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Abstract

This paper investigates the relationship between education and employer– provided training, both on-the-job and off-the-job, using a unique dataset drawn from a survey of Thai employees conducted in the summer of 2001. The authors find a negative and statistically significant relationship between educational attainment and on-the-job training (OJT) and a positive and statistically significant relationship between education and off-the-job training. Since the marginal monetary returns to OJT increase with education, the negative relationship between education and OJT suggests that the marginal costs of OJT are higher for the better educated, perhaps because the opportunity costs of the time spent receiving OJT increase with educational attainment.

KEYWORDS: education, training

ARE EDUCATION AND TRAINING ALWAYS COMPLEMENTS? EVIDENCE FROM THAILAND

KENN ARIGA and GIORGIO BRUNELLO*

This paper investigates the relationship between education and employer–provided training, both on-the-job and off-the-job, using a unique dataset drawn from a survey of Thai employees conducted in the summer of 2001. The authors find a negative and statistically significant relationship between educational attainment and on-the-job training (OJT) and a positive and statistically significant relationship between education and off-the-job training. Since the marginal monetary returns to OJT increase with education, the negative relationship between education and OJT suggests that the marginal costs of OJT are higher for the better educated, perhaps because the opportunity costs of the time spent receiving OJT increase with educational attainment.

The economic literature stresses the importance of schooling in increasing productivity. Schooling can affect productivity both directly, by improving basic skills, and indirectly, by influencing training. Are the better-educated more likely to receive employer-provided training? A positive association between education and training would stimulate individual productivity but would also have the socially undesirable effect of amplifying initial differences in the individual level of human capital in the labor market.

In a recent review of empirical studies on employer-provided training in the United States and the United Kingdom, Blundell et al. (1999) answered the above question in the affirmative and emphasized the strong complementarity between the three main components of human capital—early ability, formal education, and training. In another review, Leuven (2005) attempted to explain the empirical regularity that more educated workers participate more in training than do less educated workers. One

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The data used in this paper, as well as the full questionnaire, are available for those interested in further scientific research at http://www.kier.kyoto-u.ac.jp/21COE/ADBI-KIERdatabase.html#english. (If the link becomes dated, search for "ADBIKIER Employee Survey on Education and Training for Selected Manufacturing Firms in Thailand and Philippines.") Corresponding author: Giorgio Brunello, Department of Economics, University of Padova, via del Santo 33, 35100 Padova, Italy; giorgio.brunello@unipd.it.

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reason the better-educated receive more training is that they are easier to train (see Blondal et al. 2002). According to Thurow (1975) and Rosen (1976), education improves learning skills and reduces (marginal) training costs. Since optimal investment in training occurs when marginal costs are equal to marginal benefits, a reduction in marginal costs increases investment.[1]

The empirical relationship between education and training can vary, however, with the type of training. Lynch (1992) used U.S. data to distinguish between on-the-job training (OJT) and off-the-job training (OFFJT) and found a positive, statistically significant relationship between education and OFFJT, but no relationship between education and OJT. Focusing on the concept of over-education—which occurs when workers are in occupations that require less schooling than they actually have—Sicherman (1991) found that over-educated individuals received less OJT than individuals with lower education and interpreted this result as evidence that education and OJT are substitutes in the production of human capital. Since over-educated workers are more likely than other workers to quit and move to a more suitable job, employers are less willing to train them in firm-specific skills. Hersch (1991) obtained similar results and argued that the over-educated are less willing, or less able, to learn than are individuals with the suitable level of education.

The existing empirical studies focus mainly on developed countries. Schooling and training, however, are of perhaps even greater importance in developing countries, not only for increasing productivity growth but also for improving health and nutrition and reducing fertility and income inequality (see Berhman 1987, 1999). The current paper investigates the relationship between education and employer-provided training in Thailand, using the results of a survey of Thai employees conducted by a team led by one of the authors during the summer of 2001. The survey is a case study of 1,737 employees belonging to 20 large firms operating in four selected industries in the Bangkok area. These employees completed a questionnaire especially designed to elicit information on earnings, education, training events, and family background.

Following Lynch, in our investigation we distinguish between OJT and OFFJT. The former is carried out in the workplace and is likely to be more specific in its content than the latter, which takes place in the classroom either within or outside the firm.[2]

Empirical Set-up

When training is provided by the firm, a basic tenet of human capital theory is that the privately optimal investment is attained when the marginal costs of training, incurred by the firm during the training period, are equal to the marginal benefits, which are spread from the point of training to the end of the employment relationship. Using F for the flow of OFFJT and O for the flow of OJT, we can represent training incidence or intensity as

$$F_t = b_{0F} + b_{1F}Y_t + b_{2F}E + \mu + \varepsilon_{Ft} \tag{1}$$

$$O_t = b_{0O} + b_{1O}Y_t + b_{2O}E + \mu + \varepsilon_{Ot}, \tag{2}$$

where Y is a vector of controls, both time-varying and time-invariant, μ is a time-invariant individual effect, ε are random errors, and the relationship between years of schooling E and training is made explicit. Equations (1) and (2) can be interpreted as

[1]This view is not supported by a study of employer-provided training carried out by Groot, Hartog, and Oosterbeek (1994) for the Netherlands. These authors found evidence that marginal costs increase with educational attainment and argued that better-educated individuals demand more compensation to participate in training.

