Technical Change, Workers' Endowment and Returns and Investments in Firm-level Training Evidence from Thailand

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Abstract:

This paper examines determinants of investments in and returns to training with focus on technical changes and workers' productive endowment, using employee panel data in Thai manufacuring industries. Empirical findings demonstrate significant returns to both on the job and off the job training in first-difference fixed effect estimation of wage equations, controling technological change and workers' ability (endowment) which are shown to influence, but differentially, both training investments and the returns. More specifically, first, technical change induces on-the-job training; controling technical change, returns to on the job training are even larger. Second, controling workers' unobserved productive endowment, both returns to on-the-job and off-the-job training are found to be significantly positive, and endowment is substitutable to off-the-job training. Policy implications on training and education policies are discussed in detail.

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1 Introduction

It has been increasingly accepted that the accumulation of human capital is crucial in productivity growth at both firm and aggregate levels. Among various types of the investments in human capital, training in workplace play crucial roles in the accumulation of human capital. While schooling investment mainly contributes to the accumulation of general human capital, training investments in workplace concentrate on skill formation specific to production technologies. Though the importance of skill formation and training investments is recognized in the context of productivity growth in developing countries, the quantitative assessment of the impact of training investments on productivity growth has not been seriously attempted, except qualitative case studies (e.g., Inoki and Koike,1990). The main reason for the lack of econometric analyses is conceptual difficulty in identifying the content and actual practices of training in workplace in different industries and firms due to heterogeneity at firm and industry levels, which furthermore make it difficult to design a framework to collect reliable information on training investments at individual level. The literature provides some theoretical studies postulate the roles of training and learning-by-doing on productivity (e.g., Lucas, 1993), but empirical attempts have only recently emerged to identify returns to training in developing and developed countries (e.g., Schaffner, 2001). In contrast to much well established measurements and accumulated evidence on returns to schooling, there still remains a large gap between qualitative case studies and quantitative analysis on investments in and returns to firm-level training.

In this paper, we challenge the above issue to evaluate the productivity effects of training from various angles, using two recent employee surveys in Thailand. The first survey was fielded in July to October 2001 by the Thailand Development Research Institute (TDRI), selectively focusing on the region of greater Bangkok and four industries therein. To resolve the measurement problem, the data were collected specifically on incidence, frequency and average length of on-the-job training and off-the-job training. We interviewed workers directly and asked them about training experienced at individual level. In addition to quantifying training, the unique feature of this data set is the coverage over three years of 1998 to 2001, which enables the dynamic analysis of the causality from training investments to wage and productivity changes. The second survey was fielded in 2003, following up a subset of workers and firms captured in the 2001 survey. The purpose of this follow-up survey was to collect detailed information on i) technical changes and training investments at firm and individual levels and ii) turnover behavior.[1] In the second survey, we identified timing of technical changes at plant level and what changes workers had experienced, associated with the technical changes. Section 3 describes the surveys and data in detail.

Our motivation of this paper is to disentangle factors which determine investments in and returns to training. In addition to individual-level human capital stock as such measured by years of schooling,

[1] Linking the two surveys, Yamauchi, et al (2004) identified turnover behavior over the two years 2001 - 2003 and its relationship to individual background factors including parental schooling.

tenure and past experience, the focus of this study is placed on other supply-sde factors such as technical change and workers' unobserved endowment. First, technical change describes discrete changes in production technologies at firm or industry levels. As hypothesized in the seminal work by Schultz (1975) and evidenced by Foster and Rosenzweig (1996), general human capital such as schooling is required to make optimal decisions when agents are in disequilibria as such induced by technical changes. When firms introduce new technologies, workers are required to adjust themselves to a new state of production technology and training methods also need to be changed so as to maximize the efficiency of new technologies and to enhance workers' learning capabilities in workplace. An interesting question is whether on-the-job training or off-the-job training is more required to hasten such an adjustment and for what types of workers the investment in training is most effective. Therefore, technical change may require certain types of training, both ex post and ex ante, as well as alter the returns to training.[2]

Second, we analyze the role of unobserved productive endowment in the returns to training investments. For the purpose of this analysis, we use an experimental event at the 1997 Thailand's financial crisis, which enables us to identify the effects of workers' unobserved endowment on returns to training. In other words, we use a consequence that the financial crisis had in Thai labor markets, as an instrument to control endowment distribution among sample workers. That is, better-endowed workers were selected when firms cut production and work force in the face of the 1997 financial crisis and therefore survived the crisis. Importantly, this change can be regarded as exogenous to most individual workers in labor markets. In our study, this exogenous selection serves as an experimental shift in the distributions of both observable and unobservable characteristics of workers. For example, those who were selected to remain in the firms through the financial crisis can be more productive or better matched to the firms than those who left the firms. Therefore, the comparison of postcrisis dynamics of wage and human capital investments between survivors and postcrisis entrants can identify the effect of unobservable productive endowment on the returns to human capital investments.[3] Using our detailed information on training investments available from our survey, we estimate the returns to training investments and identify whether the unobservable endowment augments or decreases the returns in the postcrisis period: 1998 - 2001.

The next section sets up our empirical framework. We estimate wage growth equations, eliminating fixed effects, from the panel data of 1867 workers from 1998 to 2001. The estimation of wage growth

[2] On the other hand, technical change has another important effect on the effectiveness of human capital in workplace: obsoleting accumulated human capital. Technical change may not only augment the returns to training but also can reduce the returns if accumulated labor skills are not useful to handling a new technology. These two offsetting effects are also examined in our empirical analysis.

[3] Comparison of wage residuals, which reflect productivity components that observable factors cannot explain, between those who entered the current firms before and after a particular year proves it most likely for structural change to have occured around 1997 - 1998. Electronics (PC/IC), auto-parts, and hard-disk drive industries screened productive workers during this period, while there was no substantial selection in food processing industry. Between 1996 and 1998, real value added of the automotive and electronics sectors fell by 66.9% and 1.1% per year, respectively, but the food processing still grew at 13.4% per year. Evidence show that during the same period a 72% reduction in car production is accompanied by a 30.6% fall in employment (Nipon 2004). Therefore, unobserved productivity is higher among survivors than new postcrisis entrants in the capital-intensive industries, which were severely affected by the financial crisis.

equations - first differenced log wage - with training investment variables is robust to unobserved fixed effects contained in the level of wage. Section 3 describes briefly our surveys and data from Thailand. In particular, the construction of training variables and the potential problems are explained in detail.

Section 4 examines the impacts of technical changes on training investments, using both 2001 and 2003 surveys. The 2003 survey on technical change and training clearly shows that technical changes induce on-the-job training. In statistical analysis using the panel data from 1998 - 2001, we also confirmed that technical change, measured by the growth rate of net fixed capital in a previous year, increases investments in both on the job and off the job training.

Sections 5 and 6 shows summarizes estimation results on returns to training. First, in general, on-the-job training has a more significant positive effect on productivity changes than off-the-job training.[4] Controlling technical change in a previous year, the returns estimates for on the job training become larger, which implies a positive correlation between technical change and on the job training, causing underestimation of the returns if omitting technical change. Second, higher endowment substitutes for off the job training significantly. Controlling the unobserved endowment, off the job training is shown to have significant and positive returns.[5] Therefore, both technical change and unobserved endowment matter in returns to training. The former influences on the job training, while the latter affects off the job training.

Policy implications of these findings are discussed in details.

