Volume Title: Productivity Growth in Japan and the United States

Volume Author/Editor: Charles R. Hulten, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-36059-8

Volume URL: http://www.nber.org/books/hult91-1

Conference Date: August 26-28, 1985

Publication Date: January 1991

Chapter Title: Technical Change and Human Capital Acquisition in the U.S. and Japanese Labor Markets

Chapter Author: Hong W. Tan

Chapter URL: http://www.nber.org/chapters/c8454

Chapter pages in book: (p. 385 - 409)

13

Technical Change and Human Capital Acquisition in the U.S. and Japanese Labor Markets

Hong W. Tan

The contribution of education to productivity growth is widely accepted among economists and is reflected in its inclusion in growth accounting studies. Less well understood is the role played by postschooling investments in human capital, such as training or informal learning on the job. What kinds of training are most important for productivity growth? Do these tend to be general skills or firm-specific skills? How do labor markets provide price signals to induce investments in the appropriate kinds of training? What kinds of employment relationships and compensation schemes are needed to encourage investments in skills required by technical change? Answers to these questions should provide insights into how labor markets function to facilitate technical change and productivity growth.

In this regard, a comparison of how U.S. and Japanese labor markets operate, and the way in which they facilitate productivity growth, is particularly interesting. Some observers in the past have sought to explain higher rates of productivity growth in Japan than in the United States in terms of differences in labor market organization, contrasting Japan's unique institutions of lifetime employment (*syushin koyosei*) and seniority-based wage compensation (*nenko joretsu seido*) with a spot-market characterization of the way U.S. labor markets operate. These institutions, they argue, instill loyalty and motivate increased work effort and training among Japanese workers, and reduce workers' opposition to introduction of new technologies. In contrast, weak worker-firm attachment and high labor turnover in the United States may retard work incentives and investments in training and inhibit innovation.

Neither characterization of U.S. and Japanese labor markets appears well

---

Hong W. Tan is an economist in the Economics and Statistics Department of the RAND Corporation.

Views expressed in this paper are the author's own and are not necessarily shared by RAND or its research sponsors.

founded. The culturally based argument for Japan is at odds with evidence that these labor practices are concentrated only among larger firms, that they are of recent origin (after the 1920s), and that they arose with the onset of modern economic growth. Recent studies indicate that long-term jobs are also prevalent in the U.S. labor market (Hall 1982). However, jobs are typically of shorter duration and have slower rates of wage growth with seniority as compared to Japan (Hashimoto and Raisian 1985). Explanations for these cross-national similarities and differences in employment and wage practices offer potentially important insights into how labor markets operate to facilitate technological change.

This paper presents a model of technology-specific skills that seeks to explain why these labor market practices are found in some firms but not others, and how such practices may be related to productivity growth in the two countries. The model hypothesizes that technological change is associated with a greater demand for firm-specific investments in learning about new technologies and, to the extent that more-educated workers are better adept at learning, with a greater demand for a better educated work force as well. If the potential for technical change differs across industries, differences in specific training and the resulting returns to such investments should be reflected in interindustry wage-tenure profiles (and schooling returns), which vary systematically with the rate of total factor productivity growth. Given the technology gap between the two countries (see Jorgenson, Kuroda and Nishimizu 1985), learning opportunities are also greater in Japan and, if translated into increased training investments, should be reflected in cross-national differences in wage profiles as well. Another implication of the model—that long-term jobs are more common in technologically progressive industries—follows from skill specificity, since neither workers nor employers have any incentive to invest in specific training in the absence of a durable employment relationship. This prediction, though not explicitly addressed in this paper, may explain why jobs in Japan tend to be of relatively longer duration.

The paper also addresses the complementary hypothesis that rapid growth itself may induce increased firm-specific training. For a given commodity or product class, the derived demand for skills specific to that particular production technology is larger the more rapid the output growth of that industry. To the extent that demand growth outstrips the supply of these skills in the open market, employers must devote increased resources to developing these technology-specific skills in-house. Cross-national differences in the rate of output growth—over 8% in Japan and about 3.5% in the United States over the 1960–79 period—may account for both greater training investments and more frequent internalization of training in Japanese companies than in American firms. The technology-specific skills and output-growth hypotheses are jointly tested in the paper.

Tests of these hypotheses use the May 1979 Current Population Survey for the United States and the 1977 Employment Status Survey for Japan. Both surveys are broad-based nationally representative samples of the labor force in the two countries, containing similar information on schooling attainment, work experience, years of tenure on the current job, and earnings. To these data are merged industry indices of total factor productivity growth estimated by Jorgenson, Gollop, and Fraumeni (1986) for the United States and unpublished estimates by Kuroda (1985) for Japan. Because information on firm size is available, the analysis also explores variations in the postulated relationships across firm sizes. Previous studies, both in the United States and in Japan, have found systematic variations in earnings and job tenure across firm size (e.g., Shimada 1981; Mellow 1982; Hashimoto and Raisian 1985). Though these differences could reflect differential investments in firm-specific training (Kuratani 1973), they may also reflect the idiosyncratic nature of production in large firms (Oi 1983) or problems of monitoring worker performance that are exacerbated in larger firms.

The last point highlights a potential difficulty in distinguishing between firm-specific training explanations on the one hand and a broad class of implicit labor contract theories on the other. Both predict steeply rising wage-tenure profiles, though the implicit contract theories make no assumptions about training. Instead, steeply rising wage profiles are offered by employers to reduce incentives to shirk (Lazear 1981) or to attract workers with low quit propensities (Salop and Salop 1976). Another difficulty, raised by several recent papers (Abraham and Farber 1987; Altonji and Shakotko 1987), is in the interpretation of wage-tenure profiles. They argue (and demonstrate) that the estimated tenure coefficient in cross-sectional wage models is upward biased by the omission of measures of job-match quality. Both issues are addressed for the U.S. case, using information on reported training, and evidence is found to support the maintained hypothesis that wage-tenure profile differences are attributable primarily to specific training investments.

Section 13.1 provides the justification for the technology-specific skills model and reviews both U.S. and Japanese labor-market research for insights into the link between technical change and human capital investments. Section 13.2 describes the U.S. and Japanese data and the specification of the earnings models to be estimated. Section 13.3 presents the empirical results and discusses the similarities and differences in the relationship between technical change and skill acquisition in the two labor markets. Several qualifications about the interpretation of wage-tenure profiles are also addressed here. The conclusions are summarized in section 13.4.

13.1 The Link between Technical Change and Human Capital

The relationship between technical change and skill acquisition is based on an economic model of technology-specific skills (Tan 1980). This model draws upon, and integrates, elements from the technical change literature, human capital theories (Becker 1975), and the allocative efficiency of schooling hypothesis (Welch 1970). The hypotheses are that individuals working with new technologies acquire new and more productive skills specific to that technology, and that better-educated labor are more adept in this learning. The theoretical justification for these hypotheses are developed below.

13.1.1 The Technology-Specific Skills Model

First, consider the notion that skill acquisition is greater in more technologically progressive firms. We know from microeconomic studies of the innovative process that much of the productivity gains from introducing a new technology comes from making cumulative small modifications in it, essentially through an intensive learning-by-doing process (Enos 1962; Hollander 1965). Indeed, the Horndal effect—a phenomenon in which labor productivity increases of 2%–4% per annum are observed in plants with fixed facilities—may be a consequence of these learning and innovative activities. If so, then innovative firms have an incentive to motivate increased worker investments in learning about new technologies and to monopolize the new information embodied in workers' skills.