[2]The economic literature often distinguishes between general and firm-specific training. While the skills produced by general training are fully transferable, those produced by firm-specific training are more idiosyncratic.

quasi-reduced forms—because education is potentially endogenous—derived from a standard model of inter-temporal profit maximization (see, for instance, Ariga and Brunello 2002).

Training generates private benefits by increasing individual productivity. Since this variable is difficult to observe, however, we follow the literature in assuming that individual earnings are proportional to productivity and estimate the Mincerian earnings function

$$\ln W_t = \alpha_0 + \alpha_1 E + \alpha_2 X + \alpha_3 T_t + \alpha_4 ET_t + \alpha_5 J_t + \alpha_6 EJ_t + \mu + \eta_t, \quad (3)$$

where X is a vector of controls, $T_t = F_t + T_{t-1}$ is the stock of OFFJT, $J_t = O_t + J_{t-1}$ is the stock of OJT, and η is random noise.[3]

Our information on training is available either as a dummy variable (for whether the individual experienced any training event during the reference period) or as a continuous variable (the average number of hours of training per month) with left censoring at zero hours. Assuming that the individual effect μ and the errors ε_F and ε_O are normally distributed, we use either a probit or a tobit model to study training incidence and intensity. In the former case we explicitly take into account the possibility of contemporaneous correlation between errors by using a bivariate probit.

A feature of equations (1)–(3) is that they include unmeasured individual talent μ, which is correlated with educational attainment if the more talented are also more likely to be better educated, a plausible assumption. If education affects the returns to training, but unmeasured talent does not, then a fixed-effects estimator will remove the time-invariant individual effect from (3) and produce unbiased estimates. However, if talent affects the private returns to training, fixed-effects estimation will produce a biased estimate of the impact of education on these returns. To avoid this bias, we have to instrument education in the fixed-effects estimate of the earnings equation.[4]

The training equations (1) and (2) can be treated as limited information simultaneous limited dependent variable models, as in Smith and Blundell (1986), and the correlation between education and unmeasured ability can generate a simultaneous equation bias. We deal with the potential endogeneity of education as follows. First, we assume that unobserved ability is partly the consequence of the genetic and environmental contributions of the family (see Willis 1986; Plug and Vijverberg 2003) and include in the training equations the father's, mother's, and oldest sibling's education[5] and the number of siblings. The underlying idea is that cognitive development in relatively poor economies is affected both by parental education and by nutritional status—see, for instance, Behrman et al. (2003) and Martorell (1997)—and that the latter is determined in part by the resources devoted to each child, which are related in turn to the number of siblings. We also add province of birth dummies, because the local environment matters in the development of individual talent.[6] Even after the analysis conditions on family background and the province of birth, however, residual ability could be correlated with educational attainment. Therefore, we need instrumental variables. Let educational attainment E be given by

$$E = \pi Z + \varepsilon E, \quad (4)$$

where Z is a vector of exogenous variables, which includes individual characteristics such as gender and a third order polynomial in age, family background variables,

[3]These definitions of training stocks assume no depreciation.

[4]We are grateful to an anonymous referee for bringing this issue to our attention.

[5]When the interviewed individual is the oldest, we use the educational attainment of the second oldest sibling.

[6]Although the survey was conducted in the vicinity of Bangkok, the sample employees were originally from 56 (out of 79) different provinces of the country. Regional disparities in income and educational attainment are large.

and province of birth dummies, plus at least one variable omitted from equations (1)–(3).

Our instruments for educational attainment—which we omit from the training and earnings equations—are birth order (a dummy taking the value 1 if the individual is the oldest son or daughter and 0 otherwise), the mother's age at the time of the individual's birth, and the interaction of those two variables. These variables capture household preferences in the decision to provide education to the offspring, and are not related in any obvious way to unobserved ability, once we have conditioned for parental education, the number of siblings, and province of birth. For instance, the older son/daughter may have priority in the allocation of the resources devoted by the household to education. Moreover, very young mothers may value education of the offspring less than do more mature mothers. We focus on the mother rather than the father because the age of the former at the time of the interviewed individual's birth is less likely to be correlated with available household resources—and nutrition—than the age of the latter, due to the lower labor force participation of women, the less accentuated life-cycle pattern of female earnings, or both.

We fit years of education on the variables included in the vector Z and use the Bound F-test to verify whether the selected instruments are jointly statistically significant in the first stage regression. Following Smith and Blundell (1986), we also compute residuals and add them to the explanatory variables in (1) and (2), in order to test whether education can be treated as weakly exogenous with respect to training.

Data

The employee survey on which our empirical investigation is based covers firms belonging to four manufacturing sectors: food processing, auto parts, hard disk drives, and computer components. The latter two industries are high-tech and dominated by subsidiaries of foreign manufacturers. Thailand is one of the largest production locations for hard disk drives and related components, and this industry is one of the country's major exporters (see Doner and Brimble 1998). The first two industries use more labor-intensive production technologies and include a substantial share of domestic firms. Despite being high-tech, HDD and computer firms are also fairly labor-intensive, as production gets outsourced in Thailand from abroad to take advantage of the favorable price of labor.

Although we do not pretend that this selection of industries results in a statistically representative sample, we believe it provides reasonable coverage of Thai industry. Due to research budget constraints, we restricted our attention to firms with plants located in the Greater Bangkok area and with more than 100 employees. Firms in the four industries were approached and asked to participate in the survey. Overall, twenty firms agreed to participate—five in food processing, five in auto parts, six in personal computers, and four in the HDD industry. Each of the firms in the sample had more than 100 employees (in the HDD industry, more than 1,000). After restricting our sample to production workers, technicians, and engineers, we stratified employment in each firm by age and education and randomly sampled employees within each cell, using larger weights for smaller firms.

