Industry-Specific Human Capital, Occupation and Firm Size: Evidence from Taiwan

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ABSTRACT. This paper investigates the importance of various types of human capital and highlights the role played by industry tenure in determining wages in Taiwan. It also aims to offer possible explanations as to why industry-specific human capital is much less significant than it is in the United States. Empirically, it is found that, other things being equal, accumulating industry tenure decreases earnings for both the least-skilled workers and those employed in mid-sized firms. Industry-specific skills are not yet deeply implemented in most occupations and firms of all sizes. This might also account for the remarkable level of labor reallocation among industries that is observed in Taiwan. Furthermore, the capital stock accumulated through education is found to be the most crucial in determining wages in all estimations and a factor considered the engine of growth during the miraculous development of Taiwan's economy. However, the importance of other types of human capital on earnings – namely, general labor market experience and firm-specific human capital, varies substantially across groups.

I. Introduction

In the literature on human capital, job-specific skills accumulated from work experience were once viewed as being nontransferable between firms.[1] Two decades ago, however, researchers began to contend that some skills that are neither specific to a given firm nor completely general could be obtained from work experience. These include industry-specific or sector-specific human capital, such as an individual's credentials in the predisplacement industry, information regarding enhancing workers' productivity, an efficient job search,[2] etc.

Empirically, specific measures were employed to indirectly or directly estimate the possible losses sustained by industry switchers. For instance, Neal (1995), Carrington and Zaman (1994) and Fallick (1993)[3] used duration of unemployment and lost wages as measures of this and found that the longer the industry tenure one possesses before separation, the greater the loss is to a worker who switches industries. Thus, they asserted that human capital should be decomposed into general, firm-specific and industry-specific categories, and showed that industry specificity is as crucial as the others in wage determination. Parent (2000) further showed that the net effect of firm specificity was markedly reduced when workers' industrial tenure was directly included as an additional explanatory variable in the earnings function. The return to firm seniority virtually disappears after correcting for the endogeneity problem. Thus, Parent claimed that what matters most in the wage profile in terms of human capital is industry specificity, not firm specificity.

In Taiwan, dramatic changes in industrial structure have been a prominent feature in the process of economic development. For example, the percentage of workers employed in the service sector increased rapidly from 35% in 1975 to 53% in 1998, a much faster rate of reallocation than that observed in the United States.[4] Thus, it is interesting to analyze to what extent the rapid labor reallocation is related to workers' earnings in Taiwan. Had industry tenure raised wages in Taiwan, senior switchers should suffer *larger* wage reductions than stayers as documented in the literature on the United States. Figure 1 compares the mean change in the log of monthly earnings of new and old jobs for switchers with that of stayers to obtain a first glance at this link in Taiwan.[5]

Surprisingly, Figure 1 casts some doubt on the

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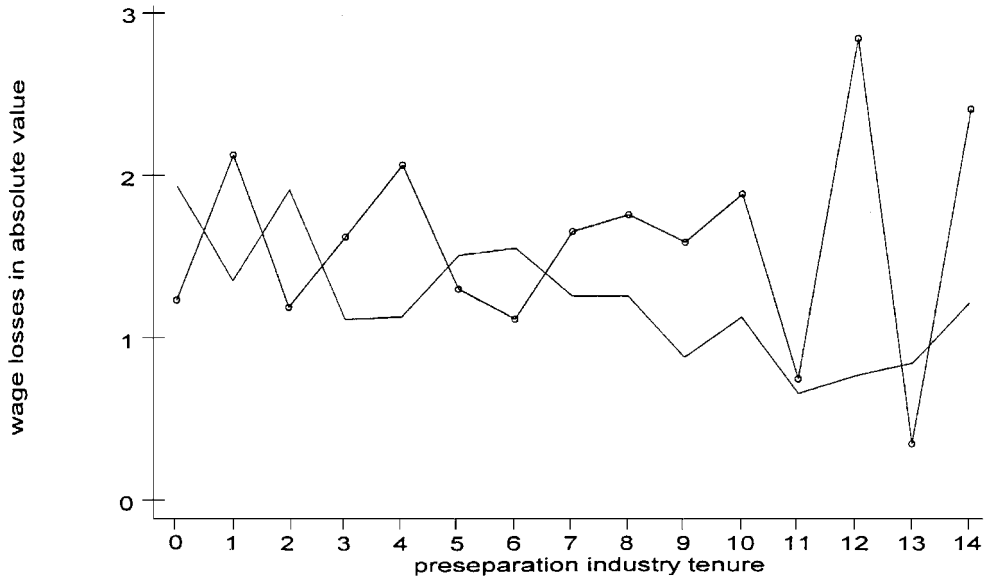

Notes:
1. Data source: the Taiwan Women and Family Survey (TWFS). Detailed description of the TWFS is presented in the main text (Section II).
2. The preseparation industry experience variable is measured by the number of years a female worker was in the industry (one-digit code) of her previous job, while wage loss is defined as the change in the log of begining pay of a worker's current job and monthly pay when she terminated her previous job.
3. Since there are less than 50 observations in some groups of workers with longer (preseparation) industry tenure, they are all summarized in the category of 14 years of industry tenure.

Figure 1. Wage changes by years of industry seniority, –: industrial stayers; ○: industrial switchers.

cost of switching across industries as has been laid out above. First, industry switchers are only observed to incur larger wage losses than stayers with seven or more years of experience in a particular industry, while the difference in wage losses between them does not increase with length of industry experience. Second, Figure 1 demonstrates relatively less loss in compensation for switchers with some levels of industry tenure – for instance, workers with less than one year of industry tenure and those with two, five and six years of tenure. Thus, Figure 1 shows that the wage losses of industry switchers do not have a tendency to increase more with industry tenure over stayers. This interesting observation suggests that more detailed and thorough investigation into the relationship between industry-specific human capital and earnings determination should be undertaken, providing the motivation for this work.