They can do this by sharing in the costs of skill acquisition and paying workers out of that component of productivity that is specific to the innovating firm. The familiar bilateral monopoly problem associated with skill specificity (Becker 1975) arises here as well. On the one hand, workers have few incentives to learn about new technologies since skills acquired may not be readily transferred to alternative uses; furthermore, such skills are subject (presumably) to more rapid rates of obsolescence when innovation is high. Employers, on the other hand, are denied any innovative rents since new technologies cannot be used effectively without these skills. The solution is for worker-firm sharing of the costs and returns to specific training (Hashimoto 1979). "Lifetime employment" guarantees could allay concerns about risky skill investments and encourage increased training and retraining as older skills become obsolescent over time.

Innovative firms are also more likely to use highly educated and technically skilled workers, especially at the outset of a new technology when experience is so limited. This assertion is based on the argument that better-educated workers are more adept at critically evaluating new information, and therefore learn more (Welch 1970). The evidence from U.S. farming appears to support the hypothesis about schooling's "signal-extraction" effects. The schooling attainment of farmers is positively correlated with farm incomes and the speed with which farmers allocate resources in a dynamically changing environment (Schultz 1975). Several case studies also document the decline in the industrial demand for educated workers as technologies become routinized and widely diffused (Setzer 1974). More broadly based empirical research by Bartel and Lichtenberg (1987) reveal that the relative demand for educated workers across manufacturing industries declines as the capital stock (and presumably the technology embodied in it) ages.

These perspectives provide the basis for the model's predictions about the relationships between technical change, specific training, and schooling. Unlike firm-specific human capital, which is thought to be idiosyncratic, technology-specific skills are hypothesized to be firm-specific only in so far as the company retains exclusive access to that technology. Over time, these embodied technology-specific skills become general as that technology diffuses to other firms; accordingly, the quasi rents that these skills command also fall. However, firms that innovate faster than the rate at which their technologies diffuse to others can continue to generate new skills and quasi rents. Thus, this model predicts systematically higher returns both to specific training and to schooling in firms experiencing rapid technical change.

Rapid economic growth may also lead to increased firm-specific training. For a given product, the derived demand for skills specific to that particular production technology is likely to vary systematically with the rate of output growth. To the extent that demand growth outstrips the ability of the labor market to supply these skills (firms can either develop these skills internally or hire workers away from competitors using the same production technology), employers must devote increased resources to developing these technology-specific skills in-house. Thus, holding technical change constant, this ancillary hypothesis predicts that firms in rapidly growing industries invest more in specific-training than do slow-growing firms.

Another implication of the model—that long-term jobs are likely to be found in more technologically progressive industries—follows from skill specificity. In essence, neither workers nor employers have any incentive to invest in specific training in the absence of a durable employment relationship. Though we do not explicitly examine this implication of the model, it is useful to briefly review several recent studies that seek to explain Japanese lifetime employment and wage practices in terms of technological change.[1]

13.1.2 A Selective Review of Japanese Research

A major focus of labor-market research in Japan has been on explaining "dualism" in the wage and employment practises of large and small firms. Large firms in Japan not only pay higher wages but also extend the guarantee of lifetime employment to workers; this in contrast to small firms, where pay is lower and labor turnover higher. One explanation for this dualism is that it is technology induced. Taira (1970) dates the origin of lifetime employment and *nenko-joretsu* (seniority-based) wage practices in Japan at some time during the 1920s or 1930s. These practices were adopted primarily by large firms—who were the major importers of foreign technology—to reduce high rates of labor turnover (by present-day standards) among skilled workers. Dualism exists, he argued, because of the coexistence of large firms using modern technology and small firms using traditional (indigenous) production methods.

Yasuba (1976) extends this line of argument to examine the model's implication that firm-size wage differentials in an industry increase with the induction of foreign technology but subsequently diminish with its diffusion to other firms in the industry, including small firms. For four cross sections in time from 1909 to 1951, he allocates industries to either a "dualistic" or a "homogeneous" category on the basis of the coefficient of variation (to measure wage spread) and the size elasticity of wages (to measure the association of high wages and firm size). With information on which industries had purchased foreign technology and when, Yasuba finds considerable support for this hypothesis. For example, the period preceding World War I was a period of rapid foreign-induced technical change in textiles, and six of ten dualistic industries were textile related. In later years, the dualistic industries were no longer concentrated in textiles, and, in fact, for the apparel and hosiery industries, firm-size wage differentials narrowed in the face of generally widening trends. Iron and steel, bricks and tiles, and printing industries all experienced rapid technical change after World War II and appeared in the dualistic category. These findings suggest that firm-size wage differentials in dualistic industries may be associated with quasi rents from the use of foreign technology by large firms, rents that disappear when technology is widely diffused to other firms.

Research by Saxonhouse (1976) also establishes a link between the nature of technology and labor turnover. He speculates that the use of identical technology contributed to high labor turnover in the Japanese cotton-spinning industry at the turn of the century. He rejects the hypothesis that employers had few incentives to retain workers because no productivity advantages were gained by increased tenure in the firm. Estimating a translog production function whose parameters are explained by variables such as schooling, years of tenure, and the number of trained engineers, he finds that increases in these variables had large productivity effects. This finding leads him to conclude that the uniformity of technical practices among firms using identical English looms inhibited incentives to train workers since skills were easily transferred to other competing firms. Some skills, it appears, are specific to particular production technologies and not necessarily to the firm. As such, incentives to invest in training workers are diminished unless institutional arrangements—such as lifetime guarantees or seniority-based wage and promotion practices—are developed to cement worker-firm relationships.

A study by Tan (1980) suggests that interindustry differences in the rate of technical change are related systematically with some components of earnings but not others. Using data from the 1961 Basic Wage Survey, a document comprising male workers in 11 manufacturing industries for which independent estimates of technical change were available, Tan estimated separate wage models for schooling, occupation, and education group by industry.[2] From the estimated wage profiles, present values of specific training (ST) and general training (GT) returns were calculated for each group of workers, assuming continuous employment in the same firm for 35 years. These wage components were regressed on estimates of industry rates of technical change (TFP) and a set of controls for structural factors such as unionization (UNION), market concentration (CON), profitability (PR), and the share of wage bill in value added (WB). These regression results are reported below:

$$\text{ST} = 8{,}334 + 1{,}496^{*}\ \text{TFP} + 677\ \text{HS} + 525\ \text{JC} + 4{,}351^{*}\ \text{UNIV} - 11\ \text{CON} - 47\ \text{PR} - 36\ \text{WB} - 81\ \text{UNION}, \quad (R^2 = 0.525),$$

$$\text{GT} = 3{,}917 - 233\ \text{TFP} + 826\ \text{HS} + 7{,}088^{*}\ \text{JC} + 7076^{*}\ \text{UNIV} + 23\ \text{CON} + 224\ \text{PR} + 77\ \text{WB} - 14\ \text{UNION}, \quad (R^2 = 0.771),$$

where HS, JC, and UNIV are dummy variables for completion of high school, junior college, or university, respectively, and an asterisk denotes statistical significance at the 1% level. From these results, Tan concluded that higher rates of technical change in an industry are associated with an increase in specific training as measured by the present value of specific training returns (ST), but not with general training (GT). In other empirical specifications, which considered the simultaneous determination of ST and TFP, this relationship remained very robust.[3]

To summarize, extant research appears to provide corroborative evidence for some of the predictions of the technology-specific skills model, at least for Japan. The issue examined below is whether these perspectives carry over to the U.S. labor market and to cross-national comparisons of U.S. and Japanese labor markets in a more recent period.