Each selected employee was interviewed in the summer of 2001 by trained personnel hired by the Thailand Development Research Institute (TDRI), which cooperated in the project. Because the questionnaire was rather lengthy (121 questions), individual interviews lasted, on average, 40 minutes. The questionnaire asked for detailed information on family background, education, previous job experience, current job or position, training, and monthly labor income net of bonuses but including overtime.

The questions on wages and training were asked not only for the reference period of the survey (year 2001) but also for the years 1998–2000. The time framing of some of the retrospective questions was designed to generate predetermined vari-

Table 1. Distribution of Employees by Education, by Industry, and Overall.

	Industry				
Education	*Foodstuffs*	*Computer Electronics*	*Auto Components*	*HDD Components*	*National Average (OECD)*
Primary	0.40	0.00	0.04	0.03	0.75
Lower Secondary	0.19	0.11	0.27	0.26	—
Upper Secondary	0.24	0.46	0.37	0.36	0.16
Tertiary	0.17	0.45	0.32	0.35	0.09

Note: Lower and upper secondary education are aggregated together in the national average.

ables. For example, monthly wages were asked with reference to January of each year, and questions on training incidence referred to the calendar year. Therefore, training in 1999 could be considered as predetermined with respect to wages in 2000, which are measured in January 2000. Our empirical results are based on the sample covering all available years. Since recall data are affected by different types of measurement error (see Beckett et al. 2001 for a review), we also check to see whether restricting attention to the subsample covering only the last year in the sample (2001) makes an appreciable difference.

As noted, we do not have a statistically representative sample, given the selection of industries and the endogenous selection associated with the participation of firms in the project—limitations resulting mainly from the project's budgetary constraints. By the same token, however, the dataset has important strengths: it includes detailed current and retrospective information on family background, education, and different types of training.

Table 1 shows the distribution of employment by education and industry in the sample (columns 1–4) and in the total labor force (column 5). Because our sample excludes agricultural employment, where average educational attainment in Thailand is very low, and includes only firms with over 100 employees and a young labor force—and younger cohorts in medium to large firms are more educated than average—the fact that it is more educated than the Thai labor force as a whole is not surprising.[7] The differences, however, are arresting. The share of employees with only primary education in our sample, for example, is close to zero in three industries out of four and significantly different from zero only in food processing. In Thailand as a whole, this share is as high as 75%. College graduates are 45% of all employees in the personal computers industry, compared to only 9% of employees across the country as a whole.

Table 2 presents summary statistics for a selection of variables in the survey for the year 2001, separately for men and women. Women outnumbered men in the sample, which partly reflects the already mentioned fact that women hold the majority of jobs in Thai export-oriented firms.

The average age of the sampled employees was about 28 years, and their average tenure in 1998, the start of the reference period, was about 2-1/2 years for men and over 3 years for women. Previous labor market experience in 1998, defined as the time spent in the labor market from the start of the first job up to (but not including) the current job, was close to 2 years for both men and women.[8] The vast majority of the employees in the survey had started their current spell and their labor market experience before 1998. For these individuals, tenure and experience after 1998

[7] Another factor is that several firms in our sample are high-tech.

[8] When the current job is the first job, experience is equal to zero.

Table 2. Means and Standard Deviations of the Main Variables, by Gender, 2001.

	Men		Women	
Variable	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Observations	690		1,047	
Wage	14,386	(8,237)	9,347	(5,260)
OJT Incidence	0.55	(0.49)	0.67	(0.46)
OFFJT Incidence	0.67	(0.46)	0.58	(0.48)
OJT Intensity	2.62	(6.66)	3.18	(7.49)
OFFJT Intensity	1.57	(3.04)	0.87	(1.56)
Cumulated OJT	8.95	(22.26)	11.63	(25.9)
Cumulated OFFJT	6.07	(12.59)	3.93	(6.49)
Years of Education	12.90	(2.59)	10.67	(3.05)
Age	28.26	(5.34)	28.09	(6.31)
Tenure in 1998	2.58	(3.53)	3.29	(3.72)
Previous Experience in 1998	2.17	(3.45)	2.28	(3.72)
No. Siblings	3.12	(2.18)	3.36	(2.23)
Father's Education	0.26		0.18	
Mother's Education	0.15		0.09	
Oldest Sibling's Education	0.21		0.09	

Variable definitions. Wage: nominal monthly wage, in baths. OJT incidence: dummy equal to 1 if any OJT occurred in year *h*. OFFJT incidence: dummy equal to 1 if any OFFJT occurred in year *h*. OJT intensity: average duration of OJT in hours per month. OFFJT intensity: average duration of OFFJT in hours per month. Cumulated OJT: sum of OJT intensity from 1998 to year *h*. Cumulated OFFJT: sum of OFFJT intensity from 1998 to year *h*. Father's and mother's education: higher than primary = 1, primary or less = 0. Oldest sibling's education: percentage with college degree. Previous experience in 1998: labor market experience net of tenure in 1998.

are equal to tenure and experience in 1998 plus a linear trend.