Nonetheless, all related work in Taiwan follows the traditional method of estimating the wage function. That is, the stock of human capital is measured by only two components – general and firm-specific human capital; the possible impact of industry specificity is ignored (Chuang and Hsu, 1999; Tan and Yu, 1996; Tallman and Wang, 1994; Liu, 1989; Liu and Liu, 1989; Jiang, 1988, etc.). Examining the data sets available for Taiwan, we found one set of retrospective data, the Taiwan Women and Family Survey (TWFS). The TWFS records the respondent's work experience on each job, enabling us to obtain a precise measure of industry tenure for each observation. Thus, the effects of industry-specific human capital can be directly estimated by adding industry tenure in the earnings function as one of the regressors as was done by Parent (2000).

In this paper, besides illustrating the less significant relationship between earnings and

industry-specific human capital in Taiwan econometrically, we also aim to offer some reasonable explanations for the phenomenon. Because of the distinct stages of economic development in Taiwan and the U.S., we proceed with our analysis by decomposing the full set of samples into several groups by workers' occupation and firm size. The motivation for this is, first, that if a particular time of work requires a particular type of human capital that can mainly be obtained from a specific employer, then firm specificity might be dominant in determining earnings for workers with those jobs. It is also true that other types of human capital might matter for jobs with certain characteristics. Further, skill application is likely to be larger where there is greater automation such that the degree of skill transferability across jobs has to do with the degree of automation. This factor might be very important in an economy in which skills vary substantially across jobs, such as a newly industrialized country like Taiwan. Finally, persistent wage differentials between firms of different sizes are documented not only in the U.S., but also in Taiwan (Chuang and Hsu, 1999; Reilly, 1995; Oi, 1990; Pearce, 1990). Wages paid by smaller-sized firms are usually below those of larger-sized firms. Wage growth in smaller firms is also observed to rise more slowly with experience. Under these circumstances, the effect of firm size might cause the importance of the type of human capital to vary across workers in firms of different sizes. Firm size might be especially crucial for an economy that consists of relatively more small and medium-sized firms.[6] As a consequence, we conduct an earnings estimation by occupation and firm size in the empirical section. By doing so, we should get a closer look at this relationship and provide some explanation for the absence of a link in the industry tenure and earnings factors.

Empirically, it is found that industry-specific skill is generally much less important for the wage profile in terms of human capital in Taiwan than what is observed in the United States. Other things being equal, accumulated industry tenure even decreases earnings for both the least-skilled workers and those employed in mid-sized firms. Thus, the industry-specific skills are not yet deeply implemented in most occupations and firms of various sizes. This might also account for the remarkable level of labor reallocation among industries seen in Taiwan. Second, the capital stock accumulated through education is found to be the most crucial factor in determining wages, and is a factor considered the engine of growth during the miraculous development of Taiwan's economy. Finally, the importance of other types of human capital on earnings – general labor market experience and firm-specific human capital – varies substantially across groups.

In the following two sections, the data and econometric model are described and econometric results presented. The earnings function is first estimated, in which industry tenure is included as a regressor. Samples are further decomposed by workers' occupation and firm size to control for the possibly unequal effects of different job characteristics. In the final section, the conclusions and implications of this paper are presented.

II. Data

In 1989, the Ministry of the Interior undertook the Taiwan Women and Family Survey (TWFS) to gather information regarding employment and family life for females.[7] The TWFS asked respondents retrospective questions concerning their employment history since the age of 15. It should be noted that the TWFS is the only retrospective data set that has ever been assembled by the Taiwanese government. The data contains information about job starting date and pay, job ending date and pay, and industry and occupational codes for each job (including the current one) that a female worker had ever held. It also contains detailed information on personal characteristics in the survey year.

Since information on past periods of employment for each job is collected in the data, a worker's industry tenure can be calculated precisely by adding up all the years the worker stayed in a particular industry during her entire work history, as well as her total amount of work experience. In addition, the TWFS contains abundant information to investigate the relationship between various types of human capital and wages. These suffice to allow us to study possible losses in compensation as women change jobs and analyze workers' wage determination.[8]

In this paper, we focus on workers aged 19 to

64 who answered all the relevant questions regarding their employment history and were employed in the private sector. Individuals who had ever worked but were not employed at the survey date were not counted as employed; in other words, information regarding labor force status refers to the survey date. The industry experience variable is measured by the number of years a worker has been in her *current* industry, including tenure with her current employer. Total work experience is the sum of the respondent's job tenure in all jobs up to the survey year. The number of observations that meet these criteria is 1,170. Among these, the average length of work experience is 14.30 years, of which 10.57 years are in their current industry. Workers, on average, stayed with the same employer for 7.56 years. The sampled women were approximately 38 years old on average and in their 2.51th job. Detailed statistics are presented in Table I.

III. Model and empirical results

The wage equation is specified as[9]

$$\ln(wage) = \alpha(experience) + \beta(industry\ tenure) + \gamma(firm\ tenure) + \delta(education) + \eta X + \varepsilon, \quad (1)$$

where ln(*wage*) is the log of monthly wages of the worker's current job. Vector *X* includes an individual's personal characteristics, e.g., hours worked, occupation, graduated from public school, married, worked in firms of more than 100 employees, worked full time, felt accomplishment at work and lived in an urban area.[10] The error term, ε, is distributed with zero mean. If longer industry tenure increases workers' wages, β will be positive, as will the coefficients of other variables that represent workers' stock of human capital. The earnings function (Equation (1)) is estimated in two versions using the full samples – with and without industry tenure. The sample is then further divided into several subgroups sorted by workers' occupation and firm size.