2 Empirical Framework

We use wage equations to infer productivity effects of training. It is of course arguable whether training investments are linked with changes in wage if they raise productivity in a short period. As discussed in human capital theory (Becker, 1962), the investment in general human capital is financed by employees, since it raises productivity in other workplaces. Employers do not have incentives to pay the costs of the investment. On the other hand, the investment in purely firm-specific human capital is financed by employers, because the productivity gain accrues to only the company where the investment is done. However, most firm-specific investment is partially specific to the company, so the cost is likely to be shared by employees and employers. Although the magnitudes may differ between on the job and off the job training, we assume that the effects of training investments on workers' productivity

[4] A study in 1991 found that OJT had significant and positive effect on log of wage of industrial workers, while off-the-job training did not (Nipon, et.al., 1992).

[5] Workers who survived the crisis with higher endowment - higher productivity - experience larger wage growth in the postcrisis period. This finding contradicts a conventional view in labor economics that seniority leads to slower wage growth. If wage is linked to productivity, this finding implies that workers with higher endowment (but more senior) demonstrated rapid productivity growth in the postcrisis period. However, we should be careful about the interpretation, since those who survived the crisis might have larger training before the crisis, which substitutes for additional investments.

are captured by the marginal effect of the training on log of wage (i.e., rate of return). Furthermore, our interest is to disentangle the heterogeneity in the returns along with individual characteristics such as schooling, tenure past experience, and unobserved ability, and firm-level changes such as technical changes.

We assume that log wage is linearized as below.

$$\ln w_{ikt} = \beta_0 + \beta_1 h_{ijt} + \gamma_1 S_i + X_{it}\delta + \mu_i + \varepsilon_{ijt}$$

where subscripts i, j, and t represent individual, firm and year respectively, h_{ijt} is human capital that has been accumulated through training investments, S_i is years of schooling, X_{it} is a vector of individual characteristics including age and sex, μ_i is fixed effect and ε_{ijt} is a composite shock to worker and firm. We accept a possibility that parameters differ across different groups of workers, i.e. production workers, and technicians and engineers. We next assume that human capital accumulates through

$$h_{ijt} = \sum_{\tau=1}^{T} \alpha^{\tau}(\theta_{jt-2}, z_i, \mu_i) tr^{\tau}_{ijt-1}(\theta_{jt-2}, z_i, \mu_i) + [1-d]\, h_{ijt-1}$$

where θ_{jt-2} is technical change and z_i includes predetermined individual characteristics, which potentially affect the effectiveness of training investments and the depreciation rate of the past investments. We make two important assumptions. First, training investment is a function of technical change in a previous year. Second, technical changes that affect the returns to training are also from a previous year. In empirical analysis, we examine the effects of schooling, past full-time job experience, technical change (proxied by growth rate of net fixed capital in a previous year), and entry year indicators. There are T types of training, each of which has a different α function. If training is complementary to technical change and schooling, the function α is increasing in both arguments. In other words, technical changes raise the necessity of training investments, and the productivity effect of training is larger for the educated since they can learn fast. Similarly, since technical change often involves the introduction of new machines, it accelerates depreciation of skills accumulated through training investments in the past, the function is increasing in θ_{jt-2}.

An increment of human capital is written as,

$$\Delta h_{ij(t,t-1)} = \sum_{\tau=1}^{T} \alpha^{\tau}(\theta_{jt-2}, z_i, \mu_i) tr^{\tau}_{ij,t-1}(\theta_{jt-2}, z_i, \mu_i) - dh_{ijt-1}$$

It is therefore assumed that an increase in human capital depends on technical changes and schooling that represent general human capital, through complementarity of training to technical change and schooling and the depreciation of past investments. We use, as measures of training investment, incidence and estimated number of days that workers received on-the-job training and off-the-job training.

In the above equation, the past history of training investments is likely to be correlated with the individual fixed effect that includes trainability if firms screen those who are trainable, and with shocks if firm or workers face borrowing constraints and shocks are serially correlated. Therefore, the OLS estimate will be biased. To avoid biased estimates, we take the first difference.

$$\begin{aligned}\Delta \ln w_{ij(t,t-1)} &= \gamma_2 + \beta_1 \sum_{\tau=1}^{T} \alpha^{\tau}(\theta_{jt-2}, z_i, \mu_i) tr^{\tau}_{ijt-1}(\theta_{jt-2}, z_i, \mu_i) - \beta_1 dh_{ijt-1} \\ &\quad + \Delta X_{i(t,t-1)}\delta + \Delta \varepsilon_{ij(t,t-1)}\end{aligned}$$

where technical change θ_{jt-2} is measured by growth rate of net fixed capital. Alternatively, we may also use firm-year specific indicators to absorb technical changes at firm level. To avoid possible bias due to a correlation between changes in capital stock (i.e., investment) and past profit shocks under liquidity constraint, we use the capital growth rate in a previous year.

We have several remarks. In the wage growth equation, liquidity constraint at both individual and firm levels may lead to negative bias in both α and d. For example, training investments in workers can be correlated with past shocks to firm profit, i.e. $E\left[tr^{\tau}_{ijt}\varepsilon_{ijt}\right] > 0$. We include firm-specific year dummies when we use only individual-level variables. However, we do not include firm-specific year dummies when our focus is on technical changes.

Second, technical change is an important determinant of training investments. With technological changes that introduce new production methodologies, on the job training is required so that workers need to master the new production methods. Therefore, it is important to control technical changes to avoid omitted variable bias in the returns estimates. Evidence for this point is provided in Sections 4 and 5.

Third, another potential concern in the estimation of the wage growth equation is a possibility of fixed effects even in wage growth. For example, if training investments are more likely to be provided to more productive workers, who experience a higher wage growth. Under some circumstances, changes in wage may capture ability or unobserved productivity of workers. If this factor is strong, we obtain upward bias in training effect estimates even in the wage-growth equations.[6]

[6] The estimation of wage-level equations with individual dummies would not solve this problem. Since wage empirically increases as tenure (years of working in the current firm) increases, most likely in a concave way, wage increases for many workers without any explicit form of training investments. Therefore, unless this tenure effect (with no training) is controlled, upward bias likely occurs in the training effect on wage level. Moreover, if the wage growth with no training is positively correlated with ability (e.g., through learning by doing) and training incidence is also positively correlated with ability, positive bias is likely to be in training effects in both level and differenced specifications. Our results of negative sign of schooling - training interactions, however, imply that the positive bias mentioned above is not large

Fourth, we also have a potential measurement problem of human capital stock h_{ijt-1} in wage growth equations. We take the simplest way to use tenure, i.e. years in which workers have been working in the current firm, as a proxy for the human capital stock. Since this measure ignores accumulated training investments and depreciations, tenure has measurement errors.

3 Data

3.1 Employee Survey in 2001

The data we use is from our employee survey targeted on selected manufacturing industries in Thailand, fielded by the Thailand Development Research Institute (TDRI) in July through October 2001. The main purpose of this survey is to assess productivity gain that is attributed to various training investments conducted on the job, off the job, in formal education and training centers, and at related/parent companies, in selected manufacturing industries. For this purpose, we collected information on wages, training, education, technical changes, job experience and various family backgrounds from individual employees in face-to-face interviews in Thailand.[7] The data can contain measurement errors as workers were asked to recall the past. The choice of industries in this survey is selective: Hard Disk Drive, PC/IC, Auto Parts, and Food Processing manufactures, all located in Bangkok. The total of 20 firms were fielded and the sample size of employees is 1867. In this survey, we tried to cover past three years. Information is collected on wages as of January 1998, 1999, 2000 and as of the previous month of survey week in 2001, and training incidences and training amounts within each of the past three years.