13.2 Data and Model Specification

The data used for the analysis come from two sources: the May 1979 Current Population Survey (CPS) for the U.S. and the 1977 Employment Status Survey (ESS) for Japan. Both surveys are broad-based representative samples of the labor force in each country. The data are also from approximately the same time period and, in terms of the business cycle, in the recovery phase following the international recession of the mid-1970s. Most important, both surveys contain similar kinds of information on earnings, job tenure in the current firm, establishment size, schooling attainment, occupation, and industry. Thus, the same model specifications can be used in studying the determinants of earnings in both countries.

In both data sets, analysis is limited to males between the ages of 18 and 65 years engaged full-time in nonagricultural wage and salary employment. For the CPS, responses to questions on usual weekly earnings and hours worked are used to construct an hourly wage variable, W. For the ESS, the corresponding wage variable is created from annual earnings, which include both contractual wages and semiannual bonus payments,[4] as well as from usual weekly hours worked.[5] To mitigate labor-supply effects on earnings, only those who worked full-time full-year are included in the Japanese sample. The vector of personal attributes included years of schooling attainment (*S*), prior work experience (EXP), and job tenure (TEN).[6] Indicator variables were also defined for white-collar occupations (WCOLAR), geographic location, and residence in metropolitan areas. A common definition of firm size was used in both data sets: small firms with less than 100 employees, medium-size firms with 100–999 employees, and large firms with over 1,000 workers. The CPS also contained information on union membership not found in the Employment Status Survey.

Measures of industry rates of total factor productivity (TFP) growth estimated by Jorgenson, Gollop, and Fraumeni (1986) for the United States and by Kuroda (1985) for Japan are merged into the two data sets by industry of current employment.[7] The U.S. TFP series is for the 1966–79 period and that for Japan for the 1966–77 period. These measures have several advantages over alternative proxies for technical change. First, both measures of technical change derive from a common methodological approach, which facilitates comparison of their effects on earnings across countries. Second, because these measures already adjust for changes in the quality of human capital inputs, the estimated correlations between technical change and the returns to technology-specific skills can be interpreted as reflecting the relationships of interest rather than a spurious correlation between wages and labor quality in the unadjusted technical change measure.

Two other industry attributes are merged into the data by industry of current employment: rate of output growth (IGR) and output variability (IVAR). Separate regressions of output on a quadratic specification of time were run for each two-digit industry, using annual output data for the United States (1960–79) and Japan (1960–77). The coefficient of the linear trend variable is used as a measure of output growth; the mean squared error of the regression is used as a proxy for the degree of cyclical variability around trend output growth. Though not central to the major thrust of this paper, IVAR is used to control for possible compensating wage effects for employment in industries with predictably high cyclical output variability.

Table 13.1 summarizes some of the variables of interest for the U.S. and Japan, both for the aggregate sample and separately by firm size. Several cross-national differences are noteworthy. First, the sample of U.S. workers have more schooling (about two extra years), they spend approximately the same amount of time working for other firms prior to joining the current employer, and on average they have shorter job tenure. The Japanese sample is older, possibly because those who were not working full-time full-year (predominantly youth) were dropped from the sample (see sample selection criteria). For this sample, however, the fraction of total work experience spent in the current firm (job tenure divided by total work experience) is slightly higher in Japan than in the United States. Second, for both countries, workers in large firms are characterized by higher average schooling attainment, longer job tenure, and a smaller fraction of total work experience spent in

Table 13.1 **Comparisons of Worker and Industry Attributes in the United States and Japan by Firm Size**

Worker and Industry Characteristics	Aggregate Sample	Small Firms	Medium Firms	Large Firms
A. U.S. sample:				
Log(hourly wage)	1.906	1.816	1.974	2.119
Schooling	12.883	12.745	12.901	13.358
Previous experience	8.778	9.490	8.394	6.848
Job tenure	8.070	6.409	9.580	11.470
TFP, 1966–79	−.198	−.286	−.130	.005
IGR, 1960–79	2.195	2.473	1.893	1.715
IVAR	.036	.029	.040	.052
B. Japanese sample:				
Log(hourly wage)	−.141	−.312	−.102	.138
Schooling	11.014	10.423	11.518	11.681
Previous experience	8.072	10.173	7.841	4.455
Job tenure	12.150	11.165	11.241	14.654
TFP, 1966–77	1.571	1.132	1.822	2.164
IGR, 1960–77	4.004	4.511	3.786	3.260
IVAR	.093	.097	.092	.085

Note: TFP = Industry total factor productivity growth; IGR = industry output growth; IVAR = industry output variability.

previous jobs. Finally, note that the average industry rate of technical change imputed to individuals rises with firm size in both countries, suggesting that industries with high rates of technical change tend on average to be made up of a higher proportion of larger firms. In contrast, rapidly growing industries appear to have a disproportionately higher proportion of smaller firms.

13.2.1 The Wage Model

The technology-specific skills hypothesis may be tested using an expanded specification of the conventional cross-sectional wage model. Consider the following wage model where, for expositional simplicity, quadratic experience terms are suppressed (these, and other interacted terms, are included in the empirical analysis):

$$\ln W_i = \alpha_1 + \alpha_2 S_i + \alpha_3 \mathrm{EXP}_i + \alpha_4 \mathrm{TEN}_i, \tag{1}$$

where for individual i, $\ln W$ = logarithm of hourly wages, S = years of schooling, TEN = years of tenure with the current employer, and EXP = years of previous labor-market experience, defined as age minus S minus 6 less years of current job tenure.

This specification of the wage model has been used by a number of recent studies to decompose earnings into the returns to specific and general skill components (Chapman and Tan 1980; Mincer and Jovanovic 1981). The rationale is that, when skills are completely general, no distinction need be made about where experience is acquired and general training returns are adequately captured by the coefficient of total labor market experience, EXP + TEN. On the other hand, if specific training increases a worker's productivity more in the current firm than elsewhere, the two experience measures should be entered separately. The added wage effects of TEN over and beyond those of EXP (i.e., $\alpha_4 - \alpha_3$) may be interpreted as reflecting the returns to firm-specific training on the current job.[8]

Equalization of the present values of training costs and returns requires an inverse relationship between initial wages and subsequent rates of wage growth with tenure. Since investments in specific training are hypothesized to increase with technical change (TFP), the model predicts that starting wages are negatively related to TFP while wage-tenure profiles are positively related to TFP. Furthermore, controlling for TFP growth, investments in specific-training are predicted to increase with the rate of output growth (IGR) so a similar pattern of lower starting wages and higher rate of wage-tenure growth varying with IGR is predicted. Finally, the proposition that schooling returns increase with TFP is tested in a straightforward fashion through an interaction term between schooling and the rate of technical change, $S \times \text{TFP}$.