A. *Full sample estimation*

Table II shows the estimation results for Equation (1). It shows that the expected coefficient estimates regarding the variables for human capital and personal characteristics are borne out when "without industry tenure" is specified (column 1).[11] The estimates are consistent with those of the corresponding variables shown in the Taiwanese literature (e.g., Chuang and Hsu, 1999; Tan and Yu, 1996; Liu, 1989; Liu and Liu, 1989; Jiang, 1988, etc.). Adding industry tenure to the wage function causes some changes to the coefficient estimates; these are shown in column 2 of Table II. However, in the literature, if variables show nonlinear effects, one must analyze them using corresponding marginal effects.[12] Based on the estimates obtained, the marginal effects on wages of all variables that measure a worker's stock of human capital are shown in the first column of the upper panel of Table III and analyzed below.

The figures for the influences of general work experience, job tenure and education are 0.82%, 1.66%, and 3.62%, respectively, at the 1% significance level. These results seem to imply that the return to educational attainment is the largest, since one year of schooling, on average, contributes an increase of approximately 3.6% to a female worker's wages. The marginal impact of firm specificity is 55% lower than that for education, while that for general labor market experience was another 32% lower. Hence, pursuing higher education seems to be the most effective way to raise a female worker's wages, with obtaining firm-specific skills as another alternative.

Moreover, industry tenure demonstrates an inverse relationship on wages, with the marginal effect being –0.40%. Based on the original estimate shown in the second column of Table II, it is found that accumulating industry-specific tenure in a worker's first 15.6 years in the same industry has a dampening effect, but after that point a positive effect is exhibited.[13] Nevertheless, since the marginal effect is quite small and insignificantly different from zero, this indicates that industry-specific skill accumulated through job experience does not seem as critical as other types of human capital in raising workers' wages. Hence, this type of human capital plays no role in the earnings function in Taiwan, confirming econometrically the observation found in Figure 1. This finding is completely different from what is observed in the U.S., where industry-specific

TABLE I
Mean sample characteristics

Variable (definition)	Mean	Standard deviation
Log of real monthly wage (1988 $)	9.67	0.80
Total work experience (total)	14.30	8.83
Service	14.49	10.2
Professional	15.05	8.49
Manual	15.09	9.35
CSC	12.73	7.33
Firm tenure (total)	7.56	7.29
Service	6.02	6.34
Professional	11.64	8.60
Manual	6.53	6.99
CSC	8.23	6.95
Industry tenure (total)	10.57	7.82
Service	8.58	7.82
Professional	14.31	8.67
Manual	10.45	7.53
CSC	10.08	7.55
Years in school (total)	8.84	4.56
Service	6.88	3.52
Professional	14.35	2.30
Manual	5.97	3.58
CSC	12.05	2.48
Hours worked	205.7	50.5
Public school (graduated from public school)	0.63	0.48
Percentage married	0.88	0.33
Large (employed in firms of more than 100 workers)	0.26	0.44
City (live in the city area)	0.60	0.49
Accomp (feeling of accomplishment at work)	2.03	0.58
Percentage full-time (work hours $\geq$ 40)	0.89	0.31
Average number of jobs to present	2.51	1.40
N	1,179	

Note: Data source TWFS. Samples include private employees aged 19 to 64 who answered all relevant questions regarding their employment history. The "industry experience" variable is measured by the number of years a worker has been in his *current* industry (one-digit code), including tenure with her current employer. "Total work experience" is the sum of the respondent's job tenure in all jobs up to the survey year. "Accomp" represents workers' feelings of accomplishment in their current job, where "1" represents high, "2" represents fair and "3" represents low feeling of accomplishment.

skills have been recently found to be the most important regardless of the worker's age group.[14]

Nevertheless, it is also worth mentioning that over the past few years, the extent to which wages rise with workers' seniority variables has been studied; see for example, the correction for bias due to firm-specificity (Topel (1991), Kletzer (1989), Altonji and Shakotko (1987), Marshall and Zarkin (1987), and Abraham and Farber (1987)), and the correction for bias related to industry tenure (Parent (2000)). These papers, in general, show that the ordinary least squares estimates of the return to seniority are biased by job matching effects, industry effect, and individual heterogeneity. Thus, they focus on the appropriate econometric method to handle the stated problems. For instance, Abraham and Farber (1987) constructed a measure of the average length of time in the current job as an instrumental variable (IV). Altonji and Shakotko (1987) adopted the GLS approach. Topel (1991) proposed a new two-stage estimation to correct for the endogeneity bias.