3.2 Training Data: 2001 Survey

In Thailand, as for on-the-job training, we asked individual workers whether or not they had training, types of training, frequency and average hours since 1998. We can easily construct incidence measures of different types of training. In the questions on training frequency, we prepared several

enough. This may call for another caution that positive correlation between past shock and training investment leads to negative bias in the training effect in differenced specifications. In this case, however, our results of a positive sign of on-the-job training and a negative sign of schooling - OJT training interaction suggest that it is rather unlikely so.

[7] We also conducted a similar survey in the Philippines. However, we only collected the information on training from human resource profiles, which the sample firms keep for each individual worker. In contrast to face-to-face interviews with workers, this method adopted in the Philippines likely leads to under-estimation of training investments, especially in the on-the-job training.

options such as daily, twice a week, weekly, and so on. In each choice, workers were asked to answer the average hours in which they had training. Therefore, we can construct the estimated numbers of days of training in each year. For details, we assigned following numbers of days for each option of training.

daily	258
weekly	51.6
twice a week	103.2
twice a month	24
ever ymonth	12
annually	1
x times a year	x

For the answer of irregular basis, we used the sample average of estimated days in the sample excluding observations that answer irregular basis (27.36774 in 2001, 27.18369 in 2000, 28.18492 in 1999, and 17.99239 in 1998). About 60% of the answers belong to irregular basis. In the conversion from answers on hours of training to days, we assigned as follows

less than 1 *hour*	1/8
$1-3$ *hours*	3/8
$3-6$ *hours*	6/8
less than or equal to 2 *days*	1
more than 2 *days*	3

The multiplication of these two measures gives the estimated total number of days of on the job training. Some obvious outliers, those larger than 250 days in Thailand, are omitted in the analysis.

On off-the-job training, we asked workers to answer the number of times and the average number of days in each event of training. It is therefore possible to estimate the number of days in off-the-job training.

3.3 ICSEAD-TDRI 2003 Survey

In September - December, we have conducted engineer and worker surveys, visiting a subset of companies that we have surveyed in 2001 in three out of four manufacturing industries: Hard Disk Drive, Auto Parts, and PC/IC. The number of firms is 10 in the 2003 survey.

The survey consists of 2 stages: on the first stage, we interviewed one senior engineer or a person who knows in detail the whole history of new technology introduction in the period of 1998 to 2003. This engineer survey provides timing and nature of new technologies introduced during the period. Given the information available from the first stage, the second stage is to know individual experience such as changes in work responsibility and training when they encountered those new technologies during the period.

3.3.1 Engineer Survey

The interviewees are mostly senior engineers. In many cases, they are managers, managing directors and executive directors who control engineering and R&D activities. Information from the three industries are summarized as follows.

Auto Parts: Three firms are in our sample. In Firm A, main technological changes were the introduction of computer design (CAD) in die and jig production to replace the manual process. Another change was to introduce a new machine to save a long lead time. In Firm B, workers started producing two new products. One was an automatic machine to be supplied to other manufacturers. Another change was to introduce a new machine to produce parts, which were previously purchased from outside suppliers. These changes required new production lines. Firm C experienced three changes. First, they introduced a new program in parts measurement after the production stage (i.e., cutting). This program guarantees higher reliability in their products for customers. Second, they introduced the Robot Welding to hasten welding. Third, it was a progressive press machine, which integrated all production processes, substituting for previous ones which were only capable of producing one process in each production line.

Hard Disk Drive: Firm A totally changed production processes for the new model products as such transforming from 20 KB/patter to 40 KB/patter or more. The advantage of new technology is time saving, with no need of inventory in various production steps. This is a drastic change from mass production to cell production methods. Firm B also introduced a big change from mass production to cell production methods. After the change, they introduced a new machine in some production steps to improve productivity. Firm C has not experienced large changes in technology, but constantly revised the production lines in general.

PC/IC: Firm A introduced cell production method, totally replacing mass production method. This transformation enables it to produce one final product in each cell, at less production time and smaller production areas. This case is the only one in this industry, which experienced a drastic technical change. Firms B to D only experienced partial changes in their production lines as such introducing new machines, additional new line, and new materials.

In terms of frequency of technical changes, the above changes can be divided into two groups. The first group is high technology industries: Hard Disk Drive and PC/IC, which have always adapted and supplied new products to markets. These cases often involve production reorganization and/or re-engineering, while they remain using same technologies for some products. The major change happened in 1999 and 2000. This change to cell production methods induces totally new ways to organize workers, production processing, and machines, and requires multiple skills and high speeds. It is easy to make partial adjustments with new machines, materials and/or products, in response to customers' requests (i.e., supply chain management).

The second group is Auto Parts. Technical changes happened mostly in 2000 and 2001. The introduction of new technologies has taken place in some steps of production lines, involving new machines, additional new lines or processing, new products, leading to the improvement of productivity and quality. The changes require various skills (i.e., multiple skilling). Training system for new technology has two steps: in-firm engineers and supervisors were trained with venders or outside engineers, and then workers were instructed by engineers and supervisors in production lines.

3.3.2 Worker Survey

The questionnaire was designed to ask about circumstantial changes associated with technical changes, such as nature and magnitude of changes, changes in responsibility and requirement, adjustment (learning) and implementation, and timing and types of training. The sample size of workers is 533. The distribution of observations by industries is: Auto parts 123, Hard Disk Drive 182, and PC/IC 228.

The survey has a series of questions: i) circumstances: positions, whether technical change happened in their line, and whether or not they were transferred to lines with technical changes. ii) involvement: whether or not they were involved to deal with new technologies, position changes, changes in responsibility, and magnitude of technical change. iii) implementation: who instructed new methods and length of period to master and adjust to new technologies. iv) training: whether or not they receive training, when received (before, after and both), types of training (on the job and off the job) and amount of training.

Information from these questions enables disentangling the impacts of technical change on changes in work environment including training.

3.4 Physical Capital Investments

For a measure of technical change in econometric analysis, we use information on net fixed capital from company balance sheets in Thailand which had been submitted to the Department of Commercial Registration and are publicly available. The net fixed-capital contains land, structure and machinery and equipment, net of depreciation. We particularly use the growth rate of net fixed capital for θ_{jt}. A large problem in the use of this measure is that this measure includes not only machinery and equipment that embody technology, but includes land and structure that are less related to production technology. Though for some companies the gross asset in machinery and equipment is available, unfortunately the use of this finer measure substantially reduces the sample size. The second problem is that this measure is firm-specific and does not vary across workers inside firms. It is often the case that some workers face technical change but some workers still use old technologies even inside the same plant. Therefore, the use of firm-specific net fixed-capital assumes the homogeneity of technical change effects on workers in different sections. To resolve this problem, we will estimate technology effects in sub-samples such as those directly engaged in production, and technicians and engineers. Finally, we could not get the information on two firms in Thailand, because the two firms do not submit the balance sheets to the Department of Commercial Registration. In the analysis of technology-training complementarities, therefore, the sample contain workers in the 18 firms.