The following wage specification, where general training returns are constrained to be equal across firms, permits tests of these predictions:

$$(2)\ \ln W_{ij} = \beta_1 + \beta_2 S_i + \beta_3 S_i x\text{TFP}_j + \beta_4 \text{EXP}_i + \beta_5 \text{TEN}_i + \beta_6 \text{TFP}_j + \beta_7 \text{TFP}_j x\text{TEN}_i + \beta_8 \text{IGR}_j + \beta_9 \text{IGR}_j x\, \text{TEN}_i,$$

where j subscripts industry and i the individual. The technology-specific skills hypothesis is supported if firms experiencing rapid technical change have low starting wages (negative β_6), higher rates of wage growth with tenure (positive β_7) coefficients, and a corresponding pattern of wage effects for output growth (negative β_8 and positive β_9). Furthermore, a positive coefficient on the interaction between schooling and TFP (β_3) would provide support for the "allocative efficiency of schooling" hypothesis.

13.3 The Empirical Findings

Two specifications of a log-linear wage model are estimated, where the logarithm of hourly wages (one U.S. dollar or 100 Yen for Japan) is related to a common set of regressors in each country. In specification (1), these include years of schooling, quadratic forms of prior work experience, and years of tenure with the current firm, an interaction between prior experience and tenure,[9] controls for firm size, union membership (United States only), occupation and location. Specification (2) adds industry estimates of total factor productivity growth (TFP) and their interactions with schooling and job tenure, output growth (IGR) and IGR interacted with job tenure, and a control for the degree of industry output variability (IVAR).

Table 13.2 reports the results of estimating these ordinary least squares

Table 13.2 **Results of Wage Regressions for the United States and Japan**

Variable Name	United States (1)	United States (2)	Japan (1)	Japan (2)
Constant	.817	.772	−1.572	−1.511
	(30.41)	(25.74)	(62.08)	(47.14)
Schooling (*S*)	.042	.046	.051	.051
	(22.73)	(24.75)	(36.77)	(29.29)
Prior experience	.031	.030	.044	.044
	(22.22)	(21.94)	(39.19)	(38.78)
Experience^2	−.0006	−.0006	−.0008	−.0008
	(16.18)	(15.75)	(30.33)	(30.16)
Experience × tenure	−.0012	−.0011	−.0013	−.0013
	(17.06)	(16.49)	(26.49)	(26.03)
Tenure	.043	.038	.063	.057
	(26.28)	(14.91)	(51.64)	(20.33)
Tenure^2	−.0008	−.0006	−.0009	−.0008
	(16.39)	(9.31)	(28.75)	(10.66)
Medium-size firm	.085	.066	.158	.146
	(8.74)	(6.69)	(19.92)	(18.06)
Large-size firm	.158	.115	.310	.290
	(12.88)	(8.98)	(39.76)	(35.36)
IVAR		1.699		.287
		(9.67)		(1.78)
TFP × schooling		.0065		.0003
		(4.96)		(.41)
TFP		−.1344		−.0092
		(7.27)		(1.06)
TFP × tenure		.0046		.0016
		(4.14)		(2.49)
TFP × tenure^2		−.0001		−.00001
		(3.13)		(.55)
IGR3149		−.0331		−.0144
		(6.27)		(3.63)
IGR × tenure		.0026		.0008
		(2.86)		(1.43)
IGR × tenure^2		−.00005		−.00002
		(2.02)		(1.09)
R^2	.3162	.3415	.4776	.4808

Note: Region, metropolitan residence, occupation, and union membership (United States only) controls included but not reported. Dependent variable is log(hourly wage). Absolute value of *t*-statistics are in parentheses.

(OLS) wage models for the two countries. The estimated coefficients of specification (1) are broadly similar in the two countries and resemble those reported elsewhere in the literature (e.g., see Hashimoto and Raisian 1985). Generally, they suggest a pattern of wage growth increasing with schooling attainment and with both prior work experience and years of tenure. In both countries, tenure on the current job is on average rewarded more highly than prior work experience, a result we interpret as tentative evidence for the presence of firm-specific training.

Nonetheless, hourly wages in the two countries differ in several important respects. First, Japanese firms appear to reward education more highly than U.S. firms (5% vs. 4%). Second, both measures of work experience are associated with more rapid wage increases in Japan than in the United States—4.4% versus 3.0% for outside experience, 6.3% versus 4.3% for job tenure, respectively. These results imply not only greater skill investments (both general and firm specific) in Japan than in the United States, but also a greater firm-specific component in Japanese training. To see this latter point, note that the relative returns to tenure and prior work experience are 1.43 (.063/.044) in Japan and 1.38 (.043/.031) in the United States. Finally, hourly wages across firm size are much more highly differentiated in Japan than in the United States. Comparing the largest firm size (over 1,000 employees) to small firms employing less than 100 workers (the omitted category), large employers in Japan pay wages that are over 30% higher; the corresponding figure in the United States is about 16%. (Results are reported separately by firm size in table 13.4 below.)

The second wage model addresses the issue of whether interindustry wage-tenure profiles vary systematically with the industry rate of TFP growth and IGR. As hypothesized, higher industry rates of technical change are associated with lower starting pay (as measured by the coefficient of TFP) and higher rates of wage growth with job tenure (coefficient of tenure interacted with TFP). Controlling for TFP, industry wage-tenure profiles also appear to vary systematically with IGR, with lower starting pay and higher rates of wage growth with tenure in rapidly growing industries. The estimated parameters for the U.S. sample are statistically significant at conventional levels; while individual parameters for Japan attain statistical significance, the relationships of interest are not measured very precisely. The interaction between schooling and technical change is also positive and statistically significant for the U.S. sample, which is consistent with the "allocative efficiency" hypothesis. It is interesting that no support for this hypothesis is found for Japan—while positive, the coefficient of S interacted with TFP is not statistically different from zero. We speculate that this result may reflect the relatively unspecialized nature of public education in Japan or, alternatively, the greater emphasis placed on team production in which individual contributions (of more educated workers) are not easily identified.

Table 13.3 provides a convenient summary of the estimated results by comparing the predicted wage-tenure profiles under several different assumptions about TFP and IGR. A convenient starting point is at the mean level of TFP and IGR (case 1). Ignoring the quadratic term (which is very similar in both countries), the steeper wage-tenure profile in Japan implies that Japanese companies on average invest over 50% (5.22/3.29) more in their workers' specific training than their American counterparts. For the United States, a

Table 13.3 **Predicted Wage-Tenure Profiles in the United States and Japan for Alternative TFP and Output (IGR) Growth Assumptions**

Country/Wage-tenure growth profile	Mean TFP and IGR (1)	1 SD, TFP Increase (2)	1 SD, IGR Increase (3)
United States			
Intercept[a]	1.9818	1.9237	1.9343
Linear wage growth	.0329	.0384	.0367
Quadratic term	−.00081	−.00087	−.00084
Japan			
Intercept	−.3349	−.3503	−.3632
Linear wage growth	.0522	.0549	.0537
Quadratic term	−.0009	−.0009	−.0009

Source: Table 13.2 above.
Note: SD = standard deviation.
[a] Excluding tenure and its interactions with TFP and IGR, the intercept is evaluated at the sample means of the explanatory variables, plus half the standard error of log(hourly wage).

standard deviation increase in TFP (case 2) is associated with a steepening of tenure-wage growth from 3.29% to 3.84%; a standard deviation increase in output growth (case 3) increases wage growth to 3.67%. The corresponding increases in Japanese firms are, at best, marginal given the poor fit of the model. Part of the reason for this, as we shall see below, is attributable to aggregation across firm size in the Japanese sample.