TABLE II
Earnings function estimates – industry versus tenure effect (dependent variable: Log of real monthly wages)[1]

	Full sample	Full sample	Service	Professional[2]	CSC	Manual
Constant	7.205***	7.8204***	6.793***	7.0145***	8.340***	8.512***
	(0.2214)	(0.2273)	(0.1896)	(0.3819)	(0.2258)	(0.1333)
Experience	0.0207***	0.0254***	0.0101	0.0447*	0.0311*	0.0153**
	(0.0044)	(0.0057)	(0.0117)	(0.0234)	(0.0165)	(0.0066)
Experience^2	–0.0006***	–0.0006***	–0.0004	–0.0005	–0.0004	–0.0005***
	(0.0001)	(0.0001)	(0.0003)	(0.0004)	(0.0006)	(0.0002)
Firm tenure	0.0165***	0.0229***	0.0204	0.0176	0.0177*	0.0190***
	(0.0044)	(0.0051)	(0.0201)	(0.0115)	(0.0101)	(0.0067)
Firm tenure^2	–0.0003	–0.0005*	–0.0007	–0.0004	–0.0002	–0.0004
	(0.0002)	(0.0002)	(0.0007)	(0.0004)	(0.0003)	(0.0003)
Industry tenure	–	–0.0125*	0.0284	–0.0136	–0.0135	–0.0124
		(0.0066)	(0.0220)	(0.0153)	(0.0150)	(0.0082)
Industry tenure^2	–	0.0004**	–0.0005	–	0.0002	0.0002
		(0.0002)	(0.0007)		(0.0006)	(0.0003)
Years of schooling	0.0354***	0.0362***	0.0406***	0.0609***	0.0651***	0.0240***
	(0.0042)	(0.0042)	(0.0100)	(0.0163)	(0.0098)	(0.0006)
Occupation:						
Professional	0.5228***	0.5161***	–	–	–	–
	(0.0540)	(0.0498)				
Clerical	0.2340***	0.2236***	–	–	–	–
	(0.0399)	(0.0389)				
Service	0.0453**	0.0369	–	–	–	–
	(0.0344)	(0.0352)				
Hours worked	0.0010***	0.0011***	0.0005	0.0014**	0.0001	0.0029***
	(0.0003)	(0.0003)	(0.0005)	(0.0006)	(0.0006)	(0.0005)
Public school	0.0005	0.0003	0.0869	0.0711	0.0482	–0.0207
	(0.0249)	(0.0248)	(0.0738)	(0.0619)	(0.0451)	(0.0400)
Married	0.0818**	0.0801**	–0.0518	0.0919	0.1372***	–0.0697
	(0.0302)	(0.0302)	(0.0606)	(0.0733)	(0.0465)	(0.0472)
Large	0.0589**	0.0619**	0.2187***	0.0724	0.0580	0.0804***
	(0.0228)	(0.0229)	(0.0824)	(0.0916)	(0.0448)	(0.0267)
City	–0.0059	–0.0089	0.0330	0.2073***	0.0461	–0.0966***
	(0.0234)	(0.0235)	(0.0821)	(0.0672)	(0.0500)	(0.0276)
Accomp	–0.0499**	–0.0503***	0.0168	–0.0779	–0.0615**	–0.0549*
	(0.0196)	(0.0195)	(0.0494)	(0.0510)	(0.0339)	(0.0284)
Full-time	1.219***	1.295***	1.793***	1.117***	–	–
	(0.2174)	(0.2235)	(0.1291)	(0.2847)		
R^2	0.4781	0.4797	0.5103	0.5624	0.2173	0.2538

Notes:
[1] White-corrected standard errors are in parentheses.
[2] The variable for squared industry tenure is highly correlated with other regressors in the equation; correlation coefficients were 0.83 to 0.96 and a serious multicollinearity problem was observed, so it was removed from the regression function. It applies to the case of "Full-time"in the estimation of CSC and Manual equations.

TABLE III
Marginal effects evaluated at the respective means

	By occupation				
	Full sample	Service	Professional	Manual	CSC
Experience	0.0082***	–0.0015	0.0297*	0.0002	0.0209***
	(0.0026)	(0.0047)	(0.0154)	(0.0018)	(0.0096)
Firm tenure	0.0166***	0.0120	0.0083*	0.0138***	0.0144***
	(0.0029)	(0.0127)	(0.0048)	(0.0039)	(0.0061)
Industry tenure	–0.0040	0.0198*	–0.0136	–0.0082***	–0.0095
	(0.0033)	(0.0113)	(0.0153)	(0.0036)	(0.0068)
Education	0.0362***	0.0406***	0.0609***	0.0240***	0.0661***
	(0.0042)	(0.0100)	(0.0163)	(0.0006)	(0.0098)
N	1170	118	135	551	366
	By firm size				
	Workers < 20	20 ≤ Workers < 100	100 ≤ Workers < 500	Workers ≥ 500	
Experience	0.0029	0.0102***	0.0029	0.0134***	
	(0.0056)	(0.0034)	(0.0048)	(0.0045)	
Firm tenure	0.0163*	0.0169***	0.0170***	0.0105***	
	(0.0080)	(0.0064)	(0.0065)	(0.0033)	
Industry tenure	–0.0040	–0.0149***	–0.0036	–0.0023	
	(0.0082)	(0.0053)	(0.0052)	(0.0056)	
Education	0.0299***	0.0236***	0.0342***	0.0466***	
	(0.0100)	(0.0067)	(0.0089)	(0.0073)	
N	315	264	211	380	

Note: *: 10% statistically significant. **: 5% statistically significant. ***: 1% statistically significant.