4 Technical Change and Training Investments

4.1 Impacts of technical Change

We use data from the 2003 worker survey on technical change and training. First, we assess the direct involvement of workers in new technology. In the sample, 191 out of 416 workers have experienced technical changes on their production lines that they had worked at technical change. Even among those workers without technical change in their lines, 49 workers were transferred to the lines where technical changes happened. In total, 240 workers experienced technical changes directly in production lines. More interestingly, 311 out of 494 workers answered that they were assigned to deal with new technologies. Therefore, even if they were not in the places where new technologies were introduced, they had opportunities to deal with technical changes directly or indirectly. Table 1 shows the tabulations of the above two questions. Even among those who were not in the lines with new technologies before the change, nearly a half of them had actually dealt with new technologies. This observation suggests that in our sample, a substantial portion of workers had involved in technical changes.[8]

Table 1 to be inserted

What is the actual consequence of technical changes in work environment? For many, technical change did not involve changes in position. 285 out of 313 workers did not experienced any position changes at the time of technical change. Therefore, the majority of workers remain in the same position. However, 229 out of 312 workers experienced some changes in their responsibility and work requirements. Table 2 shows the details on specific changes. Here we tried to assess workers' responsibilities in team work, problem solving, multiple skills, supervising, and amount of work. In all measures, responsibilities increased.[9] Table 2 also shows three measures of work performance: speed, defect rate, and monitoring. Again, in all these measures, the standards required had increased.[10] Therefore, when technical change occurred and workers were assigned to deal with them, both responsibility and requirement increased despite the fat that they remained in the same positions.

Table 2 to be inserted

4.2 On the Job Training or Off the Job Training

We focus on the causality from technical changes to training investments. 294 out of 451 workers received some forms of training when technical change occurred. Table 3 shows that the majority received training both before and after technical change.[11] The table also clearly shows that training incidences are concentrated in on-the-job training. This implies that technical changes require implementation of new methods in production lines and/or organizations, that workers must learn about and adjust to.

Table 3 to be inserted

This observation is consistent with our previous finding that technical change increases workers' responsibilities and requirements, both of which neccesitates further investments on the job rather than

[8] The percentages of workers who were assigned to deal with new technologies are 59.48 % for Auto parts, 68.82 % for hard disk drive and 60.10 % for PC/IC industries.

[9] The decompositions into three industries are as follows. 71.01 (Auto parts), 69.10 (HDD) and 78.57 (PC/IC) percentages of workers experienced some changes in the responsibilities.

[10] Differences across the three industries are very small.

[11] In Auto parts industry, 56.48 percentage of workers had experienced some form of training when technology has changed. The figures are 75.68 and 62.05 percentages for HDD and PC/IC industries, respectively.

off the job. Next we examine the effects of technical change on training investments using the 1998 - 2001 panel data from the 2001 ADBI-TDRI survey.

4.3 The Effect of Physical Capital Investments on Training

In this section, we use growth rate of net fixed capital in a previous year as a proxy of technical change to identify the effect on incidence and amount of training in both on the job and off the job. Since the 2003 survey has a different timeframe than the 2001 survey comprising panel data of 1998 - 2001, we decided to restrict our analysis to the period of 1998 - 2001 using firm-level capital growth measures.

Table 4 to be inserted

Table 4 summarizes the estimation results. All specifications include company and year fixed effects, but do not include the interactions since the capital growth rate is time-varying but firm-specific. In columns 1 and 2, we estimate Probit and Tobit equations for on-the-job training incidences and days respectively. In both cases, the growth rate of net fixed capital in a previous year has a significant and positive effect. Columns 4 and 5 show the results on off the job training. As in the cases of on the job training, the effects of the capital growth on off the job training are also significant and positive. Therefore, our results are stronger than the previous findings that technical changes are associated with on the job training. Note that technical change has larger impact on the length of on the job training than that of off-the-job training. Columns 3 and 6 include precrisis entry indicator which takes the value of one if workers entered the firm before or in 1997, and zero otherwise, to investigate whether training is provided differentially to workers who survived the financial crisis. The results show that selection through the financial crisis does not matter in training amount. In the next section, we obtain returns to training investments consistent with the above results.

5 Returns to Training Investments and Technical Change

In this section, we summarize results on returns to training.

Table 5 to be inserted

In Table 1, we use estimated days of training on the job and off the job during the period from January to December for each year. Column 1 uses the sample of all workers. We observe a clear contrast between on the job and off the job training. On-the-job training effect on wage growth is significant, while that of off-the-job training is insignificant. With interactions of year and firm dummies, the results are robust to liquidity constraint which is possibly binding for training investments.

Column 2 includes interactions of training investments with years of schooling, tenure and previous experience. Contrary to the benchmark result in column 1, returns to on-the-job training become insignificant. Interestingly, tenure is substitutable to off the job training, and previous experience is complementary to on the job training. The latter finding implies that past experience augments the value of specific human capital. Workers are likely to have worked in similar jobs where they accumulated specific human capital which substitutes on the job training in the current workplace.

Columns 3 and 4 focus on only production workers. Interestingly, returns to on the job training are significant and larger than those estimated in the whole sample. Returns to off the job training remain insignificant, as in column 1. Column 4 includes the interactions of training days with individual characteristics. Except the interaction of previous experience and on the job training, parameter estimates are insignificant. The result suggests some transferability of specific human capital from previous workplaces to the current firm, augmenting the current on-the-job training.

Columns 5 and 6 use the sample of technicians and engineers only. In contrast to production workers, returns to off the job training are large (but still marginally insignificant) and returns to on the job training become insignificant. This result suggests that general human capital, accumulating through off the job training, is more important to productivity gain than training investments in specific human capital. In column 6, schooling is substitutable to both on the job (significant) and off the job training (marginally insignificant). Interestingly, controlling the heterogeneity due to workers' characteristics, returns to on the job training turn to be significantly positive. General technical education seems to be important in augmenting experience specific to firm.

The findings can be recapitulated as follows. First, on the job training is important in general but it is particularly so among production workers. Second, off-the-job training does not affect productivity significantly among production workers, while it matters among technicians and engineers. Third, schooling is substitutable to on-the-job training and past full-time job experience is substitutable to off-the-job training among technicians and engineers. There seem to be some qualitative differences in the content of training as well as the nature of on-the-job training between production and technical workers.

Table 6 to be inserted

We incorporate technical change measures to assess the impacts on the returns to training investments. In the previous section, we have observed from the 2003 worker survey that technical changes induce training investments, especially on the job training. The following specifications include the growth rate of net fixed capital in a previous year. The growth rate in the current year (concurrent with training investments) was used in preliminary analyses, but the effects on returns to training were found insignificant. The technical change measure from a previous year is desirable since we can minimize the endogeneity problem in physical capital investments in wage growth equations.

Columns 1 to 3 include the growth rate of previous year's net fixed capital additively. Specifications do not include the interactions of firm and year dummies since the fixed capital growth is time-varying but firm-specific. Columns 2 and 3 are estimated for production workers, and technicians and engineers respectively. With technical change measure, returns to on the job training remain significant but become larger. This effect does not exist among technicians and engineers. This finding is consistent with our understanding, since technical change in a previous year is positively correlated with error terms in the previous year, which causes a negative correlation between the technical change and wage growth. On the other hand, technical change in a previous year is found to be positively correlated with training investments in the current year. Therefore, without technical change measure, we expect upward omitted-variable bias. This bias is large in the returns to on the job training among production workers. Since technical change induces on the job training, this finding is consistent with those in Section 4.