The survey asked respondents to indicate their highest attained degree. We convert the answers to years of education by applying to each degree the required number of years of schooling.[9] Average years of attained education in the sample were 12.90 for men and 10.66 for women—statistically significantly higher, for both sexes, than attained years of education across the Thai population.

We collect information both about on-the-job training (OJT) and off-the-job (OFFJT) training provided by the firm after probation. Probation in Thailand lasts up to six months, and training during probation is typically highly structured and standardized within each firm. Therefore, we expect little variation in training incidence and intensity during probation within firms, and virtually no variation once we control for firm effects, as we do in our training regressions.[10] On-the-job training is administered in the workplace by senior employees, supervisors, or instructors and focused on the performance of daily tasks. By and large, this type of training tends to

[9]We set 0 years for no education, 6 years for primary, 9 years for lower secondary, 12 years for upper secondary and lower vocational, 14 years for upper vocational, and 16 years for college or more.

[10]Another reason for excluding training during probation is that training programs for a newly hired employee are conducted mostly before the employee's assignment to a particular section or unit in the firm. We have defined OJT and OFFJT as training taking place, respectively, inside and outside the regular workplace. This distinction does not make sense for new recruits.

Table 3. Means and Standard Deviations of the Main Variables, by Job, 2001.

	Production Jobs		*Other Jobs*	
Variable	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Observations	1,140		597	
Wage	8,915	(4,639)	16,023	(8,851)
OJT Incidence	0.65	(0.48)	0.57	(0.49)
OFFJT Incidence	0.56	(0.49)	0.74	(0.44)
OJT Intensity	3.05	(7.17)	2.76	(6.88)
OFFJT Intensity	0.85	(1.74)	1.73	(2.98)
Cumulated OJT	10.91	(24.92)	9.89	(22.13)
Cumulated OFFJT	3.56	(9.12)	7.13	(10.78)
Years of Education	10.65	(3.00)	13.28	(2.87)
Age	27.46	(6.22)	29.52	(4.91)
Tenure in 1998	2.52	(3.32)	3.94	(4.09)
Previous Experience in 1998	2.38	(3.68)	1.96	(3.47)
No. Siblings	3.22	(2.23)	3.39	(2.21)
Father's Education	0.19		0.33	
Mother's Education	0.09		0.21	
Oldest Sibling's Education	0.10		0.33	

Notes: See notes to Table 2. "Other jobs" include team leaders, foremen, technicians, and engineers.

be more informal and ad hoc[11] than off-the-job training. In the survey, we explicitly excluded learning by doing and learning by watching others because it is virtually impossible to distinguish these activities from regular work.

Off-the-job training is organized by the firm either on or outside the premises, and either during or after standard working hours. While OJT, in our sample, was provided mainly by senior workers in the same unit, team leaders, and foremen (72% of the total), OFFJT was supplied mainly by instructors from professional training centers and from outside the company (86% of the total) and concerned not only daily tasks, but also instruction in the operation of machines and tools, quality control, work standards, and safety regulations.

For each type of training, we asked whether the employee had any training during the reference period, a simple (0,1) dummy, and we also asked about training intensity. We call the former variable *OJT incidence* for on-the-job training and *OFFJT incidence* for off-the-job training. For each individual, training intensity is calculated as the product of the number of training events in each month and the average intensity of each event, measured in hours. Starting with training incidence, we find that 55% of the men in the sample had undertaken some OJT in 2001, compared to 67% of the women.

Interestingly, the opposite holds for OFFJT, with 67% of the men and 58% of the women having received it. In the case of training intensity, we find similar differences by gender and type of training. The number of hours of training per month was 2.62 for men and 3.18 for women in the case of OJT and 1.57 for men and 0.87 for women in the case of OFFJT. Thus, men experienced longer OFFJT and shorter OJT than women. Similar results hold for cumulated OJT and OFFJT, obtained by adding up average monthly hours from 1998 to 2001. Further details on the training questions are in the Appendix, and the entire questionnaire is available upon application

[11]Informal training is difficult to measure. See the discussions in Barron et al. (1997) and Lowenstein and Spletzer (1994).

Table 4. Distribution of Employees by Education.

	Years of Schooling			
No. of Siblings	*<9*	*9*	*12*	*>12*
0–1	6.18	14.61	40.73	38.48
2	8.21	19.57	33.09	39.13
3	8.84	24.39	36.59	30.18
>3	19.34	23.43	33.96	23.27

from the website http://www.kier.kyoto-u.ac.jp (or search for Institute of Economic Research, Kyoto University.)

Turning to family background, we present in the table summary statistics on the father's and mother's education, the education of the oldest sibling (or the next to oldest if the employee was the oldest), and the number of siblings. For ease of presentation, the information on the former two variables is recoded to generate two (0,1) dummies, with 0 indicating primary education or less and 1 indicating higher education. The education of the oldest sibling is expressed as the percentage of individuals with a college degree. It turns out that male employees, who had higher educational attainment than women, also had a "better" family background, with higher average education for both parents and the oldest sibling, as well as fewer siblings.

Table 3 shows the means of the same variables separately for production workers and for team leaders, foremen, technicians, and engineers. As expected, the last of those groups was better educated than the others and received more formal OFFJT and less OJT. In the questionnaire we also asked whether OFFJT was carried out in the establishment premises or outside it, either in a training center, at a supplier, or at a parent firm. Training outside the premises of the establishment was more common for technicians and engineers than for other workers.