Parent (2000) extended the concept of the bias to the case of industry tenure, in which he employed two sets of panel data (NLSY and PSID) and applied both GLS and IV for estimation. Parent then proposed that industry-specificity is even more crucial than workers' firm tenure in determining wages. All the above works exhibit a common factor. A panel data is needed to remove the above-mentioned bias. Unfortunately, there is no such data available in Taiwan. Instead, a retrospective data set, TWFS, is employed for the estimation in the subject of industry-specific human capital. Thus, the sample selectivity caused by the above bias could not be corrected in this case by any of the methodologies mentioned above. Therefore, the possibly positive or negative bias could have existed in the estimation of Taiwan.[15]

Before we move to the next section, it should be noted that the female labor force participation rate in Taiwan was only 40% in the survey year. Since a worker's decision is unlikely to be completely random, we use Heckman's two-stage procedure to produce a corrected version of the wage function.[16] Nevertheless, the selection-correction term of the estimation is insignificantly different from zero with the significance and signs of the coefficient estimates exactly the same as those obtained from the OLS regressions. Detailed estimation results are shown in Appendix A. In addition, the wage loss equation often analyzed in U.S. literature is also tested in this paper using

the difference-in-difference method proposed by Neal (1995).[17] The wage loss estimation confirms the above finding that industry skills play no role in the earnings function in Taiwan; this evidence is shown in Appendix B. Hence, the econometric results in this subsection exhibit no links between industry tenure and earnings as observed in Figure 1.

B. *Samples divided by occupation*

In this paper, in addition to pointing out the non-relationship between earnings and industry-specific human capital in Taiwan using an econometric method, we also aim to offer some reasonable explanations for the phenomenon. Because of the differing and distinct stages of economic development in Taiwan and the U.S., we proceed with our analysis by decomposing the full samples into several groups by workers' occupation and firm size.

On the one hand, if a particular type of work requires a particular type of human capital that can mainly be obtained from a specific employer, then firm specificity would rank at the top in determining wages for workers possessing those jobs. Similarly, other types of human capital might be key for jobs with certain characteristics. On the other hand, take the example of knowledge of computers for inventory management, which is applicable to similar jobs; such a skill application is likely to be greater at the stage of development when there is deeper automation. Thus, another plausible explanation for the above finding has to do with the evolution of automation. Some proportion of job seniority effects would turn out to be transferable to different jobs as the degree of automation reaches a certain point. This possibly applies to the economy of the United States. Nevertheless, Taiwan's economy might not yet have reached this turning point in the study period. The wide disparities of job features might possibly cause the importance of specific types of human capital to depend on the features of the job, such that industry- or firm-specific skills might be relatively more important for jobs that require particular characteristics rather than for all jobs. Under this scenario, pooling all samples together might be inappropriate and might cause the problem of aggregation. This consideration might be particularly important in economies where skills vary substantially from job to job, such as in a newly industrialized country like Taiwan.[18]

Recently, Wang (1999) conducted a survey to investigate the effect of on-the-job training in Hsinchu Science-Based Industrial Park in Taiwan. Wang observed that, besides the general training that can be applied to any firm, 48% of the skills obtained from the training were transferable within the same industry. In other words, nearly half of the skills obtained from training could be carried over to new jobs in the same industry. Although the Hsinchu industrial park is science-based and the employees mainly are involved in skill-related occupations (more than 69%),[19] this study, to some extent, conveys the importance of industry-specific skills accumulated from jobs for workers of certain types of jobs. It also motivates us to decompose the samples by occupation.

The occupations are in the service, professional, CSC and manual sectors.[20] The first category obviously contains service jobs. The professional sector includes workers who are professionals, supervisors, technicians, administrators, business executives, managers and teachers. The third category, CSC, stands for workers considered clerical, sales and craft employees. Manual workers are product and machine operators and related laborers. Columns 3 to 6 of Table II show the empirical results. Before getting into detail, it is worth mentioning that the hypothesis of pooling the samples together versus decomposing them into four occupational groupings was tested. The F-statistic of the hypothesis tested, 10.50, is greater than the critical value, 1.39, at the 5% significance level, which proves the appropriateness of analyzing the earnings function by occupation.

Based on the estimates obtained from the regression, the corresponding marginal effects are calculated and summarized in the upper panel of Table III. Several results emerge. First, the results for industry tenure show a diverse impact on earnings across differing groups. For workers in service jobs, industry tenure is the only variable measuring workers' stock of specific human capital to show significant marginal effects. A positive 1.98% marginal effect is reported, which means that workers in that occupational sector enjoy approximately 2% wage gains for each additional year in the sector. This result implies that

the skills accumulated by service workers in, for example, building construction are relatively more important than those obtained by other workers with manual, CSC or professional jobs. This is probably because of the impetus of automation and the nature of service jobs, which cause the skills to be easily applied to new jobs in the same industry. If these workers choose to switch to other industries, they would have to forfeit the large wage gains. Noting that 70% of U.S. workers are employed in the service sector, it is not surprising that industry-specific human capital ranks at the top in their wage determination.

More substantively, the situation is quite different for two other groups of workers – manual and CSC workers. Surprisingly, industry seniority reduces their wages; other things being constant, adding one year of experience in the same industry generally reduces earnings by up to 0.82% and 0.95% for manual and CSC workers, respectively (columns 3 and 4 of Table III). The estimate is statistically significant for the manual workers, implying that workers can gain a benefit by switching across industries, and industry-specific human capital does not exist in that sector. In other words, blue-collar workers who frequently change jobs between industries tend to gain from their mobility, unless they stay in one industry for a very long time period (more than 31 years).[21] The above finding might also account for the remarkable level of labor reallocation among industries observed in Taiwan. It is probably understandable to come to this conclusion for the least skilled workers, since a greater variety of jobs might possibly enhance a manual worker's productivity.