In columns 4 to 5, interactions of training and technical change are included. Interestingly, we observe a clear contract between production workers and technicians and engineers. The basic findings in columns 1 and 2 remain the same among production workers. Technical changes do not directly augment returns to training but seem to change the amount of training, which affects the returns estimates. For technicians and engineers, technical change decreases returns to off the job training, which implies that their general human capital is depreciated when technical change is rapid.[12]

We recapitulate the above results in the framework of Section 2. Returns to training are expressed as

$$\frac{\partial \Delta \ln w}{\partial Tr^{\tau}} = \beta_1 \alpha^{\tau}$$

[12]Some interpretations are needed for the gap in the effects. It might be in Thailand that i) capital accumulation substituted for technicians and engineers and complemented those in production, ii) labor hoarding might have been larger among technicians and engineers than production workers in our sample period after financial crisis. There is an evidence of labor hoarding practice in the automotive industry. During 1996 and 1998, vehicle sales dropped by 72 percept, but employment in the industry fell by only 30.6 percent (Nipon, 2001). Most of the skilled workers were maintained as most firms expected only a temporary downturn. But working hours and nominal wages were reduced. When the care sales began to pick up in the 2001-2002, most part companies did notincrease the employment of permanent workers. They depended heavily on the employment of temporary contract workers. iii) labor costs of production workers are variable and those of technicians and engineers are fixed in nature, or iv) technicians and engineers who were overpaid during the boom years of 1990-1996 have been experiencing relatively low rate of wage adjustment after the crisis because of excess labor supply.

where α changes with technical change θ, individual characteristics (human capital) z including schooling s, and endowment μ_i. The results basically confirmed that $\alpha^{OJT} > 0$. In this section, endowment is assumed out. We found that

$$\frac{\partial \alpha^{\tau}(\theta, z, \mu)}{\partial \theta} = 0$$

while

$$\frac{\partial Tr^{\tau}(\theta, z, \mu)}{\partial \theta} > 0.$$

where $\tau = OJT, OFF$. Technical change induces investment in on-the-job training, but does not alter the returns to training per se. The former leads to underestimation of returns to on-the-job training if technical change is omitted in wage-growth equations. At glance, the effects of z on α and Tr are complicated. However, with technicians and engineers, we may conclude that

$$\frac{\partial \alpha^{OJT}(\theta, z, \mu)}{\partial s} \leq 0,$$

which implies that general technical education is unrelated to or substitutes for firm-specific training investments. Among production workers, however, human capital measures, except previous work experience which is complementary to on-the-job training, do not alter the returns to training.

6 Productive Endowment and the Returns to Training

In this section, we examine how workers' entry time affects the productivity effects of on-the-job and off-the-job training investments. Appendix discusses with evidence that worker's entry time matters in the distribution of workers' unobserved productivity under the circumstance that the 1997 Thailand financial crisis caused downward shift of labor demands, exogenous to individual workers. If the selection of workers has occurred as such in the Thailand financial crisis, those who are selected can serve as a semi-experimental treatment group.

The unobserved productivity which are, by construction, correlated with wage levels from which productivity effects of training investments can be inferred. To solve this problem, we use first difference forms by which log-wages are differenced overtime to eliminate the unobserved fixed components in errors. Therefore, the inclusion of precrisis entry does not pick up part of correlations between fixed effects and explanatory variables.

This procedure has another advantage for the purpose of this study. The first differencing enables using information on training investments.[13] This procedure wipes out not only the correlation between training investments and earnings endowment (contained in errors) but also potentially eliminates the correlation between workers' entry time and their endowments. Since workers' entry time is correlated with their unobserved productivity through selection process (as shown in Appendix), it is important to eliminate the latter correlation to obtain consistent estimates of training effects.

Table 7 to be inserted

Table 7 shows estimation results with various demarcation points: 1989 to 1999. The estimation controls for education levels, tenure, squared tenure, gender, positions, firms and years. In particular, it is necessary to control possibly nonlinear effects of tenure to obtain correct inference on the effects of entry-time demarcation since entry time is by definition correlated with years of tenure.

There are several interesting findings. First, the survivor group experienced a higher growth of wage in the post-crisis period than new entrants did.[14] Since those who survived (were selected) have a longer average tenure, this finding is contrary to a conventional finding that wage growth slows down as tenure increases.

Second, the productivity effects of training investments - both on and off the job - depend on a demarcation point. Without any demarcation, the effect of off-the-job training is insignificant and the sign is negative, although on-the-job training has a significant positive effect on wage growth. Among various demarcation points, the most preferred specification is again those using years around 1997 - 1998. The results show that those who survived the crisis have some characteristics that substitute for off-the-job training significantly (i.e., the interaction is negative) and weakly so for on-the-job training. It is therefore shown that endowment is substitutable for training investments.

In terms of the framework in Section 2, we found that

$$\frac{\partial \alpha^{\tau}(\theta, z, \mu)}{\partial \mu} < 0$$

for both $\tau = OJT, OFF$. On the other hand, Section 4.3 showed that

[13] Although human-capital stock specific to firms is often proxied by tenure, it contains measurement errors. When we want to identify the impact of human-capital accumulation on productivity inside firms, it is necessary to use more precise information on the accumulation of specific human capital. Training investment is an increment to the stock of human capital, and is supposed to have smaller measurement errors than the stock does. The first differencing proposed above gives a specification in which wage growth rate (differenced log wage) is regressed on changes in human-capital stock, which is training investments in this paper.

[14] However, it is possible that the high wage growth of the survivor group is only temporary because during the crisis their nominal wages were either freezed or reduced. After the crisis, their wages have been adjusted to compensate for the loss, resulting in a higher wage growth.

$$\frac{\partial Tr^{\tau}(\theta, z, \mu)}{\partial \mu} = 0.$$

In contrast to technical change, therefore, workers' endowment alters returns to training but does not induce training investments.

7 Policy Implications

Perhaps, one of the most important policy implications drawn from the results is a need to reconsider the educational curriculum and teaching approach at the vocational and engineering levels. The study shows that schooling is substitutable for on-the-job training for technicians and engineers, despite the fact that on-the-job-training significantly increases the wage growth of all workers. The result may reflect the fact that the extra years in vocational and engineering schools are spent on exposing to practical training so that the newly graduated technicians and engineers can be readily employed without further on-the-job training.[15] If extra years of schooling in the upper vocational and engineering schools are to be complementary to on-the-job training, the curriculum and teachings should be re-oriented towards basic sciences and basic engineering subjects.[16] But an alternative explanation is that some type of on-the-job training is in a form of general training because technicians with less years of education may lack the required knowledge in basic sciences.[17] If this is a case, an implication is that schools should be encouraged to strengthen the teaching of basic sciences relevant to the industry in the early years of vocational education.

The finding that technical change has indirect positive effect on the wage growth of production workers via its impact on the OJT. This finding is consistent with the investment policy of the manufacturing firms in Thailand where there are abundant semi-skilled workers with secondary education.[18]

[15] During the period of labor shortage in the 1990's, there were studies which reported the employer's complaints about the guilty of newly vocational graduates, particularly a claim that those graduates could not be readily put to work (TDRI, 1995: 63). Some employers demanded that vocational students were exposed to more practical training in schools.

[16] A study comissioned by the World Bank (2000, Volume 2) found that the current education system is not producing enough graduates at the secondary or post-secondary level who have new kinds of basic skills required by new forms of work organization and production systems, e.g., ability in problem solving, finding creative solution, working in teams and language skills (particularly English) to communicate effectively with others.

[17] A tabulation of the content of OJT for technicians and engineers during the probation period between 1998 and 2001 shows that higher percentage of technicians with no more than 12 years of schooling (48% - 90%) receive the training in job responsibility, safety, machine maintenance and direction to use machine and equipment. On the other hand, technicians and engineers with more than 12 years of schooling have higher incidence in the training of new production process, new products and new machines.