Table 13.4 presents separate estimates of equation (2) for the three firm size groups in the two countries. Though qualitatively similar to the previous results, several systematic differences across firm sizes and between countries are noteworthy. First, consider the returns to schooling. Large firms in both countries reward schooling more highly than small firms—in going from the smallest to the largest firm size category, the returns to schooling increase from 4.3% to 5.0% in the United States, and from 4.3% to 5.7% in Japan. Second, like the previous results, a systematic effect of TFP growth on schooling is found in the United States but never in Japan. Furthermore, in U.S. industries characterized by rapid TFP growth, highly educated workers in large firms are paid more than "similar" employees in small firms. To see this, compare the $S \times$ TFP coefficient in large firms (1.2%) and in small firms (.05%). Third, wage-tenure profiles in small U.S. firms appear to be steeper than those in large firms (4.5% vs. 3.3%), a difference that is further amplified in industries with high TFP growth (the tenure-TFP interaction is .0075 in small firms and .0033 in large firms). In contrast, the tenure-TFP coefficients only attain statistical significance for the largest firm-size category in Japan. Finally, the effects of output growth, IGR, on wage-tenure profiles are most pronounced (and statistically significant) for medium-size and large firms in the United States and, again, only for the largest firms in Japan.

Table 13.4 **Wage Regressions for the United State and Japan by Firm Size**

	U.S.			Japan		
Variable Name	Small	Medium	Large	Small	Medium	Large
Constant	.739	.903	.984	−1.3492	−1.4289	−1.2566
Schooling (S)	.043	.047	.050	.043	.058	.057
	(16.63)	(14.28)	(1 .35)	(16.87)	(15.86)	(17.02)
Prior experience	.031	.028	.028	.039	.046	.046
	(7.12)	(10.76)	(7.43)	(23.96)	(20.24)	(20.97)
Experience²	−.0006	−.0005	−.0005	−.0007	−.0008	−.0008
	(12.56)	(7.62)	(4.86)	(20.01)	(15.55)	
Experience × tenure	−.0012	−.0010	−.0010	−.0011	−.0015	−.0015
	(11.85)	(8.91)	(5.84)	(14.45)	(13.52)	(16.30)
Tenure	.045	.034	.033	.052	.061	.051
	(10.31)	(8.74)	(6.89)	(11.41)	(11.41)	(11.28)
Tenure²	−.0008	−.0005	−.0006	−.0008	−.0007	−.0006
	(6.78)	(5.00)	(4.67)	(6.73)	(5.12)	(5.27)
IVAR	2.324	1.273	1.602	−.338	−.312	.833
	(7.69)	(4.80)	(4.60)	(1.12)	(1.01)	(3.74)
TFP × S	.0055	.0071	.0118	.0015	−.0015	.0004
	(2.94)	(3.15)	(3.47)	(1.42)	(1.13)	(0.36)
TFP	−.1198	−.1468	−.2035	−.0111	0.0124	−.0133
	(4.57)	(4.59)	(3.93)	(.81)	(.65)	(.81)
TFP × tenure	.0075	.0035	.0033	−.0003	.0025	.0028
	(4.29)	(1.82)	(1.31)	(.32)	(1.67)	(2.33)
TFP × tenure²	−.0002	−.0001	−.0001	.0000	−.0001	−.0000
	(3.67)	(1.10)	(.90)	(1.16)	(1.72)	(1.23)
IGR	−.0231	−.0404	−.0373	−.0088	−.0150	−.0431
	(2.93)	(4.53)	(3.13)	(1.45)	(1.86)	(5.75)
IGR × tenure	.0003	.0040	.0038	.0007	.0004	.0037
	(.19)	(2.62)	(2.16)	(.82)	(.38)	(3.69)
IGR × tenure²	−.0000	−.0001	−.0000	−.0000	−.0000	−.0001
	(.37)	(1.96)	(1.08)	(.21)	(.05)	(2.38)
R^2	.3004	.3390	.3239	.3488	.4862	.5034

Note: Region, metropolitan residence, occupation, and union (U.S. only) controls included but not reported above. Dependent variable is log(hourly wage).
Absolute value of *t*-statistics are in parentheses.

To summarize, on the most general level these results suggest that firms in technologically progressive industries invest more in their workers' specific skills, and that Japanese firms on average invest more heavily in training workers than do their American counterparts. These results appear to stem from two sources—from increased skill investments in industries where learning possibilities are greater; and, for a given technology, from increased specific-training investments induced by rapid output growth.

The firm-size comparisons suggest some intriguing differences between the United States and Japan. Taken together, the estimated partial effects of TFP and IGR on wage-tenure growth suggest that specific-training investments in small U.S. firms are more responsive to technological possibilities, while training decisions in larger firms are driven more by output growth, given existing technology. In Japan, on the other hand, both factors are operative but only in the largest firm size category. In small Japanese firms, some part of training appears to be firm-specific, but it is neither related to TFP nor IGR. Small Japanese firms' use of technologically standardized machinery, or reliance on large firms for technical expertise (many are subcontractors to large firms), may mean that small Japanese firms invest relatively little in new, more productive skills of the kind that are related to technical change.

13.3.1 What Do These Earnings Differences Reflect?

The previous results, while suggestive, are nonetheless subject to two qualifications. First, do steeply rising wage-tenure profiles really reflect firm-specific training or are they the outcome of wage incentive schemes suggested by implicit contract theories that make no assumptions about training? Second, are wage-tenure effects a meaningful measure of specific training returns or simply a statistical artifact of an omitted firm-worker match variable in a cross-sectional wage equation? These two qualifications are addressed below.

Specific Training and Implicit Contract Interpretations

The problem of distinguishing between the firm-specific training and recent implicit contract theories has been noted by Parsons (1986) and others. These models share a common feature: they predict rapid growth of wages in the current firm relative to opportunity wages elsewhere. Denote this pattern of relative wage growth with tenure t by $W(t)$. In one approach, workers forgo high initial wages to invest in firm-specific training that only increases their productivity, $\mathrm{VMP}(t)$, and future wages, $W(t)$, in the current firm. Since both firms and workers share initial specific training costs, subsequent returns are also shared so that $W(t) < \mathrm{VMP}(t)$. In the agency and self-selection models, employers initially pay workers less than their value-marginal product but offer them wage-tenure profiles that are steeper than their productivity growth, that is, $W(t) > \mathrm{VMP}(t)$. Such back loading of wages relative to spot marginal product serves to reduce incentives to shirk (Lazear 1981) or to attract workers with low quit propensities (Salop and Salop 1976). If early job separation occurs, workers forfeit the difference between their initial value-marginal product and wage; in effect, workers post a bond guaranteeing their nonshirking on the job or their employment stability. In these models, then, $W(t)$ grows with years of tenure even if $\mathrm{VMP}(t)$ is constant over time. Individual data on $W(t)$ and $\mathrm{VMP}(t)$ needed to distinguish between the competing theories are rarely available to the analyst.

An alternative way of empirically distinguishing between the competing models is with data on worker training. If a positive association between company training and TFP growth is found, we may, given the previous results, infer a causal relationship between increased firm-specific training and steeper wage-tenure profiles in high TFP industries. For the United States, we can draw upon the findings of a recent study of the determinants of private-sector training by Lillard and Tan (1986). Using self-reported measures of training in the National Longitudinal Surveys (NLS) of young men and mature men, they estimated separate probit models of the likelihood of training from company training programs, business and technical schools, and miscellaneous other sources. Each probit model included a common set of regressors on schooling, race, labor force experience, the industry rate of technical change, and labor-market conditions.[10] The TFP variable was interacted with five levels of schooling attainment to allow different technical change effects on the likelihood of training for more and less educated workers.

