger samples is needed than that of the 1976 Time Use Study, and employer information for the same workers needs to be matched.

4. Estimating Volumes of Annual Job Training Investments

I proceed to estimate economy-wide annual volumes (flows) of worker investments in job training, measured in opportunity costs. To estimate these costs, we need to know the number of workers engaged in training in the survey period ($n = p \cdot N$, where N is the total workforce and p the proportion of workers engaged in some training or learning on the job), the time (h = hours) they spend in training during the period, and their hourly pre-training wage (w_o). The total worker opportunity costs of training are then the product $C_w = w_o\, h\, p\, N$. Information on such statistics for a sample of the whole U.S. labor force is available only in a PSID survey of Time Use at Work during a week in 1976 (Duncan and Stafford, 1980), a part of which is shown here in Table 3. Information on hours spent in training by new hires during the first three months is available in the EOPP survey and in weeks in the new NLS young cohort. Both cover subgroups of new labor force entrants rather than the whole labor force. The CPS is a large national survey with information on the incidence but not on the hours of training.

Table 3
Time Use in Training
(Survey Week, 1976, PSID, All Workers)

Group	Hourly Wage Rate	Whether Any	On-the-Job Training Mean Weekly Hour		Sample Size
Age:	(1)	(2)	Jointly with Production (3)	Separate from Production (4)	(5)
<25	3.68	.76	9.5	3.2	50
25-34	5.55	.72	7.5	1.8	139
35-44	6.19	.58	6.4	1.7	80
45-54	6.69	.48	2.1	1.3	56
55-64	6.26	.29	2.6	0.4	42
Education (Years):					
0-8	4.08	.39	2.8	0.3	26
9-11	4.47	.56	6.9	1.3	36
12	4.79	.59	8.2	1.4	147
13-15	5.44	.71	6.5	3.2	80
16+	8.33	.58	5.7	1.5	85

Source: Duncan and Stafford (1980), Table 3, Col. (3)--Hours of Training Joint with Production.

Table 4 applies the data from the 1976 Time Use Survey to calculate weekly worker opportunity costs of training on the job, by age groups. The first three columns on wages (w), hours (h), and incidence (p) of training are taken from Duncan and Stafford (1980), here shown in Table 3. Column 4 contains BLS national employment figures (by age) for 1976. Column 5 shows total costs per week; it is a product of columns 1 through 4.

Table 4
Worker Opportunity Costs of Job Training, 1976

Age	Hourly Wage (w_a) (1)	Hours of Training per Week (h) (2)	Percent with Training (p) (3)	Number of Employees (N-millions) (4)	Costs ($mil) per Week ($w_a hpN$) (5)
<25	$3.7	6.4	76	20.0	360
25-34	5.6	4.3	72	22.5	390
35-44	6.2	3.8	58	16.5	225
45-54	6.7	2.2	48	16.1	114
55-64	6.3	1.1	29	10.9	22
				Total Cost	$1,111

Sources: Col. (1), (2), and (3) from Duncan and Stafford, Table 3 here.
Training hours in col. (3) calculated as sum of separate hours in training and one-third of hours spent jointly in training and production.
Col. (4) from Employment and Earnings, BLS, 1976.
Col. (5) is the product of col. (1) through (4).

Statistics on time spent in training by trainees both understate and overstate the time cost of training: They understate it because not only the time of trainees but also that of co-workers and of (formal or informal) instructors is spent in the process. They overstate the costs to the extent that training is joint with production and the marginal product is positive. It is the loss of production during training that represents pure training costs. Thus, if production during training is half of that achieved without training, half the work time with training should be counted as training time. The PSID Time Use Survey leaves out time spent by workers other than trainees.[6] These additional time costs plus the costs of materials do enter the picture implicitly when we turn to the question of how total costs are shared by workers and employers. The Time Use Survey does, however, list separately the hours trainees spent in training with and without production (columns 3 and 4 in Table 3).

[6] The time contributions of other workers are listed in the EOPP (Bishop, 1989).

Weekly hours spent in training by trainees were obtained as a weighted sum of these two components: Only one third of time spent jointly with production was considered as a loss of production, hence as pure training. This is a conservative estimate, but not far off the mark, judging from the work of Bishop (1989). The sum adds up to roughly 4 hours a week per trainee.[7] Thus, the average wage in the age group is an approximate estimate of a pretraining or nontraining wage of trainees.[8] The estimates are made separately by age groups, as all components vary systematically with age, then summed to obtain a total of $1.11 billion per week, or $57.7 billion per year in 1976.

Expressing this figure as a fraction of the total wage bill (Total Compensation), which was $1.04 trillion in 1976, yields a 5.6% figure. If the fraction of work time spent in training did not change over time,[9] so that the same ratio held in 1987, it would amount to $148 billion in 1987 dollars.