[18] There has been rapid increase in the secondary education enrollment since the mid 1990's. Secondary enrollment jumped from 35-40 percent in the early 1990's to 75 percent in 1998.

Since their wage cost is getting more expensive (Nipon and Surachai, 1997; World Bank, vol.2, 2000: 4), it is rational for the firms to maintain their competitiveness by investing in the technical change that can most effectively enhance the productivity of those workers with secondary education. Another explanation has to do with the legal minimum wage which is higher than the average wage in the informal sector. Moreover, the minimum wage frequently adjusted upward almost every year, taking into account the increases in cost of living and profitability of the industries. Thus, it is possible that the impact of technical change on workers' productivity is marginal or less than the increases in the minimum wage.[19] Still the third explanation is possible. In the electronics and automotive industries, the demand for final products is subject to cyclical growth and the product life-cycle has been shorten. In such situation, firms need to reinvest their surplus in new technologies so that they can readily expand their business in the next boom. Although technical change brings about higher productivity, workers' productivity does not increase permanently unless they are trained to use the new technology (because new machines are complementary with specialized human capital). Therefore, the returns from increased productivity go to the capital owners and the costs of training incurred by the employers.

The surprising result is that technical change reduces the returns to off-the-job training investment for technicians and engineers. However, this does not mean that technical change is always bad for the technicians and engineers. In fact, if they stay longer with the company and acquire cumulative experience, the technical change (and years of schooling) will augment their productivity. One implication is that the senior workers will not oppose new technology because the risk of being laid off could be offset by higher wage growth. Moreover, if the education process for the engineers and technicians could be improved in such a way that engineers and technicians acquire higher capability to cope with technical change, their productivity could be enhanced. The kinds of new basic skills required by the employers are ability in solving problems and finding creative solution.

One possible explanation, which is consistent with the above interpretation, is that the technical change is exogenously introduced by importing new production process and machinery while the engineers have played almost no role in technological development within the company. Most firms in Thailand have still heavily depended on imported technology. Foreign subsidiaries always import machine and new production process from their parent companies or machinery suppliers. A study by Technopolis (2001) shows that most of the large scale Thai manufacturing companies do not have technological development activities because there are uncertainties about returns to and high cost of such activities. Such market failure implies that there is a need for a government intervention to provide necessary financial incentives for firms to carry out the technological development activities. These activities would augment returns to education of engineers and technicians. Secondly, the kinds of off-the job training received by engineers and technicians are mostly in the areas of management, quality control, tax and other government regulations which are not directly related to the technical change introduced in the firms. So those who receive off-the-job training will have less time to deal

[19] Between 2000 and 2001, the average wage of production workers in our sample grew by 1.9 percent p.a., while the minimum wage in Bangkok increased by 1.8 percent p.a. It should be also noted that the average wage of workers with long tenure is not much higher than that of new workers as the wage distribution is highly skewed to the right.

with the new technical changes. If firms begin to carry out their own technological development, they will certainly reorient the contents of their off-the-job training programs.[20]

Finally, further researcher should focus on the measurement of training. One suggestion is that the researcher should investigate the training history of each worker from the first year of their work with the current company. It is also useful to measure the subject content of training, particularly the courses provided in the off-the-job training.

8 Conclusion

This paper examined the determinants of investments and returns to training in manufacturing industries, using two recent employee surveys in Bangkok, Thailand. Our empirical findings demonstrate significant returns to both on the job and off the job training in first-difference fixed effect estimation of wage equations, controlling technological change and workers' ability (endowment) which are shown to influence, but differentially, both training investments and the returns.

Technical change significantly induces investments in firm-level training. This effect is particularly strong in on the job training, since firms need to train workers to be capable of handling new technologies and/or adjust to new production organizations. However, technical change does not directly affect returns to training.

In contrast, unobserved ability alters the returns to training investments. Using the significant selection of better workers that occurred in electronics, auto-parts and hard-disk drive industries around 1997-1998 through the financial crisis in Thailand, it is shown that high unobserved productive endowment substitutes for training, especially off-the-job training in the postcrisis period and that returns to off the job training are significantly positive. However, workers' endowment does not enhance investments in training. The empirical results show that the efficacy of firm-level training investments depend on not only training and education policies but also other supply-side factors such as dynamics of technological change and screening in labor markets.

Appendix: Survivors and New Entrants at Financial Crisis

[20] Since the off-the-job training and schooling are complementary in the Philippines in our preliminary studies (but are not statistically significant for the Thai data), there should be a further in-depth analysis which compares the content of off-the-job training and education system in both countries.

To provide further empirical foundations to Section 6, Appendix characterizes unobserved productivity of the financial-crisis survivors and postcrisis entrants using log-wage residuals. First, log of wage in 2001 is regressed on observable worker characteristics and the residuals are interpreted as unobserved earnings endowment and some stochastic shocks. This earnings endowment - individual fixed effect - reflect productivity components that are not directly observable to researchers, but employers and workers may have better inference on it through learning-by-doing in workplace. We compare the distributions of the unobserved productivity between the groups of survivors and new entrants. If selection of better workers occurred in the face of financial crisis, the endowment distribution from the survivor group should stochastically dominate that of postcrisis entrants.

Table A1 shows benchmark estimates of wage regressions, which use cross section of year 2001 (our survey period). All workers are included in the sample.[21] Wage equations are estimated in two specifications, which differ in the assumptions on cross-firm heterogeneity. In the first column, firm dummies do not interact with any other characteristics. In the second, firm dummies interact position dummies, which capture firm-specific position effects.

Table A1 to be inserted

The residuals are estimated from each of the above two specifications. These two forms of residuals are useful to investigating the robustness of our observations. In preliminary t-tests, it is shown that in electronics, auto-parts and hard-disk drive industries, it appears that some selections of workers occurred around 1997-1998, which corresponds to the time of Thailand's financial crisis.[22] Since the residual means of the crisis survivors are statistically larger than those of new entrants after the crisis, better workers were screened during the period. However, the results become less clear in the tests using residuals from column 2 in Table A1.

Tables A2 to be inserted

For the purpose of identifying a structural change in the endowment, the wage residuals are regressed on a demarcation dummy, its interactions with industry dummies, and observable workers'

[21] We assume that this population represents the distribution of unobserved endowment in the sample firms. Alternatively, if postcrisis entrants represent the population distribution of unoberved endowment, we should estimate the log-wage residuals using only the postcrisis entrants. However, this method faces a huge reduction of sample size and small variations of observable individual characteristics, including tenure and age, which makes the estimates quite unstable. After some preliminary tests, we decide to use all workers in the estimation of log-wage residuals.

[22] Nipon (2001) found that during 1996 and 1998, the Thai automotive firms were forced to reduce employment by 30.6 percent in response to the sharp decline in vehicle sales of 72 percent. Many particularly the unskilled, semi-skilled and less abled workers.

characteristics. The results are shown in Tables A2. In each definition of the wage residuals, estimation results look quite similar. Since education, age, and tenure are already controlled in the wage regressions (Table A1), they are insignificant at this second stage (not shown in Tables A2). Consistent with the t-test results in our preliminary analysis, the effects of demarcation dummies and their interactions with industry dummies prove our conjecture. While food processing industry experienced an increase in unobservable quality among recent entrants, the other industries more capital-intensive experienced a decrease in workers' productivity after the financial crisis. Better workers were selected during the period in electronics, auto-parts and hard-disk drives industries.