Table 13.5 reports selected results for the effects of technical change on the likelihood of training from each source, holding other factors constant. For both the young men and mature men samples, company training was significantly more prevalent in industries characterized by higher rates of TFP growth, especially among the more highly educated. In contrast, the likelihood of training outside the firm of current employment—from business and technical schools and miscellaneous other sources—was lower in high TFP industries, with the more educated being significantly less likely to get such training. These results are consistent with the view that rapid technical change leads to increased reliance on in-house training, possibly because technology-

Table 13.5 **Effects of Technical Change on the Probability of Training: NLS Young Men and Mature Men**

Industry TFP Growth and Schooling Interaction	Source of Training		
	Company Training	Business and Technical Schools	Other Sources
A. NLS young men			
<12 years	4.250	18.005**	7.035
12 years	1.250	−4.796*	−5.062*
13–15 years	.283	−3.219	−7.542**
16 years	9.866**	−6.554	−8.612*
16+ years	16.877**	0.302	−13.354**
B. NLS mature men			
<12 years	.767	6.104	−.554
12 years	−5.976	8.708	−3.273
13–15 years	−1.232	−6.039	−17.600**
16 years	−4.346	−17.591	−15.266**
16+ years	32.111**	−16.564	−5.786

Source: Lillare and Tan (1986), table 3.6.
Note: TFP indices are from Gollop and Jorgenson (1980).
NSL = National Longitudinal Survey.
*$p \leq .05$
**$p \leq .10$

specific skills are not readily available elsewhere, and to greater demand for educated workers who may adapt more readily to new technologies. The results thus provide independent confirmation for the maintained hypothesis that steeply rising wage-tenure profiles reflect specific-training investments, and not just a pure incentive scheme.

Comparable data on training are not available in Japan, which makes it difficult to verify the assertion that steeper wage-tenure profiles in Japan reflect more intensive specific training in that country than in the United States. Anecdotal information, however, suggests that Japanese firms invest more heavily in the enterprise-specific skills of their workers. For example, in a comparison of male workers in auto assembly plants in Detroit and Yokohama, Cole (1979) finds that Japanese workers received a higher proportion of training courses that were company oriented as compared to their U.S. counterparts. A recent study comparing U.S. firms and Japanese firms operating in the United States finds striking differences in their hiring and training practices (Mincer and Higuchi 1988). Compared to U.S. firms, Japanese firms in this country spend more on screening new hires, provide company training to a higher fraction of their American workforce (24% vs. 13%), and, consistent with the firm-specific training model, have wage-tenure profiles that are steeper than those found in the U.S. sample.

Specific Training and Job-Match Quality

The second problem is whether positive tenure-wage effects reflect specific-training returns or the quality of the job match. This issue is at the heart of several recent papers, including those by Altonji and Shakotko (1987) and Abraham and Farber (1987). They argue that the positive cross-sectional association between job tenure and earnings does not imply additional increases in earnings with seniority over and above the returns to general work experience, but may actually reflect the unobserved returns to a good job match. Indeed, the Abraham-Farber results show that inclusion of a measure of completed job duration (an instrument for job-match quality) substantially reduces the returns to job tenure. If the effects of unobserved job-match quality are important, few inferences can be drawn from our wage models of the United States and Japan because of potential omitted variable bias in the estimated tenure coefficients.

The effects of job-match quality, however, may operate through the joint decisions of workers to get (and employers to provide) job training. A standard prediction of human capital theory is that firm-specific training increases with expected time on the job N (or expected job duration) since there is a longer period over which to amortize firm-specific investments costs. A higher quality job match (and longer N) should therefore also result in a greater likelihood of firm-specific training, other things equal. Since job-match quality and training decisions are linked inextricably, it follows that the Abraham-Farber findings cannot be interpreted as a rejection of the firm-specific training hypothesis; they may simply reflect the omission of job-training measures.

A recent paper by Tan (1988) follows this line of reasoning using comprehensive training information contained in a matched January–March 1983 sample of 4,660 males from the CPS. Two types of training variables were considered: (1) "in-house training," which combined participation in company training programs and informal on-the-job training and (2) "outside training," from all other external sources such as traditional schools, and business, and technical institutions. Training and earnings equations were estimated using a two-stage procedure suggested by Barnow, Cain, and Goldberger (1981). In essence, the procedure involved estimating separate probit models for each source of training and including their fitted values as instruments in the earnings model, which was then estimated by a two-stage least squares method. The specification of the wage model is similar to that used earlier, except that two indices of TFP growth estimated by Jorgenson, Gollop, and Fraumeni (1986) are used, one for the 1947–73 period, the other for 1973–79. TFP growth was separated into two time periods to investigate whether long-run TFP or short-run TFP had a more important effect on current earnings growth.

Table 13.6 presents selected results from the two-stage wage model and, for comparison, OLS regression results from a wage model with training treated as exogenously determined. Note that the size of the tenure coefficient is reduced dramatically from .026 to .0023 in the two-stage model, and the variable loses statistical significance. This result suggests that, if the quality of the job match is responsible for the widely reported cross-sectional wage-tenure coefficient (as suggested by Abraham and Farber), it appears to operate entirely through worker and employer training decisions. If this is the case, then wage-tenure profiles estimated from conventional cross-section data without training information may still provide a useful first approximation of investments in firm-specific training.

Several other points are noteworthy. First, the effects of training on earnings are large, especially training from in-house sources. In going from the single equation to the two-stage results, not only do the coefficients on training increase, but their relative rankings change as well, so that in-house training increases earnings more than training from outside sources, which is more plausible. Secondly, consistent with the results reported earlier, the effects of technical change (1973–79) on wage-tenure profiles remain largely unchanged in the two-stage model, with lower starting wages and higher rates of wage-tenure growth in technologically progressive industries. In fact, the effects of TFP on wage-tenure growth becomes even larger, the tenure coefficient rising from .0012 in the single equation model to .0019 in the two-stage model. Finally, contemporaneous earnings growth is only affected by recent TFP growth—the interactions between long-run TFP growth and tenure are never statistically significant. This result is intuitively plausible if older, vintage job skills are rendered obsolete by rapid technical change.

Table 13.6 **Selected Results of Ordinary Least Squares (OLS) and Two-Stage Wage Models with Training**

Variable Names	OLS Model	Two-Stage Model
Constant	4.6782**	4.2205**
Years of schooling	.01619**	.01261*
Labor-market experience	.07645**	.05866**
Experience^2	−.00147**	−.00089**
Years of tenure	.02614**	.00227
Tenure^2	−.00043**	−.00004
TC 1947–73	.00711	−.00857
TC 1947–73 × tenure	.00076	.00027
TC 1973–79	−.04420**	−.03906**
TC 1973–79 × tenure	.00120**	.00193**
In-house training	.13942**	2.02830**
Outside Training	.21293**	1.04400**

Source: January–March 1983 matched Current Population Survey.

Note: Other control variables not reported here include race, location, and state unemployment rate. The training probit models included marital status, categorical schooling indicators, and training needed to get the current job as identifying variables. $N = 4{,}171$ observations; dependent variable is log-weekly wage (mean = 5.845). TC = technical change.