Second, the capital stock accumulated through the number of years of schooling is the most crucial among all the variables that represent workers' stock of human capital in determining wages both in terms of significance and the magnitude of marginal effect. It is consistent throughout the overall sample and for all occupational groupings. It is also found that the estimated marginal effects are generally higher for more educated groups. Specifically, the average years of schooling for female workers with jobs in the professional and CSC categories are longer than those of the other two groups (Table I). They have, on average, some college education and enjoy the greatest marginal contribution from education (more than 6%). This magnitude is about twice that of the overall sample.[22] Hence, we infer that educational investment in Taiwan seems to be quite successful in enhancing workers' abilities at work. This is consistent with the finding, as documented in Tallman and Wang (1994) and Huang (1997), that education is considered the engine of growth in Taiwan during its miraculous economic development.

Finally, the importance of other variables representing a worker's stock of human capital varies with occupation. For instance, workers employed in professional and CSC jobs are the most technology savvy, and are found to retain a significant share of their returns with general experience.[23] Tenure with their current firms might raise wages with a marginal effect of 1.44% and 0.83 for the CSC and professional workers. Thus, the best strategy for more educated women to increase their wages is to accumulate labor market experiences and invest in more firm-specific human capital.

C. *Samples divided by firm size*

In this section, we offer another explanation for the nonrelationship between industry tenure and earnings mentioned above. It is well known that small and medium-sized firms have become increasingly important in the economic activities of both developed and developing nations.[24] In the literature, persistent wage differentials between firms of different sizes are documented not only in the U.S., but also in Taiwan (Chuang and Hsu, 1999; Reilly, 1995; Oi, 1990; Pearce, 1990). Workers in large firms are much better paid. Their wages are also found to increase faster with experience. Large firms also offer more opportunities for specific training than do smaller firms. That causes them to have a greater incentive to encourage the long-term loyalty of their workforce (Reilly, 1995). In this case, the effect of firm size might cause the importance of the type of human capital to vary across workers in firms of different size. Consideration of firm size might be especially crucial for Taiwan, where approximately 98% of companies employ fewer than 100 workers. The link between firm size and workers' performance, hence, deserves further investigation. Thus, the sample is divided by firm size in

this section – those with fewer than 20 workers, 20–99 workers, 100–499 workers, and those with more than 500 employees.[25]

The calculated marginal effects are shown in the lower panel of Table III with detailed coefficient estimates in Appendix A (the last 4 columns).[26] Interestingly, the estimated coefficients show diverse results across groups in the table, in which three findings are worth mentioning. First, firm-specific human capital significantly increases wages for workers in firms of fewer than 20 workers. Except for a worker's educational attainment, it is the only one variable of statistical significance when representing a worker's stock of human capital. A possible explanation for this is the highly independent production processes in the smallest firms; for example, the opportunity to work as a team is much less likely than it is in larger firms (Ehrenberg and Smith [2000]). Thus, workers might have to be trained relatively well in many more tasks than those in the larger-sized firms to handle production processes. The skills obtained from their job might be too specific to be carried over to other jobs. Firm specificity, hence, becomes very crucial in determining wages in the smallest firms.

Second, industry tenure is found to be insignificant in determining earnings for workers in firms of all sizes, with the exception of mid-sized firms with 20–99 employees. This implies that no industry-specific skills can be obtained from mid-sized firms in Taiwan. In the literature, Wallsten (2000) investigated the relationship between firm size and government grants; he contended that firms with fewer employees win fewer federal industry R&D grants,[27] a case worth considering in Taiwan. Industry-specific human capital is, therefore, less likely to be accumulated by workers in firms of smaller size. In addition, it is also noted that most workers (about 90%) in mid-sized firms are attributed to the manual and CSC occupations in the sample, where industry tenure is found to negatively influence wages. Thus, we can conclude from the above findings that industry-specific skills are not yet deeply implemented in the economy of Taiwan.

Finally, the marginal effect generally increases with average educational attainments as observed in the case of occupational groupings.

In summary, we conclude from the above findings that not only do workers' occupational features matter, but firm size is also relevant. These two factors might affect workers' wages by the way the stock of human capital is formulated, as well as the way in which they enhance workers' productivity.

IV. Conclusion

This paper examines the roles played by various types of human capital and highlights the importance of industry tenure in determining wages in Taiwan. First, industry-specific skill is generally much less important in Taiwan than what is observed in the United States. Industry tenure accumulated to the time of separation is generally unrelated to wage determination. It increases earnings only for workers with service jobs. Remaining in a particular industry is even found to reduce earnings for those in the least-skilled occupations and in medium-sized firms. Thus, industry-specific skills are not yet deeply implemented in most occupations and firms of various sizes. This finding might account for the remarkable level of labor reallocation among industries observed in Taiwan.

Second, the capital stock accumulated through number of years of schooling seems to be the most crucial factor among all the variables representing workers' stock of human capital in determining wages. This is true for the case of full samples, as well as when divided into various occupational groupings and for firms of differing size. The effect is found to generally increase with the average educational attainments of workers, which might be considered one of the major causes of Taiwan's economic take-off. Finally, skills seem to be very much firm specific for occupations that are the most technology intensive and for small firms. In the end, it should be noted that due to the lack of workers' earnings information for each time period, some kind of selection bias stated in the literature remains.

