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LABOR FORCE AGE COMPOSITION AND THE AGE-EARNINGS PROFILE IN DEVELOPING COUNTRIES: THE CASE OF TAIWAN

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NANKANG, TAIPEI, TAIWAN
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ABSTRACT

This study seeks to determine empirically the relationship between the labor force age composition and the age-earnings profile in Taiwan. Clarification of this relationship is important because it provides us with a key element in coming to a better understanding of the effects demographic changes can have on the labor market.

When the labor force of each age group is considered to be exogenously determined by demographic changes, then the hypothesis of cohort size effects predicts that the greater the substitutability between age groups in production the smaller the changes in the (relative) age-earnings profile will be. Welch (1979) suggests that imperfect substitution between age groups results primarily from workers at different career stages performing different kinds of jobs or tasks. Therefore, the value of one job or task would reasonably depend on the number of workers doing it, thus cohort size is important to affect the wages of workers doing that job or task.

In specifying the human capital earnings equations used, the study modifies the lead of previous studies in the United States by including the development characteristics of Taiwan. In addition to including the labor force age composition, we also include several structural variables in the economy, such as industrialization, urbanization, and occupational composition. These are emphasized as important determinants of Taiwan's age-earnings profiles. In the regression analysis used in this study, two types of data are used: (1) individual, cross-sectional data and (2) pooled time-series data. However, the pooled time-series data provide less information than we need for a precise over time study. Thus, the results of the pooled time-series data can only be treated as supplemental in our analysis.

According to our cross-sectional analysis, we obtained several results that are very different from findings of previous studies done in the United States. First, the negative cohort size effects on male earnings in Taiwan only prevail for those workers who have not received any college education and still are in the early stage of their careers. After this early stage, given an educational level, the earnings of those male workers without a college education tend to be independent of their cohort sizes or their age composition. These findings imply that within each of the male education groups, with the exception of the college group, the degree of substitutability of new entrants for the experienced or older workers in production increases as experience rises. It is quite reasonable in Taiwan that in those professions characterized by low skills (usually for workers without higher education), workers soon become perfect substitutes for one another in spite of their differences in experience after some initial years of learning.

The second result we observed was that for those male workers with a college education the effects of cohort size are not significantly different from zero at the very early stage of their careers. Also, significant and positive cohort size effects were observed for the earnings of those who have passed this very early stage in the male college group. These results indicate that male workers with a college education tend to be perfect substitutes for one another when they are in the very early stage of their careers. After this early stage, the workers at different levels of experience become imperfectly substitutable for one another in production because of the differences in their professional skills. However, the question as to what factors lead to a positive sign of cohort size effects for the male college group still remains. If our specification for the earnings equations does not miss any important explanatory variable, the likely answer is that at the current stage of Taiwan's economic development, those experienced workers with a higher education generally experience increasing returns from their labor inputs.

In the pooled time-series analysis of group data, we find that the cohort size effects are negative but insignificantly different from zero. However, the results are not sufficient to reject the possibility that there are some negative cohort size effects on young workers' earnings around the entry level. The aggregation of labor force into only four large groups and the lack of further information about the groups do not allow us to examine the cohort size effects for each age. Therefore, we cannot

capture the variation of cohort size effects at the different career stages. We also find that the aggregate age-earnings profile tends to be independent of the business cycle. However, the relative earnings of workers under 45 years old have been improved by the time trend since 1964. This result may be due to improvement in the quality of schooling and training of younger workers, or structural changes in the economy which favor younger workers, or both.

The firm conclusion that can be made here is that the age-earnings profiles in Taiwan are much more affected by the economic structure (and education) than by the labor force age composition.

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CHAPTER I

INTRODUCTION

Recently Freeman (1979) and Welch (1979) discussed the determinants of the age-earnings profile for the United States. They present evidence which supports the idea that the rapid increase in the proportion of young workers, due to the post-World War II baby boom, was associated with a reduction in their relative earnings in the U.S. labor market. For Japan, Martin (1980; 1982) also finds that the relative size of young workers versus older workers affects the wage ratio. These findings suggest that as far as production is concerned, young workers are not perfect substitutes for older workers. The hypothesis of cohort size effects on the age-earnings profile, therefore, asserts that an increase in the (relative) size of a cohort has a negative effect on its (relative) earnings in the labor market. Taiwan's post-war "baby boom' cohorts entered the labor market from the mid-1960s to the mid-1970s, but the relationship between the cohort size and the age-earnings profile has not been so clear-cut as in the United States and Japan.