We conclude this section by discussing how years of education vary with family background, the number of siblings, and birth order.[12] Respondents had an average of 11.56 years of schooling. This average falls to 11.29 if the father had at most primary education and increases to 12.55 if the father had higher education. A similar range becomes apparent when we focus on the mother's education. The relationship between birth-order position in the household and years of education varies with gender.

The percentage of men aged between 21 and 30 with at least 12 years of education is 66.8% for the oldest son in the household, 60% for the youngest son, and 54.5% for those in intermediate position. The corresponding percentages for women in the sample are dramatically lower, at 21%, 24.9%, and 15.7%, respectively.

Table 4 shows how the distribution of educational attainment varies with the number of siblings. It is clear that the percentage of individuals with low educational attainment is substantially higher when the number of siblings is larger, probably because of stronger competition for household resources in those circumstances.[13]

Results

Training Incidence and Intensity

We estimate a bi-probit model for OJT and OFFJT incidence and a tobit model for OJT and OFFJT intensity, after pooling all available observations over the period 1998–2001 and including in the vector Y in (1) and (2) gender, a third order polynomial in age, firm dummies, and a linear trend and quadratic trend, which capture the influence of aggregate effects.[14] We present our estimates in Tables 5 and 6, which are organized in four columns. The first two

[12]The importance of family background for education in East Asian countries is discussed by Woessmann (2003).

[13]A larger number of siblings can also reflect heterogeneous preferences across parents regarding child quality and quantity within the standard quality-quantity fertility models.

[14]These trends also capture the time-varying effects of experience and tenure.

columns treat years of education as exogenous, and the latter two test the exogeneity of education using the procedure devised by Blundell and Smith (1986).

We implement the exogeneity test by regressing years of education in 2001 on the vector *Z* and by computing the (first step) residuals. Appendix Table A1 reports the key estimated coefficients from this regression, as well as the Bound test statistic. We find that both the mother's age at birth and the individual's birth order had statistically significant effects on education. The sign of the former effect is positive, but turns negative when the individual is the oldest son or daughter. The sign of the latter effect depends crucially on the mother's age: it is positive when mothers are younger than 26, and negative when mothers are older. Finally, a higher number of siblings in the households was associated with a statistically significant reduction in educational attainment.

Since the Bound test is equal to 5.47 (p-value: 0.001), we reject the null hypothesis of no (joint) statistical significance of the additional instruments at the 1% level of confidence. Next, we run the bi-probit model for training incidence and the tobit model for training intensity after adding the first step residuals to each model and test whether this variable is statistically significant.[15] A positive result would reject the hypothesis that education is exogenous for training. It turns out that the estimated coefficients of the first step residuals are never statistically significant at the 0.05 level of confidence. Therefore, we cannot reject the null hypothesis of exogeneity of education in the training equations.[16]

Table 5 focuses on training incidence and shows that individuals with higher education were less likely than others to receive OJT and more likely to receive OFFJT. We also find that the probability of receiving training increased with age. The effects of tenure and experience varied with the type of training, and were negative for OJT and positive for OFFJT. Finally, women were statistically significantly more likely than men to receive OJT.

Table 6 looks at training intensity and confirms the relationship between education, OJT, and OFFJT. The estimates in Tables 5 and 6 refer to the overall effect of education on training, which includes both the direct effect and the effect mediated by the allocation of individuals to jobs and positions. One would like to know, however, whether an individual endowed with higher formal education who filled a given position was likely to receive more or less OJT or OFFJT. To answer this question we need to hold constant the type of position, for clearly different positions require different degrees of training, in both extent and type.

We control for the position held by restricting our sample to production workers, and by excluding team leaders, foremen, and other positions. The results reported in Tables 7 and 8 confirm the qualitative findings of Tables 5 and 6, with the sole exception that the positive effect of education on OFFJT is not statistically significant in the case of training incidence.

Our estimates use four years of retrospective data. A drawback of these data is that they introduce measurement error, as respondents may suffer from recollection problems, which are expected to increase with the period of time between the training spell and the interview and with the detail of the training questions (see Leuven 2005). To minimize the influence of these measurement errors and check the robustness of our results, we replicate Tables 5 and 6 in a subsample that retains only the observations for the last year (2001), and find that the sign of the relationship between years of education and type of training is confirmed. In a further effort to

[15]With panel data, one might expect the error term to be correlated across individuals. With Stata, robust standard errors are easily computed for the bi-probit model. Since this option is not available for the tobit model, we bootstrap standard errors, using 50 replications of the estimates. Bootstrapping uses Monte Carlo simulation to compute adjusted standard errors. See Wooldridge (2001).

[16]Under the null hypothesis that residuals are not statistically different from zero, we do not have to adjust standard errors for the presence of generated regressors. See Blundell and Smith (1986).