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Appendix A: Earnings function estimates

	Selection	Corrected	OLS (by firm size)			
	(1)	(2)	Worker < 20	20 ≤ worker ≤ 99	100 ≤ worker ≤ 499	Worker ≥ 500
Constant	7.836***	7.373***	7.857***	9.041***	8.580***	6.717***
	(0.3257)	(0.3115)	(0.3223)	(0.1549)	(0.1923)	(0.1290)
Experience	0.0177***	0.0235***	0.0162	0.0371***	0.0140	0.0195*
	(0.0067)	(0.0078)	(0.0111)	(0.0102)	(0.0096)	(0.0118)
Experience^2	–0.0004**	–0.0006***	–0.0005*	–0.0009***	–0.0004*	–0.002
	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0003)
Firm tenure	0.0166***	0.0242***	0.0260**	0.0175*	0.0221*	0.0170**
	(0.0051)	(0.0056)	(0.0116)	(0.0101)	(0.0119)	(0.0080)
Firm tenure^2	–0.0002	–0.0005*	–0.0008**	–0.0004	–0.0004	–0.0003
	(0.0002)	(0.0002)	(0.0004)	(0.0004)	(0.0006)	(0.0003)
Industry tenure	–	–0.0146*	–0.0110	–0.0324	–0.0155	0.0004
		(0.0075)	(0.0148)	(0.0136)	(0.0131)	(0.0133)
Industry tenure^2	–	0.0004	0.0004	0.0009*	0.0006	–0.0001
		(0.0002)	(0.0004)	(0.0005)	(0.0005)	(0.0003)
Years of schooling	0.0326***	0.0362***	0.0279***	0.0193***	0.0342***	0.0466***
	(0.0074)	(0.0069)	(0.0100)	(0.0073)	(0.0089)	(0.0073)
Occupation:						
Professional	0.5255***	0.5217***	0.1200	0.7245***	0.5083***	0.3772***
	(0.0644)	(0.0625)	(0.1402)	(0.1162)	(0.1175)	(0.0698)
Clerical	0.2710***	0.2583	0.0955	0.3092***	0.2016**	0.1830***
	(0.0471)	(0.0457)	(0.1018)	(0.0739)	(0.0898)	(0.0546)
Service	0.0258***	0.0153	0.0054	0.1263	0.2115**	–0.0321
	(0.0394)	(0.0401)	(0.0635)	(0.0869)	(0.0794)	(0.0585)
Hours worked	–	–	0.0016***	0.0008*	0.0010*	0.0004
			(0.0005)	(0.0004)	(0.0006)	(0.0006)
Public school	0.0027	0.0200	–0.0960	0.0341	0.0401	0.0068
	(0.0284)	(0.0282)	(0.0631)	(0.0506)	(0.0638)	(0.0360)
Married	–	–	–0.0341	0.0047	0.1655**	0.1394***
			(0.0723)	(0.0600)	(0.0717)	(0.0426)
Large	0.0802***	0.0835***	–	–	–	–
	(0.0260)	(0.0257)				
City	0.0194	–0.0140	–0.0405	–0.0631	0.0070	0.0504
	(0.0560)	(0.0550)	(0.0531)	(0.0452)	(0.0476)	(0.0360)
Accomp	–0.0494***	–0.0504**	–0.0384	–0.0742*	–0.0432	–0.0809**
	(0.0214)	(0.0213)	(0.0448)	(0.0411)	(0.0415)	(0.0289)
Full-time	1.274***	1.279***	0.7780***	0.0162	–	1.831***
	(0.2179)	(0.2239)	(0.2707)	(0.1095)		(0.1292)
ρ	–0.2335	–0.2134	–	–	–	–
	(0.4825)	(0.4360)				
Log Likelihood	–0.20448	–0.2042.9	–	–	–	–
R^2	–	–	0.2125	0.5049	0.4449	0.6274

Note: White-corrected standard errors are in parentheses.

Appendix B: Determinants of wage-cost differential between switchers and stayers with the same firm tenure – difference-in-difference approach

	(1)	(2)
Constant	–0.9739***	–1.135***
	(0.3433)	(0.3654)
Industry tenure (preseparation)	0.0818	0.1259
	(0.0691)	(0.0772)
Industry tenure^2	–0.0055	–0.0068
	(0.0039)	(0.0042)
Married (current)	0.3045	–0.1902
	(0.3139)	(0.3413)
R^2	0.0086	0.0125
∂ log(*earning*)/∂ (*industry tenure*)	0.0190	0.0462
	(0.0324)	(0.0367)
N	455	322

Notes:

1. The difference is formed by subtracting each switcher's actual wage loss from the mean wage loss among stayers with the same firm tenure. Thus, it is treated as an endogenous variable in the difference equation. The White-corrected standard errors are in parentheses, while *** represents 1% statistically significant. The samples are restricted to persons between the ages of 19 and 64. Monthly earnings are measured in 1988 dollars. Industry tenure (preseparation) is a worker's real working years in the industry of her prior job.
2. These derivatives shown in the end of the table are evaluated at mean industry tenure.
3. Model 2 restricts samples to those terminating their previous job and switching to the current one within the past five years.

Notes

[1] Willis (1986) provides a good overview.

[2] The search theory initially proposed the above concept. Shaw (1987) was the first to examine it empirically.

[3] These studies use data from the Displaced Worker Survey (DWS) to demonstrate that wages partly compensate for industry-specific skills. However, the DWS does not provide data on industry tenure.

[4] The agricultural sector represented more than 30% of GDP in the 1950s, while by 1994, the share in the service sector rose to more than 60% (Yearbook of Manpower Survey, R.O.C.). In the U.S., it took 32 years for the percentage of workers employed in the service sector to increase from 30% to 45% (from 1946 to 1978), more than twice the time it took in Taiwan.

[5] Data source: the Taiwan Women and Family Survey (TWFS). The preseparation industry experience variable is measured by the number of years a worker was in the industry (one-digit code) of her previous job, while wage loss is defined as the change in the log of beginning pay of a worker's current job and monthly pay when she terminated her previous job.

[6] In Taiwan, about 97.97% enterprises are the small and medium enterprises (Data source: Small and Medium Enterprise Administration, Bureau of Ministry of Economic Affairs, 1995).