*$p \leq .05$.

**$p \leq .10$.

13.4 Summary and Conclusions

The starting point of this paper was the proposition that many employment and wage practices found in the United States and in Japan may actually reflect rational labor-market responses to the exigencies of technological change. New technologies, before they can be used effectively, require extensive modification and learning; less than optimal amounts of learning may result because of the bilateral monopoly issue associated with these new and more productive specific skills. By clarifying the property rights of employers and workers to these efficiency gains, long-term employment relationships and seniority-based wage and promotion practices create a context that induces the appropriate investments in learning. By viewing the emergence of these institutions as demand induced, it follows that, where there was less need to develop technology-specific skills, these labor-market practices did not arise or were not retained.

To test this proposition, we presented a model of technology-specific skills that yielded several (refutable) predictions about the relationships between industry rates of technical change and output growth on one hand, and wage-tenure growth and schooling on the other. These predictions were tested using comparable labor-market data for the United States and Japan. The hypotheses were strongly supported in the U.S. sample, both in the aggregate and by firm size, and among Japanese workers employed in large firms. The first hypothesis, that rapid technical change induces increased investments in specific skills, found support in steeper rates of tenure-wage growth in technologically more progressive industries. Holding the level of productivity growth constant, rapid output growth was also associated with faster wage growth with tenure. A related hypothesis—that better-educated workers have better "signal extraction" abilities—also found support in the positive interaction between schooling attainment and technical change, but only in the U.S. sample.

Several competing interpretations for the empirical findings were also evaluated using information (some anecdotal) on training. Evidence was presented for the United States that indicated that rapid technical change leads to increased reliance on in-house training—possibly because technology-specific skills are not readily available elsewhere—and to a lower demand for training from outside sources. These findings were interpreted as providing independent confirmation for the hypothesis that steeply rising wage-tenure profiles reflect specific-training investments, and not the (pure) incentive schemes derived from implicit labor contract theories. The findings of several recent papers on job-match quality—which indicated a potential bias in estimated wage-tenure profiles—were also shown not to be inconsistent with a specific-training interpretation. Results were presented that suggest that the wage effects of job-match quality may actually operate through the joint decisions of workers to get (and employers to provide) job training. By implication, wage-tenure profiles estimated from conventional cross-sectional wage models without training information may provide a useful first approximation of specific-training returns.

Overall, the cross-national comparison has provided some insights into how U.S. and Japanese labor markets operate to provide the human capital skills required for productivity growth. Surely, part of the Japanese success of rapid economic growth is attributable to more intensive job training, of both general and specific types, as revealed in higher returns to both general work experience and job tenure in Japan than in the United States. Our empirical analyses were successful in explaining only part of the systematic interindustry and cross-national variation in wage profiles, and there, more successfully for the U.S. than for Japan. In this regard, the preliminary results reported here raise more questions than they answer. For example, how do we explain differences between the United States and Japan in the responsiveness of small and large firms to productivity growth? Why is schooling more productive in technologically progressive industries in the United States but not in Japan? Further refinement and tests of the technology-specific skills model are needed to address these (and other) issues.

Notes

1. For interested readers, Tan (1982) provides a comprehensive survey of the recent literature on wage determination in Japan.
2. The wage specification (and justification) used for the decomposition of earnings

into general training and specific training components is similar to that discussed in section 13.2.

3. Simultaneity might arise if the residual measure of TFP included specific training as one component of unmeasured labor quality so that TFP and ST were positively correlated. This possibility of simultaneity bias was addressed by formulating a structural model of ST and TFP, in which TFP is determined by ST and other inputs into the innovative process including the number of imported technology licenses, R&D spending, investments in new plant and equipment, and research staff. Allowing for the endogenous determination of ST and TFP reduced, but did not change, the positive effects of technical change on specific-training investments.

4. Semiannual bonuses are an important component (as much as one-third) of total wage compensation in Japan. Hashimoto (1979) argues that these bonus payments represent the worker's share of specific-training returns.

5. In the ESS, the variable for weekly hours worked is reported in broad categories that may result in some (unknown) measurement error in the construction of hourly wage rates.

6. Unlike the CPS, where schooling attainment is continuous, this variable is categorical: middle school (8 years), high school (12 years) and college (16 years) graduates.

7. I am grateful to Masahiro Kuroda for kindly providing unpublished estimates of industry rates of TFP growth in Japan, as well as the input series used to create the TFP measures. Similar thanks go to F. M. Gollop and D. W. Jorgenson for the companion TFP series for the United States.

8. A problem (which we discuss later) is that steeply rising wage-tenure profiles may also reflect wage schemes designed to reduce incentives to shirk (Lazear 1981) or to attract workers with low quit propensities (Salop and Salop 1976).

9. This interaction term adds flexibility to the model specification since the returns to job tenure are allowed to vary with prior work experience. We would expect lower investments in specific training for those with long prior experience since the remaining time on the current job is correspondingly shorter.

10. The TFP measures in that study referred to the period between 1966 and 1973, and were derived from Gollop and Jorgenson (1980).

References

Abraham, Katharine, and Henry Farber. 1987. Job duration, seniority, and earnings. *American Economic Review* 77 (June):278–97.

Altonji, Joseph, and Robert Shakotko. 1987. Do wages rise with seniority? *Review of Economic Studies* 54 (179):437–59.

Barnow, Bart, Glen Cain, and A. Goldberger. 1981. Issues in the analysis of selection bias. Typescript. University of Wisconsin-Madison, Department of Economics.

Bartel, Ann, and Frank Lichtenberg. 1987. The comparative advantage of educated workers in implementing new technology. *Review of Economics and Statistics* (February).

Becker, Gary S. 1975. *Human capital*, 2d ed. New York: Columbia University Press.

Chapman, Bruce, and Hong Tan. 1980. Specific training and inter-industry wage differentials in U.S. manufacturing. *Review of Economics and Statistics* 62 (August):371–78.

Cole, Robert E. 1979. *Work, mobility, and participation*. Berkeley and Los Angeles: University of California Press.

Enos, John L. 1962. Invention and innovation in the petroleum refining industry. In *The rate and direction of inventive activity,* ed. Kenneth Arrow. Princeton, N.J.: Princeton University Press.

Gollop, Frank M., and Dale W. Jorgensen. 1980. U.S. productivity growth by industry, 1947–1973. In *New developments in productivity measurement and analysis,* ed. John W. Kendrick and Beatrice N. Vaccara. NBER Studies in Income and Wealth 44. Chicago: University of Chicago Press.

Hall, Robert. 1982. The importance of lifetime jobs in the U.S. economy. *American Economic Review* 72 (September):716–24.

Hashimoto, Masanori. 1979. Bonus payments, on-the-job training and lifetime employment in Japan. *Journal of Political Economy* 87 (October):1086–1104.

Hashimoto, Masanori, and John Raisian. 1985. Employment tenure and earnings profiles in Japan and the United States. *American Economic Review* 75 (September): 721–35.

Hollander, Samuel. 1965. *The sources of increased efficiency.* Boston: MIT Press.

Jorgenson, Dale, Frank Gollop, and Barbara Fraumeni. 1986. Productivity and growth of sectoral output in the United States, 1948–1979. Discussion Paper no. 1217, Harvard University, Harvard Institute for Economic Research, February.