Figure 1.1 compares the population age composition of Taiwan with those of the United States and Japan. We find some similarity among these three populations. This similarity is to be found in the presence of some unusually large cohorts in these populations resulting from a high fertility rate in some particular years after World War II. One noticeable difference, however, is to be found in the average ages of the populations of the United States, Japan, and Taiwan. The average ages of the populations of the first two countries are much greater than that of the population of Taiwan.

Table 1.1 presents both changes in the labor force ratio and changes in the wage

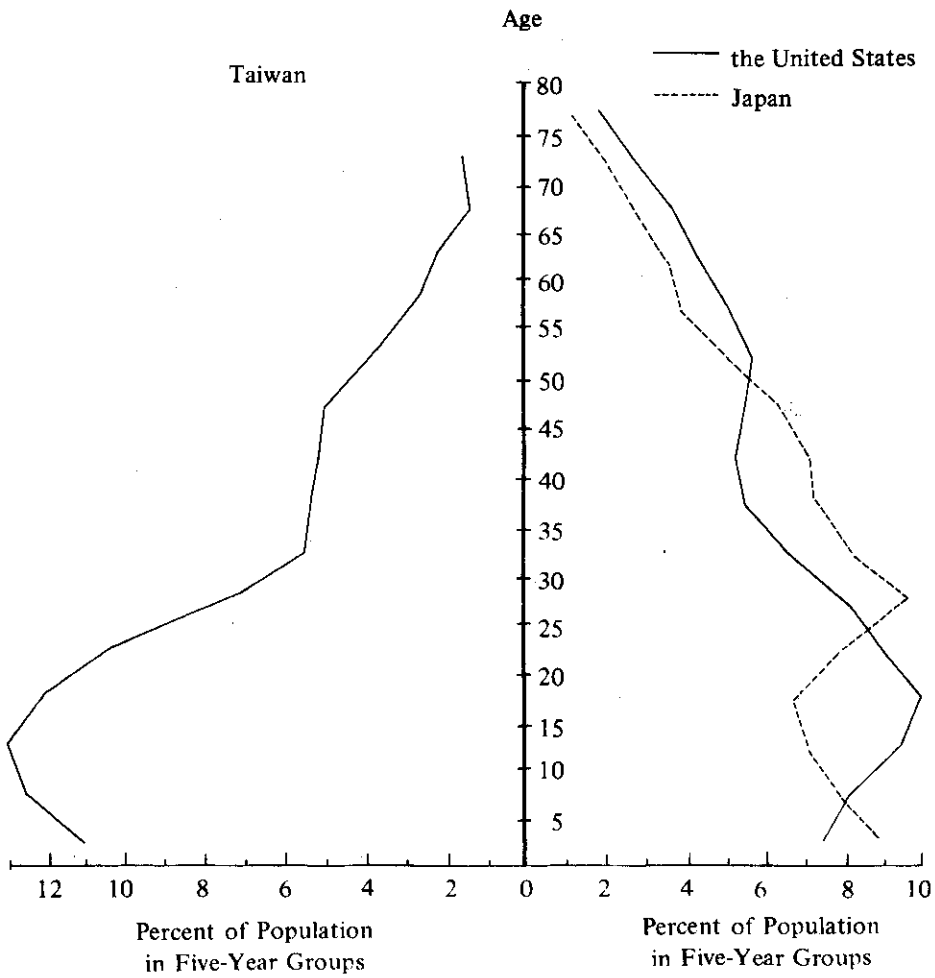


Figure 1.1 Population Age Compositions of Taiwan, Japan, and the United States, 1975

Table 1.1. Changes in the Labor Force Ratio and Changes in the Wage Ratio in Taiwan, 1964-76