Table 5. Bivariate Probit Estimates of Training Incidence, Full Sample, 1998–2001.
(dependent variables: OJT and OFFJT incidence; robust standard errors in parentheses)

	Years of Education Treated as Exogenous		*Testing for Exogeneity of Education*	
Variable	*OJT*	*OFFJT*	*OJT*	*OFFJT*
Sex	–0.160***	0.092*	–0.031	0.020
	(.047)	(.050)	(.107)	(.110)
Age	0.305***	0.213**	0.397***	0.141
	(.102)	(.099)	(.133)	(.128)
Age^2	–0.010***	–0.005*	–0.013***	–0.003
	(.003)	(.003)	(.004)	(.003)
Age^3 * 10	0.001***	0.000*	0.001***	0.000
	(.000)	(.000)	(.000)	(.000)
Tenure in 1998	–0.009	0.022***	–0.010	0.021**
	(.007)	(.008)	(.008)	(.008)
Previous Experience in 1998	–0.013**	0.005	–0.013*	0.004
	(.006)	(.006)	(.007)	(.007)
Years of Education	–0.055***	0.032***	–0.140**	0.079
	(.008)	(.009)	(.069)	(.068)
First Step Residuals	—	—	0.084	–0.048
			(.068)	(.068)
ρ	0.334***		0.326***	
	(.025)		(.022)	
Observations	5,525	5,525	5,465	5,465

Notes: Each regression includes firm dummies, family background variables, and a linear and a quadratic trend. ρ = correlation between training error terms. Sex: men =1, women = 0.
*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

reduce measurement error, we re-define training incidence by allowing it to take a value of one if any training occurred during the period 1998–2001 and zero otherwise, and we re-define training intensity as average hours of training over the sample period. Again, our statistical results are qualitatively unchanged.[17]

The Mincerian Equation

Our measure of earnings is monthly earnings in January of each year, including overtime pay and excluding bonuses. The stock of training at time t is defined as the sum of average monthly hours of training from 1998 to the calendar year t–1. Therefore, we associate in (3) wages in year t with the training undertaken up to year t–1, and treat the latter as a predetermined variable. As in the case of the training equations, we pool the available information and include in the vector of controls X firm dummies, a linear trend, and a quadratic trend. Since we estimate (3) using fixed-effects, the coefficients associated with time-invariant variables, such as education, gender, tenure, and experience in 1998, cannot be estimated. Moreover, the inclusion of trends precludes the identification of age effects.

Our results in Table 9 are organized in four columns. In the first and third columns we assume that unobserved and time-invariant talent does not affect the private returns to training and estimate (3) on the full sample and on the subsample of production workers using fixed-effects. In the second and fourth columns we allow pri-

[17]Results are available from the authors upon request.

Table 6. Tobit Estimates of Training Intensity, Full Sample, 1998–2001.
(dependent variables: OJT and OFFJT intensity;
bootstrapped standard errors [50 replications] in parentheses)

	Years of Education Treated as Exogenous		*Testing for Exogeneity of Education*	
Variable	*OJT*	*OFFJT*	*OJT*	*OFFJT*
Sex	–0.433 (.353)	0.549*** (.157)	0.540 (.994)	0.709** (.304)
Age	0.794 (.756)	0.616* (.320)	1.420 (.939)	0.695* (.424)
Age^2	–0.029 (.023)	–0.016 (.010)	–0.046 (.031)	–0.018 (.013)
Age^3 * 10	0.002 (.002)	0.001 (.001)	0.004 (.003)	0.001 (.001)
Tenure in 1998	0.083 (.066)	0.036* (.022)	0.086 (.067)	0.034 (.022)
Previous Experience in 1998	–0.176*** (.060)	–0.009 (.018)	–0.166*** (.063)	–0.009 (.015)
Education	–0.572*** (.066)	0.145*** (.023)	–1.186* (.615)	0.037 (.190)
First Step Residuals	—	—	0.608 (.638)	0.104 (.199)
Observations	5,374	5,506	5,316	5,446

Notes: See notes to Table 5.

vate returns to training to be affected by unobserved talent and replace the observed years of education with the predicted years from the estimate of equation (4). By so doing, we combine fixed effects with instrumental variables.[18]

The Wald test in the table shows that the interactions between educational attainment and training are statistically significant. Evaluated at the sample mean years of education, the estimated percentage increase in (monthly) wages following a one-unit increase in the hours of monthly training ranges from 0.0016 to 0.0025 for OJT and from 0 to 0.0024 for OFFJT. The p-values of the Wald tests, reported within brackets below the estimated effects of training on log wages, show that these effects are precisely estimated only in the case of OJT. We conclude that the marginal returns to training $\partial W/\partial SOJT$ and $\partial W/\partial SOFFJT$—also evaluated at sample mean education—are increasing in training investment.

Are these returns low? To answer this question, suppose that an additional year of education represents about 1,000 hours of instruction.[19] This is equivalent to about 83.3 hours per month. If we increase the monthly hours of OJT and OFFJT by a similar amount, and use the results in the second column of Table 9, monthly earnings in the full sample increase by 18.3% (83.3 × 0.0022) and 7.5%, respectively.

[18]As suggested by a referee, we also experimented with a non-linear specification of the wage equation, using the square root of training rather than training. This trial produced no substantial qualitative change in the results.

[19]The mean number of hours of instruction received per year by pupils older than 14 in the United States was 1,032 in 1991 (OECD 1992).