Worker investments represent a part of total investment in job training. Employer investments are the other part. How large are these? Accounting data from employers usually provide costs of formal training programs. That these account for a smaller part of the total is apparent from a recent survey conducted by Training Magazine, in which the average time a recipient spent in such a program per year was 32 hours, much less than the 150 hours in 3 months in the EOPP or the 11 weeks per year in the NLS or the close to 200 hours per year in the 1976 Time Use Study. But even if such data were complete and also covered informal training, it is not at all obvious that these are costs borne by firms, that is, that they are not offset by reductions in wages or in wage gains of workers. A nearly complete offset would indeed be expected if skills enhanced by training received in the firm were easily transferable to other firms. Firm specificity in training would, of course, enable and indeed compel firms to bear additional costs to those of workers. In principle, the best way to assess how much firms invest is to compare increases in productivity resulting from training with increases in

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[7] This is an average for all workers, including women. For men alone, average hours are closer to 6. The profitability estimates in Table 2 were calculated for men for whom wage gains were estimated in the PSID.

[8] Even if all their opportunity costs were financed by trainees, training costs would be underestimated by no more than 6%, according to the Time Use data.

[9] A preliminary estimate of the average time spent in training in the 1985 PSID sample is quite close to that in 1976.

wages. If productivity increases more than wages, the excess is the return on costs borne by the firm. Two recent studies using very different data and approaches suggest that the productivity increase is about twice that of the wage increase caused by training. This is found by Barron et al. (1989) in the EOPP data, where a productivity scale is used to gauge the increase. Blakemore and Hoffman use aggregate production and turnover data to estimate effects of tenure on wages per hour and compare these with effects of tenure on output per hour. They find a similar doubling of productivity compared to wages.

If the estimates of productivity effects are correct and rates of return on training similar for workers and firms, total volumes of job training investments should be doubled to $115 billion in 1976 and to $296 billion in 1987.

It is of interest to note that the survey of companies (with 100 or more employees) published in Training Magazine (1988) reported expenditures on formal training programs of about $40 billion in 1987. Based on a Columbia University survey of a national sample of firms, Bartel (1989) reports a larger figure of $55 billion in 1987. These estimates clearly leave out the apparently much larger expenditures on informal training processes. Thus our conservative estimate based on the 1976 Time Use Study suggests that trainees spent an average of 4 hours per week or close to 200 hours in training per year, which is over six times the number of hours (32) reported for formal training by Training Magazine. If the hourly costs of training were the same for formal and informal training, a global estimate based on formal training costs alone would be $240 billion or $330 billion, depending on which survey in used. Our figure of $296 billion for 1987, estimated in an entirely different manner, is very much within the range of such estimates. We should remember, however, that the validity of our estimate for 1987 depends not only on the correctness of the calculation for 1976 in Table 4 but also on the proposition, based on some empirical evidence, that returns and probably also costs of training were shared equally by workers and employers, and on the conjecture that average time (per worker) spent in training did not change between 1976 and 1987 (see note 9).

5. Comparing Direct with Indirect Estimates of Training

Extrapolating our estimate of 1976 worker training costs back to 1958 in the same manner as we did in the 1987 extrapolation, that is, assuming that the time spent in training (per worker) did not change, yields a figure of $14.4 billion for 1958. This "direct" estimate for the whole work force compares closely with the indirect estimate of $13.5 billion obtained from wage profiles for the 1958 male labor force (Mincer, 1962, Table 2). Adding another 10 to 15% for costs of women's training would have raised the 1958 indirect estimate for the whole work force to about $16 billion.

The closeness of the two estimates is rather surprising. It would imply that at least[10] 90% of the observed growth in the wage profiles (summed by education levels in the 1958 data) is attributable to training on the job! If other factors affect wage growth positively, and theories to that effect were cited earlier, the extrapolation back to 1958 of the 1976 training ratio is likely to be too high. At the same time, if depreciation of human capital is important, the indirect (based on wage profiles) estimate may be an underestimate merely because it estimates net investments, while the direct training costs measure the larger gross investments.

The basic assumption that the same fraction of work time was devoted to training in 1958 as in 1976 may also be questioned, on the following grounds: All studies (listed earlier) show a net positive relation between education and the incidence of or the time spent in training. This relation reflects the fact that persons who have greater learning ability and better opportunities to finance human capital investments invest more in all forms of human capital, including schooling and job training. Moreover, schooling is often a basis from which job training starts and better schooling may impart a greater ability to learn on the job. If training is affected by schooling, we would expect that an expansion of schooling would bring about an expansion of training. Thus, the expansion of schooling between 1958 and 1976 suggests that training volumes, measured as a proportion of work time should have been less in 1958 than in 1976 rather than equal as the extrapolation assumed.