[7] Yu (1996) provides a detailed introduction of the TWFS and compared it with other data sets.

[8] Although the TWFS data provides workers' employment histories, there is no wage information for each time period available and, hence, cannot be treated as panel data. This limits the correction for job matching effects and an individual's fixed effect in this paper, which will be explained in detail in the next section.

[9] See Neal (1995) and Parent (2000).

[10] Monthly hours worked equal to workers' weekly hours times 4.25. Although union status is documented to be crucial in determining wages in the U.S., the related variable is not included in regression analysis in Taiwan literature due to the lack of union status in the data set. However, since union activity in Taiwan was very much controlled by the government during the survey year, the possible omitted variable bias should not be serious. The author would like to thank an anonymous referee for these comments.

[11] Yu and Chu (1988) explained why the dummy of living in an urban area shows a negative relationship with wages, a phenomenon commonly observed in the earnings function in Taiwan. According to them, it may be caused by the relatively few opportunities for part-time or seasonal work in cities.

[12] The marginal contribution of the variables representing a workers' stock of human capital to wages is obtained from the partial derivative of wages with respect to the variable and is evaluated at its mean value (expressed as $\partial Y/\partial X_1 = \eta_1 + 2\eta_2\bar{X}_1$, where Y, X_1, $\bar{X}_1$, η_1, and η_2 are the dependent variable, independent, the mean value of X_1, and the coefficients of X_1 and X_1^2, respectively). The corresponding standard error is calculated to be $\text{var}(\eta_1) + 4\,\bar{X}_1^2 \times \text{var}(\eta_2) + 4\,X_1 \times \text{cov}(\eta_1, \eta_2)$, where the variance and covariance can be obtained from the variance-covariance matrix of the coefficients from the software used (*STATA* in this paper) (Kletzer, 1989). For instance, the marginal effect of industry-specific human capital for the full sample (column 2 of Table II) is $-0.0125 + 2 \times 0.0004 \times 10.57$, –0.0040. The standard error is estimated to be the square root of $0.0066^2 + 4 \times 10.57^2 \times 0.0002^2 + 4 \times 10.57 \times (-1.2(e\ -6))$, *0.0035*. Thus, the estimated marginal effect is statistically indifferent from zero in this case.

[13] It is calculated as $\partial Y/\partial X_1 = \eta_1 + 2\eta_2 X_1 = 0$, i.e., $2 \times 0.0004 \times X_1 = 0.0125$, so $X_1 = 15.6$. Please refer to footnote 12 for notations.

[14] Parent (2000) found the importance of industry-specific human capital in wage determination, which was true for the National Longitudinal Survey of Youth (NLSY), youth data and the Panel Study of Income Dynamics (PSID) data sets.

[15] I thank an anonymous referee for this comment.

[16] To implement this method, we estimate the selection equation using a standard probit model, where the explanatory variables include the worker's age, age squared, years of

schooling, and dummies for marriage, graduating from public school, a major in science, living in an urban area, having children under 6 and husband's wages.

[17] The difference-in-difference function of wages is formed by subtracting each switcher's actual wage change from the mean wage change among stayers with the same firm tenure. The difference-in-difference is then regressed on the industry tenure of each switcher.

[18] Carrington (1993) analyzed the impact on wages of industrial switchers by occupation and found the importance of industry-specific human capital in wage determination. Shaw (1987) discussed the transferability of occupational skills and contended that a portion of occupational investment is transferable upon change. Individuals appear to change occupations to maximize the present value of their returns to investment.

[19] Figure is obtained from the Web site of the Hsinchu Science-Based Industrial Park, www.sipa.gov.tw.

[20] The TWFS contains the occupations professionals, administrators and managers, business executives, teachers, clerical and crafts, sales, service and production workers, machine operators and related labor. However, some occupations contain only small samples, so we divided the samples into only four groups.

[21] Please see footnote 13 for similar derivation.

[22] This finding might be considered a corroboration of Huang (1997), in which the rates of return on education in Taiwan rose continuously during Taiwan's economic development.

[23] The variable of squared industry tenure is highly correlated with other regressors in the equation of professional workers, the correlation coefficients being 0.83 to 0.96, so it has been removed from the regression function.

[24] Japan and Italy have the highest percentage of small enterprises among the OECD countries (Whittaker, 1990).

[25] Doi and Cowling (1998) offer several definitions of small and medium-sized firms for the OECD countries. In Taiwan, manufacturing, construction, mining or quarrying enterprises with employees less than 200 are officially identified as medium and small enterprises. Agriculture, forestry, fishing, animal raising, plumbing, electrical power, gas and fuel-oil supply, commerce, transportation, warehouse, communications, finance, insurance, real estate, industrial service, commercial service, social service or personal service enterprises with employees less than 50 are identified as the medium and small enterprises (Data source: Small and Medium Enterprise Administration, Bureau of Ministry of Economic Affairs). By this standard, 97.97% enterprises (in 1995) are the small and medium ones.

[26] The specification test for pooling the full sample together versus decomposing them into four firm-sized groupings is also executed. Empirically, the *F*-statistic of the hypothesis tested, 1.83, is greater than the critical value, 1.36, at the 5% significance level; these results demonstrate the appropriateness of analyzing the earnings function by group. The results are robust in the decomposed samples of three groups – firms with fewer than 20 workers, 20–99 workers and those with more than 100 workers.

[27] Please see also Irwin and Llenow (1996) and Levy and Terleckyj (1983), who found a positive correlation between government R&D funding and employment.

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