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Table 1 Technical change and workers' involvement

		Technical change occurred in your lines	
		yes	no
Assigned to deal	yes	157	107
with new technology	no	33	117

2003 ICSEAD-TDRI Survey on Technical Change and Training.

Table 2 Impacts of technical change

	Team work	Problem solving	Multi skill	Supervision	Work amount
Increased	179	166	181	169	211
Decreased	16	16	7	13	6

	Speed	Defect rate	Monitoring
Higher	224	19	207
Similar	19	38	13
Lower	5	176	22

2003 ICSEAD-TDRI Survey on Technical Change and Training. 229 workers experienced changes in their responsibility and requirement, and 83 did not.

Table 3 Timing and types of training when technical change occurs

Timing of training	Before	After	Before and after
Number of response	45	56	181

Before technical change		Off the job training	
(percentage %)		no	yes
On the job	no	31.63	8.16
training	yes	57.14	3.06

After technical change		Off the job training	
(percentage %)		no	yes
On the job	no	28.62	14.14
training	yes	52.76	4.48

2003 ICSEAD-TDRI Survey on Technical Change and Training. The sample is 294 workers who received some training.

Table 4 Incidence and days of training investments

	On the job training			Off the job training		
	Incidence	Days	Days	Incidence	Days	Days
	Probit	Tobit	Tobit	Probit	Tobit	Tobit
Growth %: Net fixed capital	0.3854	12.246	12.258	0.3577	3.3879	3.4452
(t-1)	(3.38)	(1.77)	(1.77)	(2.20)	(2.07)	(2.04)
Years of schooling	-0.0677	-2.982	-2.957	0.0129	0.2330	0.2470
	(5.71)	(5.11)	(5.05)	(1.28)	(1.73)	(1.80)
Tenure	-0.0334	-1.894	-2.015	-0.0104	-0.0297	-0.0859
	(3.18)	(3.91)	(3.69)	(1.00)	(0.28)	(0.70)
Age	-0.0227	0.6600	0.5436	0.0167	0.1899	0.1674
	(0.64)	(0.40)	(0.33)	(0.68)	(0.53)	(0.45)
Age squared	0.00010	-0.0142	-0.0124	-0.00014	-0.0024	-0.0021
	(0.19)	(0.56)	(0.49)	(0.36)	(0.44)	(0.38)
Male	-0.1966	-0.7134	-7.1822	-0.0749	0.1859	0.1590
	(1.82)	(2.03)	(2.05)	(0.99)	(0.23)	(0.19)
Enter before 1997			1.8069			0.7906
			(0.48)			(0.89)
Position fixed effect	yes	yes	yes	yes	yes	yes
Firm fixed effect	yes	yes	yes	yes	yes	yes
Year fixed effect	yes	yes	yes	yes	yes	yes
Number of observations	3490	3490	3490	3490	3490	3490
Pseudo R squared	0.1070	0.0123	0.0123	0.1042	0.0089	0.0089

Numbers in parentheses are absolute asymptotic z values. Net fixed capital is taken from official balance sheets reported to the Department of Commercial Registration.

Table 5 Returns to training and individual human-capital stock

Dependent: differenced base wage	All workers		Production workers		Technical workers	
Days OJT	0.0004	0.0011	0.0005	0.0009	0.0001	0.0071
	(2.66)	(1.61)	(2.84)	(1.12)	(0.50)	(2.83)
* years of schooling		-0.00007		-0.00006		-0.0004
		(1.70)		(1.00)		(2.63)
* tenure		0.00004		0.00004		-0.0002
		(1.09)		(0.90)		(1.35)
* previous experience		0.00003		0.00003		0.00003
		(2.39)		(1.94)		(0.42)
Days OFF JT	-0.00016	0.0032	-0.0002	0.0041	0.0018	0.0328
	(0.76)	(0.55)	(0.87)	(0.58)	(1.61)	(1.39)
* years of schooling		-0.00007		-0.0001		-0.0019
		(0.17)		(0.24)		(1.42)
* tenure		-0.0004		-0.0004		-0.0006
		(1.09)		(1.13)		(0.82)
* previous experience		-0.00007		-0.00007		-0.0005
		(0.89)		(0.53)		(1.63)
Years of schooling	0.0026	0.0036	0.0025	0.0017	0.0038	0.0201
	(1.11)	(0.89)	(0.96)	(0.38)	(0.55)	(1.61)
Tenure	0.0010	0.0016	0.0017	-0.0004	-0.0032	0.0042
	(0.62)	(0.23)	(0.78)	(0.05)	(0.70)	(0.34)
* years of schooling		0.00002		0.0003		-0.0002
		(0.04)		(0.52)		(0.19)
Age, age squared and male dummy						
Position, firm, year, and firm-year fixed effects included						
R squared	0.1122	0.1136	0.1321	0.1333	0.1044	0.1219
Number of observations	3881	3881	3086	3068	513	513

Robust estimates are used for robust standard errors, with company clusters. The estimation excludes observations of extremely large numbers in estimated days of OJT, i.e. those larger than 200 days.

Table 6 Technical change and returns to training

Dependent: differenced base wage	All workers	Production	Technical	All workers	Production	Technical
Days OJT	0.00059	0.00069	0.00026	0.00058	0.00066	0.00023
	(2.18)	(2.20)	(0.73)	(2.22)	(2.14)	(0.58)
* Growth %: Net fixed capital				-0.00084	-0.00055	-0.00140
(t-1)				(0.87)	(0.48)	(0.65)
Days OFF JT	-0.00039	-0.00045	0.00157	0.00040	0.00074	-0.00065
	(1.55)	(1.64)	(1.59)	(0.35)	(0.50)	(0.38)
* Growth %: Net fixed capital				0.00513	0.00770	-0.01337
(t-1)				(0.78)	(0.87)	(1.75)
Growth %: Net fixed capital	-0.1635	-0.1993	-0.1420	-0.1638	-0.2142	0.1102
(t-1)	(1.39)	(1.21)	(0.13)	(1.18)	(1.17)	(0.69)
Years of schooling, tenure, age, age squared and male dummy						
Position, firm and year fixed effects included						
R squared	0.0976	0.1137	0.0948	0.0981	0.1142	0.0994
Number of observations	2380	1864	336	2380	1864	336

Numbers in parentheses are absolute t values, based on robust standard errors with firm-level clusters. Net fixed capital is taken from official balance sheets reported to the Department of Commercial Registration.

Table 7 Returns to training and entry-time

Entry time before		1989	1990	1991	1992	1993
Days OJT	0.00044	0.00044	0.00045	0.00044	0.00047	0.00053
	(2.90)	(2.84)	(2.73)	(2.56)	(2.68)	(2.74)
Days OFF	-0.00026	-0.00028	-0.00026	-0.00026	-0.00033	-0.00010
	(1.31)	(1.32)	(1.25)	(1.28)	(1.05)	(0.85)
Entry time		-0.0309	-0.0171	-0.0357	-0.0440	-0.0449
		(2.61)	(1.14)	(2.20)	(2.19)	(2.60)
Entry time*Days OJT		0.00002	-0.00002	0.00083	-0.00060	-0.00022
		(0.05)	(0.11)	(0.47)	(0.38)	(1.03)
Entry time*Days OFF		0.0020	-0.00042	-0.00063	0.00020	-0.00037
		(1.38)	(0.23)	(0.39)	(0.57)	(0.77)
R squared	0.0624	0.0628	0.0626	0.0635	0.0640	0.0647
# Obs.	3875	3875	3875	3875	3875	3875