Data in the 1976 Time Use Study also indicate (Table 3) that hours spent in training increase with schooling.[11] Workers with less than high school spent a little over a half the hours in training that more educated workers did. The size of the two groups in the labor force was about equal in 1958, but the group with less than 12 years shrank to 25% of the labor force by 1976. Hence, average

[10] According to calculations in PSID data, job mobility accounts for about 15% of the growth in the wage profiles of males (Mincer, 1988a). Thus, the figure of $16 billion is an overstatement.

[11] Table 3 shows the gross relation with schooling, rather than the net effect discussed in the preceding paragraph. For the purpose of the calculation here, the gross relation is appropriate.

hours of training would have increased by over 15 percent if hours within each education level remained fixed. If so, the $14 billion in 1958 should be corrected downward to $12.2 billion. Even the reduced estimate suggests that over 75% of the growth observed in the wage profiles can be attributed to job training!

However, a positive relation between education and training does not mean that they are related in fixed proportions. To the extent that an (exogenous) expansion of education leads to a substitution of school education for job training, education may grow faster than job training. Indeed, (direct) educational expenditures grew from 4.8% to 7.1% of GNP between 1958 and 1976. If substitution was present, job training grew more slowly than education, suggesting that hours of training declined within school groups. In the aggregate, therefore, time spent in training may not have grown over the period, in which case the initial extrapolation may be valid.

The comparison of direct and indirect estimates is less problematic if carried out for the same year. This requires a calculation of job training costs based on the 1976 wage profile. The use of a parametric wage function (Mincer, 1974) makes such calculation much less laborious than was necessary when the 1958 data were analyzed (Mincer, 1962). The human capital earnings functions contain, among other variables, years of work (experience), variable X, which enters in a nonlinear fashion. Its coefficients are interpretable as postschool human capital investment parameters. On the assumption that time spent in investment declines linearly as working age increases, the expression is:

$$\ln w = Z + rk_o X - (rk_o/2T) + \ln[1-(k_o/T)X]$$

Here Z is a set of other independent variables, while k_o is the fraction of earnings devoted to human capital investments in the early working age, T the period in the working life at which investments cease, and r the rate of return on the net investments.

In a recent paper, Rosen (1982) estimated these parameters from the 1976 PSID for the male sample. He found $k_o = .32$, $T = 26$, and $r = 12\%$. Assuming that investments of a typical woman worker (in terms of k, or time) are half as large, k_o for all workers is a weighted average of the male and female investment ratio, the weight being total earnings ($N \cdot w$) of each. Since the female work force was 2/3 the size of the male workforce, and earnings per woman worker 60% of male earnings, the weights are 1 to .4, yielding a k_o of .27. Since T = 26, k falls approximately .01, or 1% per year. Thus investments cease at about age 44. Average k in each age group is shown below:

Calculation of 1976 Worker OJT Investments
Derived from Wage Function

Age	Mean Age	k	Nw	Nwk		
<25	22	.23	74	17.0		
25-34	30	.15	126	18.9		
35-44	40	.05	102	5.1		
45+		0	182	0	**Ratio**	**Dollars**
Total			484	41.0	8.5%	$88.4 billion

Sources: k estimated from Rosen (1982); N and w from Table 4.

The ratio of training investments to wage per hour is $\Sigma Nwk/\Sigma Nw = 41/484 = 8.5\%$. This is higher than the direct estimate of 5.6%. We may say that job training costs in 1976 account for 5.6/8.5 = .66 or 66% of observed growth in the wage profile in that year. Translating the 8.5% ratio to dollar figures by applying it to total compensation of workers in 1976 (it was $1,040 billion) yields a figure of $88.4 billion for the cost of worker training based on wage profiles. This figure is reduced to $75 billion if 15% of the estimate based on wage profiles is attributable to job mobility[12] rather than training. Direct estimates of annual worker investments in training, in Table 4, amounted to $58 billion in 1976. The comparison with the $75 billion figure estimated by the wage function suggests that three-quarters (75%) of the growth in the wage profile can be attributed to worker investment in training in 1976. This conclusion is supported by another piece of indirect evidence contributed by Rosen (1982). The PSID sample was divided into two parts: workers who received some training in

[12] See note 10.

1976 and those who did not. Wage functions of the form indicated above were estimated for each group. The estimated k_o for the group without training was less than a third the size of the k_o for the group with training. Indeed, the experience wage profile was very flat in the no-training group.