Jorgenson, Dale, Masahiro Kuroda, and Mieko Nishimizu. 1985. Japan-U.S. industry level productivity comparison, 1960–1979. Paper presented at the NBER Conference on Research in Income and Wealth. Cambridge, Mass., 27–30, August.

Kuratani, Masatoshi. 1973. The theory of training and employment: An application to Japan. Ph.D. Diss., Columbia University.

Lazear, Edward. 1981. Agency, earnings profiles, productivity and hours restrictions. *American Economic Review* 71 (September):606–20.

Lillard, Lee, and Hong Tan. 1986. Training: Who gets it and what are its effects on employment and earnings. R-3331-DOL. The Rand Corporation (March).

Mellow, Wesley. 1982. Employer size and wages. *Review of Economics and Statistics* 64:495–501.

Mincer, Jacob, and Yoshio Higuchi. 1988. Wage structures and labor turnover in the U.S. and Japan. *Journal of Japanese and International Economies* 2:97–133.

Mincer, Jacob, and Boyan Jovanovic. 1981. Labor mobility and wages. In *Studies in labor markets,* ed. Sherwin Rosen. Chicago: University of Chicago Press.

Oi, Walter. 1983. The fixed employment costs of specialized labor. In *The measurement of labor cost,* ed. Jack Triplett. Chicago: University of Chicago Press.

Parsons, Donald. 1986. The employment relationship: Job attachment, work effort, and the nature of contracts. In *Handbook of labor economics,* ed. O. Ashenfelter and R. Layard, chap. 14. Amsterdam and New York: Elsevier Science Publishers.

Rosen, Sherwin. 1972. Learning and experience in the labor market. *Quarterly Journal of Economics* 86 (August):326–42.

Salop, Joanne, and Steven Salop. 1976. Self-selection and turnover in the labor market. *Quarterly Journal of Economics* 90 (November):619–27.

Saxonhouse, Gary. 1976. Country girls and competition among competitors in the cotton spinning industry. In *Japanese industrialization and its social consequences,* ed. Hugh Patrick. Berkeley and Los Angeles: University of California Press.

Schultz, Theodore. 1975. The value of the ability to deal with disequilibria. *Journal of Economic Literature* (September):827–46.

Setzer, Francis. 1974. Technical change over the life of a product: Changes in skilled inputs and production processes. Ph.D. diss., Yale University.

Shimada, Haruo. 1981. *Earnings structure and human investment: A comparison between the United States and Japan.* Tokyo: Keio University.

Taira, Koji. 1970. *Economic development and the labor market in Japan.* New York: Columbia University Press.

Tan, Hong W. 1980. Human capital and technological change: A study of wage differentials in Japanese manufacturing. Ph.D. diss., Yale University.

———. 1982. Wage determination in Japanese manufacturing: A review of recent literature. *Economic Record* (May), 46–60.

———. 1988. Productivity growth, training, and earnings. Working paper. RAND Corporation, April.

Welch, Finis. 1970. Education in production. *Journal of Political Economy* 78 (January–February):350–66.

Yasuba, Yasukichi. 1976. The evolution of the dualistic wage structure. In *Industrialization and its social consequences,* ed. Hugh Patrick. Berkeley and Los Angeles: University of California Press.

Comment Romesh Diwan

1. The revised version of this paper has successfully incorporated some of the specific suggestions I made at the NBER conference where it was originally read. There are still a number of issues that merit discussion.

2. One of the basic limitations of the paper follows from the model itself. The stated objective of the paper is to develop and quantify a model of technology-specific skills in order to explain differing, and different, labor market practices. However, in its final form, the model in Tan's equation (1) ends up in attempting to explain *partial* changes in wage profiles by three factors that measure labor quality, namely, (i) level of education, (ii) level and growth in prior job experience, and (iii) level and growth in the job, that is, experience with a particular employer or tenure. The model is able to explain *only* partial changes in wage profiles because it is not based on any theories of supply of or demand for labor. The statistical results confirm this *partial* explanation.

3. In equation (2), the model is augmented by the introduction of technical change and industrial growth, both factors existing at the industry level while the rest of the model is at the firm/enterprise level. Technical change is measured by total factor productivity (TFP) at the industry level. The estimated single equation in table 13.2 is given a *selective* translog form. Thus, there are variables for experience^2 and tenure^2 but no term for schooling^2. Similarly, there are interaction terms: experience × tenure, TFP × schooling, TFP × tenure, IGR × tenure, but there are no variables for schooling × experience, TFP × experience, IGR × experience; IGR × schooling. Again, there are two additional variables for TFP-tenure squared and IGR-tenure squared. It is not clear, or explained, why some square and interaction variables are included and others omitted.

There are two sets of problems here. One, the *selective* use of the translog

Romesh Diwan is professor of economics at Rensselaer Polytechnic Institute, Troy, New York, and a member of the NBER Conference on Research on Income and Wealth.

form has resulted in the omission of a number of interaction variables. Unless the interaction effects are small, such omission has the effect of biasing the estimated coefficients. Fortunately, the value of the interaction effects, as estimated below, are quite small. Two, measurement of TFP poses all sorts of difficulties, conceptual as well as quantitative. By and large, TFP has been estimated as a "residual" so that it is highly sensitive to model specification. As a residual, TFP can be meaningfully interpreted *only* with the reference to the model of which it is a residual. To treat TFP as a variable, in and of itself, even if it has been estimated by experts such as Gollop and Jorgenson and Kuroda, is to stretch the argument, the logic, and the estimates a little too far.

4. Given the *selective* translog form, one can develop an alternative interpretation of the estimated parameters. In view of the square and cross-product terms in the estimated equation, one can distinguish the following *four* effects: (i) first-order effects, (ii) second-order effects associated with the square terms, (iii) interaction effects derived from cross-product terms, and (iv) total effect, which is the sum of the three effects. We have calculated these four effects for the tenure variable for both the United States and Japan. These are given in table 1.

These calculations suggest that the totality of interaction effects are similar for both the United States and Japan. Furthermore, these effects are rather small. The major effect is given by the first-order term.

5. There are two stories that we in the United States tell to each other: one about United States and the other about Japan. The story about the United States is that it does not pay to stick with one firm or company. Instead, one gains in wages/salaries by regularly switching jobs from one company to the other. Based on the market philosophy, the "theory of exit" is recognized, respected, and well practiced. There is ample evidence to prove it.

The story about Japan that we tell in the United States is just the opposite. In Japan it pays to stick with one company. One does not gain in wages/salaries by switching jobs from one company to the other. Instead, job switching is discouraged. The celebration in Japan is of lifetime employment with one company. The theory that is practiced is of "loyalty," not of "exit." Quite a large number of experts have written about it.

The story that emerges from these results is that the wage changes are most

Table 1 **First-Order, Second-Order, Interaction, and Total Effects of Tenure**

	Effects			
Country	First Order	Second Order	Interaction	Total
United States	.038	−.0048	−.0050	.0282
Japan	.057	−.0097	−.0048	.0425

Note: The second-order effects and interaction effects have been calculated at the average values for the aggregate sample given in table 13.1 above.

affected by the initial situation, whether it is prior experience or job tenure. Given the initial situation, additions to years in tenure and/or a combination of tenure with other qualitative variables does not help in the rate of change of the wage rate. These results conform with the story about the United States. They seem to be at odds with the story about Japan. These results point out to the similarities rather than differences between the United States and Japan. Given much of the information about the differences between the United States and Japan, these results suggest that the search is not over.