Entry time before	1994	1995	1996	1997	1998	1999
Days OJT	0.00053	0.00050	0.00059	0.00064	0.00089	0.00167
	(2.56)	(2.32)	(2.24)	(1.80)	(1.28)	(1.72)
Days OFF	-0.00010	-0.00003	0.00196	0.00358	0.00846	0.00709
	(0.84)	(0.25)	(1.69)	(2.01)	(2.33)	(1.96)
Entry time	-0.0256	-0.0149	0.0088	0.0587	0.1181	0.1293
	(1.32)	(0.85)	(0.48)	(3.32)	(4.27)	(3.24)
Entry time*Days OJT	-0.00020	-0.00015	-0.00025	-0.00030	-0.00051	-0.00128
	(0.93)	(0.60)	(0.95)	(0.80)	(0.74)	(1.35)
Entry time*Days OFF	-0.00043	-0.00053	-0.00231	-0.00394	-0.00877	-0.00737
	(0.89)	(1.03)	(1.95)	(2.16)	(2.40)	(2.05)
R squared	0.0634	0.0630	0.0631	0.0661	0.0709	0.0675
# Obs	3875	3875	3875	3875	3875	3875

Entry time is an indicator variable which takes the value of one if a worker entered the current firm before the corresponding year and zero if entered in or after the year. All specifications include education, male, position, year and firm dummies, tenure, tenure squared, age and age squared. Tenure and age variables control spurious correlation between Entry time and wage growth.

Table A1 Wage Equations

Dependent: log monthly base wage 2001

	(1)	(2)
educ 2	0.0850	0.0602
	(2.62)	(2.38)
educ 3	0.0953	0.0775
	(2.44)	(2.27)
educ 4	0.1585	0.1512
	(3.71)	(4.31)
educ 5	0.2600	0.2390
	(6.97)	(6.68)
educ 6	0.3790	0.3343
	(5.97)	(6.75)
educ 7	0.6317	0.5592
	(8.14)	(7.81)
educ 8	0.5647	0.5449
	(7.08)	(8.08)
educ 9	0.8750	0.8215
	(6.89)	(7.13)
tenure	0.0229	0.0229
	(5.40)	(5.66)
age	0.0446	0.0451
	(4.63)	(4.82)
age squared	-0.00047	-0.00052
	(2.83)	(3.54)
male	0.1121	0.0846
	(3.28)	(2.42)
level 2	0.0512	0.0554
	(2.37)	(2.69)
level 3	0.1003	0.1127
	(5.49)	(5.17)
position dummies	yes	yes
firm dummies	yes	yes
firm*position dummies	no	yes
firm*educ dummies	no	no
firm dummies*tenure	no	no
R sq	0.7410	0.7798
# obs.	1662	1662

The numbers in parentheses are t values. Robust standard errors are used with company clusters. Observations of no education are dropped from sample, and elementary school graduates are chosen as a benchmark. School quality (level) is not constructed for postgraduate level, so those observations are dropped. Education dummies: educ1=elementary (omitted), educ2=lower secondary, educ3=upper secondary, edu4=lower vocational, educ5=upper vocational, educ6 to educ9 = university degrees with different majors.

Table A2-1 Structural Change

Dependent: Residuals from wage equation (1)

Entry time before	1989	1990	1991	1992	1993	1994	1995	1996
Entry time	-0.0857	-0.0820	-0.1161	-0.1433	-0.1361	-0.0862	-0.0949	-0.0695
	(2.44)	(2.66)	(3.47)	(2.69)	(2.75)	(1.79)	(2.36)	(1.42)
*Ind2	0.0786	0.0528	0.1052	0.1074	0.1161	0.1038	0.1292	0.1264
	(1.76)	(0.72)	(1.61)	(1.91)	(2.31)	(2.39)	(3.12)	(2.77)
*Ind3	-0.1039	-0.0540	0.0691	0.0782	0.0797	0.0992	0.0956	0.0679
	(3.33)	(1.96)	(1.07)	(1.11)	(1.23)	(1.92)	(1.49)	(1.15)
*Ind4	-0.3448	0.1630	0.1863	0.2107	0.1550	0.1400	0.1559	0.1217
	(9.94)	(1.42)	(2.63)	(3.89)	(2.28)	(2.36)	(2.92)	(2.60)
R sq	0.0079	0.0056	0.0064	0.0108	0.0089	0.0072	0.0102	0.0085
# obs	1662	1662	1662	1662	1662	1662	1662	1662

Entry time before	1997	1998	1999
Entry time	-0.0176	0.0108	0.0003
	(0.64)	(0.34)	(0.01)
*Ind2	0.0904	0.0705	0.0777
	(2.88)	(2.33)	(2.59)
*Ind3	0.0952	0.0940	0.0847
	(2.96)	(2.47)	(2.43)
*Ind4	0.0658	0.0172	0.0143
	(2.24)	(0.57)	(0.58)
R sq	0.0081	0.0090	0.0065
#obs	1662	1662	1662

d_time is a dummy variable which takes the value of one if a worker entered the current firm before the corresponding year, and zero if entered in or after the year. Interactions with industry dummies are estimated. Ind2 = Electronics, PC/IC; Ind3 = Auto parts; Ind4 = Hard disk drives. Industry dummies and other individual characteristics such as education, tenure and age are also included. Education dummies, tenure and age are insignificant in all specifications.

Table A2-2 Structural Change

Dependent: Residuals from wage equation (2)								
Entry time before	1989	1990	1991	1992	1993	1994	1995	1996
Entry time	-0.0666	-0.0668	-0.1044	-0.1238	-0.1238	-0.0831	-0.0912	-0.0818
	(1.92)	(2.13)	(3.79)	(2.49)	(2.64)	(2.04)	(3.00)	(1.84)
*Ind2	0.0442	0.0748	0.0949	0.0718	0.0868	0.0918	0.1210	0.1211
	(1.20)	(1.40)	(2.09)	(1.57)	(2.12)	(2.24)	(2.72)	(2.34)
*Ind3	-0.0501	-0.0172	0.0551	0.0625	0.0617	0.0722	0.0681	0.0531
	(0.97)	(0.32)	(0.72)	(0.78)	(0.88)	(1.34)	(1.14)	(0.94)
*Ind4	0.0349	0.1861	0.2348	0.2206	0.1481	0.1267	0.1290	0.1044
	(1.03)	(2.09)	(8.42)	(5.17)	(2.45)	(2.60)	(3.31)	(2.55)
R sq	0.0034	0.0044	0.0083	0.0120	0.0089	0.0064	0.0088	0.0079
#obs	1662	1662	1662	1662	1662	1662	1662	1662

Entry time before	1997	1998	1999
Entry time	-0.0360	-0.0097	-0.0150
	(1.27)	(0.25)	(0.51)
*Ind2	0.0902	0.0718	0.0779
	(2.02)	(1.53)	(1.60)
*Ind3	0.0868	0.0866	0.0790
	(2.53)	(2.08)	(2.04)
*Ind4	0.0557	0.0009	0.0018
	(2.10)	(0.02)	(0.05)
R sq	0.0061	0.0070	0.0055
#obs	1662	1662	1662

Entry time is a dummy variable which takes the value of one if a worker entered the current firm before the corresponding year, and zero if entered in or after the year. Interactions with industry dummies are estimated. Ind2 = Electronics, PC/IC; Ind3 = Auto parts; Ind4 = Hard disk drives. Industry dummies and other individual characteristics such as education, tenure and age are also included. Education dummies, tenure and age are insignificant in all specifications.