Since new information on training was provided in the 1978 PSID survey, I replicated the procedure for that year. The linear (B_1) and quadratic (B_2) coefficients on experience (x and x^2) were:

Group	B_1	B_2
With some training in 1978	.0226	-.00027
	(10.2)	(5.6)
No training in 1978	.00686	-.000082
	(1.7)	(.8)

Note: t-ratios in parentheses.

The growth of wages over a year is (B_1 - $2B_2$ X). It is over three times as fast for any given working age in the group with training as compared to the group without training.

It is noteworthy that three entirely different methods of estimating volumes of job training yield comparatively similar figures, as shown in Table 5.

It is also interesting to note that by 1976 directly estimated job training costs (see columns marked b) amounted to about half of schooling costs (direct and opportunity costs). In the 1962 study the ratio for 1958 appeared to be higher (first row of Table 5). If a decline in the ratio actually occurred, the substitution of schooling for training may have been dominant. Apparently, increased public expenditures on schools (including especially the growth of 2-year colleges) moved relative prices against training.

The comparison of direct and indirect estimates of job training investments summarized in Table 5 for 1976 (where no extrapolation is involved) suggests that OJT investments account for more than two-thirds of the observed growth in the (cross-sectional) wage profiles. This represents strong support for the human capital interpretation of the wage profile. As suggested in the introduction, an empirically substantial link between wage profiles and training volumes can be used to infer changes

Table 5
Estimates of Job Training (OJT) and of Its Ratio to Total Compensation (TC)

	OJT ($billions)			**OJT/TC**			**School/TC**
Workers[1]	**(a)**	**(b)**	**(c)**	**(a)**	**(b)**	**(c)**	
1958	16.0	14.4		6.2%	5.6%		8.3%
1976	88.4 (75.0)	57.7		8.5 (7.2)	5.6		11.7
1987		148.0			5.6		11.3
Total[2]							
1987		296.0	240.0		11.2%	9.0%	22.6%
1987			330.0			12.4	

[1] Upper Panel: Worker Investments in OJT, School Direct Expenditures
[2] Lower Panel: Worker and Employer Investments in OJT, School Direct Opportunity Costs

(a) OJT estimates derived from wage profiles. 1976 estimate (in parenthesis) is adjusted for wage growth attributable to job mobility.
(b) OJT estimates based on time spent in training in 1976.
(c) Two OJT estimates based on costs of formal training in 1987, multiplied by ratio of time in all training to time in formal training.

in training investments over time. Such changes cannot be observed directly, as training data are reported only sporadically and fragmentarily. Whether and in what way job training was a factor in the pronounced changes in the wage structures over the past two decades in the U.S. is a question left for future research.

Summary and Conclusions

With information on time costs of training and gains in wages attributable to training, rates of return for training can be computed. A downward adjustment is required, however, as the acquired skills erode due to obsolescence, or, to the extent that the skills are firm specific, to job mobility. The range of estimates based on several data sets generally exceeds the magnitude of rates of return usually observed for schooling investments. Given the data on workers' firm tenure, it appears also that training remains profitable to firms, even in the face of average worker mobility.

The rates of return here calculated may suggest underinvestment in training relative to that in schooling. However, such conclusions must be qualified in two respects: (1) Schooling investments receive heavy public subsidies, which may lead to overinvestment, and (2) returns to schooling contain leisure during school years and lifetime consumption benefits (skills) not included in the calculation. For both of these reasons observed rates of return are lower on schooling than on job training. Another relevant comparison concerns the trade-off between training and labor mobility: Optimal allocation of human resources in the labor market requires equal marginal rates of return in both activities. The image of the U.S. labor market as one in which mobility is rampant and job training modest (in comparison with Japan and Western Europe) does not necessarily imply that the marginal rates are far out of line: Since they are less reluctant to move, American workers may search more intensively for opportunities afforded by job changing than by attachment to a firm. The picture is suggestive, but better data and deeper studies are needed.

A further objective of this paper was to estimate total annual costs of job training in the economy. Three entirely different methods were used to estimate these volumes for 1958, 1976, and 1987. (1) The "direct" method used information on time spent in training and on wages. For 1976, investments so calculated amounted to 11.2% of Total Employee Compensation, and about half of the costs of school education. (2) In the "indirect" method, training costs were estimated from wage profiles, using a wage function fitted to 1976 PSID data. The indirect estimate provides an upper limit, since other factors, job mobility among them, also affect the slope of the wage profile. Indeed, the direct estimate for 1976 is about 75 percent of the indirect estimate once gains due to labor mobility are netted out of the wage growth in the profile. (3) A third method uses information on costs of formal training programs and on average time spent in them and inflates the figures to a total training level. Rather remarkably, the three estimates are not far apart. Of course, the estimate based on wage profiles represents an upper limit.

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