Table 7. Bivariate Probit Estimates of Training Incidence, Production Workers Only, 1998–2001. (dependent variables: OJT and OFFJT incidence; robust standard errors in parentheses)

	Years of Education Treated as Exogenous		*Testing for Exogeneity of Education*	
Variable	*OJT*	*OFFJT*	*OJT*	*OFFJT*
Sex	–0.028	–0.026	0.090	–0.147
	(.075)	(.075)	(.151)	(.152)
Age	0.189*	0.270**	0.266*	0.158
	(.114)	(.116)	(.155)	(.154)
Age^2	–0.007*	–0.008**	–0.008*	–0.005
	(.003)	(.003)	(.004)	(.004)
$Age^3 * 10$	0.007*	0.007**	0.001**	0.000
	(.003)	(.003)	(.000)	(.000)
Tenure in 1998	–0.019*	0.011	–0.022**	0.010
	(.010)	(.010)	(.011)	(.011)
Previous Experience in 1998	–0.013*	0.015*	–0.012	0.013
	(.008)	(.008)	(.008)	(.008)
Education	–0.064***	0.014	–0.143*	0.095
	(.011)	(.011)	(.086)	(.085)
First Step Residuals	—	—	0.079	–0.083
			(.086)	(.085)
ρ	0.320***		0.307***	
	(.031)		(.028)	
Observations	3,523	3,523	3,487	3,487

Notes: See notes to Table 5.

According to Psacharopoulos (1994), the private return to an additional year of education in Thailand is close to 10%, about half the size of the returns to an additional year of OJT and about the size of the returns to OFFJT. Our estimates of the returns to training are lower than those obtained for the United States by Frazis and Lowenstein (2005), who found that 60 hours of training increased wages by 3–4%, but not far from the rates of return reported for the United States by Carneiro and Heckman, which were in the range between 16% and 26% (2003).[20]

As for the training incidence equations, we checked to see whether our results are driven by the measurement error associated with retrospective data by replicating the fixed-effects estimates in a subsample consisting of the last two years in the sample. We found that in the shorter sample the marginal returns to OJT and OFFJT are equal to 0.0041 (p-value of the Wald test: 0.003) and 0.0021 (p-value of the test: 0.64), respectively.

[20]We do not include in the computation of the returns to OJT and OFFJT the return to tenure and labor market experience, because upward-sloping earnings profiles are not necessarily generated by investments in human capital.

Discussion

In summary, we find that the relationship between education and training is positive, as expected, for OFFJT and negative for OJT. How do we explain these results? As anticipated in the introduction, a useful starting point is the definition of equilibrium investment in training as the level of investment that equalizes the marginal costs and marginal benefits of training. Our estimates of the Mincerian earnings function suggest that the marginal returns to both types of training—

Table 8. Tobit Estimates of Training Intensity, Production Workers Only, 1998–2001.
(dependent variables: OJT and OFFJT intensity;
bootstrapped standard errors [50 replications] in parentheses)

	Years of Education Treated as Exogenous		*Testing for Exogeneity of Education*	
Variable	*OJT*	*OFFJT*	*OJT*	*OFFJT*
Sex	0.590	0.208	0.509	–0.055
	(.531)	(.205)	(1.125)	(.405)
Age	0.483	0.625**	0.313	0.371
	(.664)	(.313)	(1.163)	(.407)
Age^2	–0.018	–0.019**	–0.013	–0.012
	(.020)	(.009)	(.034)	(.013)
Age^3 * 10	0.002	0.001**	0.001	0.001
	(.000)	(.000)	(.002)	(.001)
Tenure in 1998	–0.012	0.017	–0.022	0.014
	(.096)	(.028)	(.097)	(.024)
Previous Experience in 1998	–0.089	–0.007	–0.078	–0.012
	(.067)	(.023)	(.096)	(.021)
Education	–0.618***	0.094***	–0.627	0.272
	(.090)	(.031)	(.507)	(.211)
First Step Residuals	—	—	–0.011	–0.181
			(.526)	(.212)
Observations	3,466	3,508	3,432	3,472

Notes: See notes to Table 5.

evaluated at the sample mean value of education—are increasing in the level of training. Therefore, a stable equilibrium in the training market requires that (unobserved) marginal costs also be increasing with training investment, and at a faster pace than marginal benefits.

Suppose now that educational attainment increases marginally over the sample mean. Since the marginal benefits of training are higher for the better educated, a marginal increase in education shifts the marginal benefits schedule upward. For given marginal costs, the new training equilibrium occurs at a higher training investment, which is consistent with the results for OFFJT but inconsistent with the results for OJT. For this latter type of training, our empirical results show that the new equilibrium level of investment should be lower than the original level, not higher. An equilibrium with lower training intensity (incidence) can be obtained in this framework only if the marginal costs of training also increase when educational attainment is marginally increased above the mean.

The natural reason marginal training costs increase for the better educated is that employees with higher education are more productive and thus have higher opportunity costs for the time spent receiving training. An alternative, but we believe less compelling, possible reason is that the better educated, who have higher cognitive skills, are either less willing or less able than other workers to master the practical skills associated with OJT, contrary to the view suggested by Thurow and Rosen.

Conclusions

Our analysis of data from a survey of Thai employees has shown that the relationship between education and training depends on the type of training. In particular, we found that OJT is a substitute for and OFFJT a complement to higher education. The negative relationship between educational

Table 9. Fixed-Effects Regression of the Mincerian Equation, Full Sample and Production Workers Only, 1998–2001.
(robust standard errors within parentheses, p-values within brackets)

Description	*All Workers*	*All Workers with Years of Education Treated as Endogenous*	*Production Workers*	*Production Workers with Years of Education Treated as Endogenous*
Sum of OJT from 1998 to Year *t* (SOJT)	–0.003 (.002)	–0.010** (.004)	–0.004 (.003)	–0.013*** (.005)
Sum of OFFJT from 1998 to Year *t* (SOFFJT)	–0.019* (.011)	–0.018* (.011)	–0.006 (.016)	.002 (.013)
Years of Education * SOJT	0.0005** (.0002)	0.001*** (.0003)	0.0006** (.0003)	.0013*** (.0004)
Years of Education * SOFFJT	0.0017** (.0007)	0.0016* (.0008)	0.0006 (.010)	.00003 (.001)
Wald Test for the Interactions of Training and Education	[.002]	[.0002]	[.004]	[.005]
$\frac{\partial \ln W}{\partial SOJT}$	0.0024 [.000]	0.0022 [.001]	0.0025 [.005]	0.0016 [.074]
$\frac{\partial \ln W}{\partial SOFFJT}$	0.0000 [.990]	0.0009 [.680]	0.0010 [.779]	0.0024 [.569]
Observations	4,536	4,481	2,979	2,943
R^2	0.033	0.035	0.018	0.019

Notes: See notes to Table 5. Each regression includes a linear and a quadratic trend.

attainment and OJT suggests that the firms in the sample were compensating for the relative scarcity of human capital among their less educated employees by investing more in on-the-job training for those employees. This compensation might have been necessary given the rapid growth of manufacturing in Thailand during the past twenty years, which has greatly outpaced the growth of educational attainment.

When individuals with higher education are systematically more likely to receive employer-provided training, the skill gap between them and less educated individuals increases, with important consequences for the earnings distribution. Widening differences in human capital can be a problem in a developing country such as Thailand, with its relatively low educational attainment and its dispersed distribution of income. Our findings suggest that OJT in Thailand partially offsets the existing differences in educational attainment.

We have explained the negative relationship between education and OJT by arguing that the marginal costs of this type of training are higher for the better educated, who are more productive than other workers and therefore have higher opportunity costs for the time spent receiving training.

It should be borne in mind that this study is limited to training in a handful of business sectors in Thai manufacturing. Whether the results apply to the Thai economy as a whole is an open question that can only be addressed using data with more generality.

Appendix

Table A1. The Education Equation: Year 2001, Full Sample.
(dependent variable: years of education)

Independent Variable	*Coefficient*	*Standard Error*
Age	1.472***	(.298)
Age^2	–0.040***	(.009)
Age^3	0.0003***	(.000)
Sex	1.506***	(.095)
Oldest Son or Daughter	1.450**	(.635)
Age of Mother at Individual's Birth	.042***	(.010)
Oldest Child * Age of Mother at Individual's Birth	–.057**	(.026)
Number of Siblings	–.081**	(.036)
Bound Test on Additional Instruments	5.47	
	[p-value: 0.001]	
Observations	1,585	

Note: See Table 5. The regression includes a constant and dummies for province of birth, father's education, mother's education, and older sibling's education.

Excerpts from the Questionnaire

Part VI-A. On-the-Job Training

This type of training is often conducted by your immediate supervisor, senior fellow worker, team leader or foreman. The purpose of the training is to guide you and/or evaluate the tasks that you are expected to perform. This is usually held during regular working hours at your workstation.

In Year 2001,

1. Did you receive on-the-job training? ❑ Yes ❑ No

If you answered ***NO, proceed to question 6****. If you answered* ***YES****, please* ***continue****.*

2. How frequent was the training conducted?
   - ❑ Daily
   - ❑ Once a week
   - ❑ Twice a week
   - ❑ Twice a month
   - ❑ Every month
   - ❑ Not on a regular basis
   - ❑ Others (*please specify*) ______________________
3. What was the usual length of the training sessions?
   - ❑ Less than 1 hour
   - ❑ 1 to 2 hours
   - ❑ 2 to 3 hours
   - ❑ More than 3 hours
4. Who conducted the training?
   - ❑ Senior worker belonging to the same unit
   - ❑ Team leader / Immediate supervisor
   - ❑ Foreman
   - ❑ Instructor from parent company
   - ❑ Instructor from training center
   - ❑ Others (*please specify*) ______________________
5. The training was about: (*Choose more than one if appropriate.*)
   - ❑ Daily tasks performed
   - ❑ Maintenance, operation and mechanics of machines and tools
   - ❑ Orientation for new machines and equipment
   - ❑ Safety regulations and rules

- ❑ Improving skills in general
- ❑ Others (*please specify*) ______________________

(similar set of questions for earlier years)

Part VI-B. Off-the Job Training

This type of training is more formal and organized than on-the-job training. The trainers may or may not be employed by the company. The training is held outside the workstation. It may be conducted during or outside working hours. Examples are: (1) training and orientation to new employees, and (2) training on new equipment.

In Year 2001,

1. Did you receive off-the-job training? ❑ Yes ❑ No

If you answered ***NO, proceed to question 6****. If you answered* ***YES****, please* **continue**.

2. During the year, how many times did you have off-the job training? ______ *times*
3. What was the usual length of the training sessions? ______ *days*
4. Who conducted the training?
   - ❑ Engineer
   - ❑ Instructor from the training center of the company
   - ❑ Instructor from a parent company
   - ❑ Instructor from another training center
   - ❑ Others (*please specify*) ______________________
5. The training was about: (*Choose more than one if appropriate.*)
   - ❑ Daily tasks performed
   - ❑ Maintenance, operation and mechanics of machines and tools
   - ❑ Orientation for new machines and equipment
   - ❑ Safety regulations and rules
   - ❑ Improving skills in general
   - ❑ Others (*please specify*) ______________________

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