Unit: %

Year	Age Group					
	15-24		45-59		60 and over	
	Changes in Labor Force Ratio*	Changes in Wage Ratio*	Changes in Labor Force Ratio*	Changes in Wage Ratio*	Changes in Labor Force Ratio*	Changes in Wage Ratio*
1964-1966	−9.08	−2.13	2.86	16.36	−33.33	−12.73
1966-1968	13.04	−8.70	−2.78	−10.16	−25.00	2.08
1968-1970	13.46	9.52	−2.86	−2.61	33.33	6.12
1970-1972	−6.78	6.52	26.47	9.82	−25.00	3.85
1972-1974	−3.77	4.08	−2.33	−8.13	33.33	4.63
1974-1976	5.66	−1.96	2.38	−0.88	0	−9.73

*The ratios are calculated with the 25-44 group's cohort and wages as bases

Source: Chiang, S. H. and Hu, C. T., *Attributes of Gini Coefficients of Wage Rates* (Taipei: Academia Sinica, 1979), pp. 11-15.

ratio in the past for Taiwan, using the 25-44 age group as a base. Although the table clearly indicates that the zenith of the entries of "baby boom" cohorts into Taiwan's labor market caused rapid increases in the number of workers in the 15-24 age group relative to the number of older workers in the 25-44 age group in the period from 1966 to 1970, we have not found the consistent, negative impact on the wage ratio of these large entries of young workers.

Contrary to the cohort size effects hypothesis again, changes in the labor force ratio of the 45-59 age group and changes in its wage ratio versus the 25-44 age group moved in the same direction during the years from 1964 to 1974. Additionally, there were large variations in the labor force ratio of the 60 and over age group versus the 25-44 age group; but we still were unable to find a clear-cut relationship between the labor force ratio and the wage ratio for this age group. These phenomena do not imply that there is no important influence of the cohort size on the age-earnings profile for Taiwan. Other important factors are at work including the increasing educational attainment of younger workers, changes in the sex composition of labor force, the fluctuations in the business cycle, the rapid industrialization and urbanization, and other structural changes in an economy that is rapidly growing. Exclusion of these factors from the analysis would lead to a severely biased estimate of the cohort size effects in Taiwan's labor market.

Theoretically, the magnitude of the cohort size effects depends on how substitutable age groups in production are. When different age groups of labor are highly substitutable for one another, large changes in the number of workers in any particular age group will only cause some modest changes in the age-earnings profile. Conversely, when this substitutablity is fairly limited, changes in the age composition of the labor force will lead to sizable changes in wages profile by age. This is because the degree of substitutability of inputs will directly affect the demand elasticity for labor of different age groups in the standard factor demand analysis. The demand for labor schedule becomes a wage-determination schedule in the labor market if the number of workers of different age is taken as exogenously determined by demographic changes.

The substitutability of one age group for another may primarily come from the fact that workers at different stages of their careers are engaged in different kinds of jobs or tasks. This reality could be a result of the organizational hierarchy of job

arrangement influenced by such factors as the seniority system, or it could result from an individual's sequential investments in human capital and its depreciation over his career.

A summary of the literature on cohort size effects will be presented in the second chapter which will be followed by a survey of Taiwan's demographic situation and labor force in the development process. The determinants of Taiwan's age-earnings profile will be discussed before we proceed to the empirical test. We also acknowledge that the twist in Taiwan's male age-earnings profiles could be affected by the influx of female workers, who could be better substitutes for young male workers than for old male workers. It would be more possible for women to compete for entry-level or early career jobs than for more senior positions. However, the limitations of our current data do not allow us to include female workers in the analysis. The further study of the substitution of female workers for various male age groups is urged for Taiwan.

A summary of findings and the policy implications are presented in the last chapter.

CHAPTER II

REVIEW OF LITERATURE

According to human capital theory, age-earnings profiles are products of individual investment behavior and depreciation of acquired skills and physical ability. The theory posits that the returns of a person from labor market activities are a function of his stock of human capital or his acquired skills and knowledge devoted to such activities. Since an individual's life is not infinite, a rational individual has to make sequential decisions to maximize the present value of his expected income stream. Optimizing behavior implies that an individual would tend to concentrate his investment in human capital at the early stage of his life and that his investment would then decline as he ages. Income, corresponding to these changes in human capital investment, should rise initially with age, peak, and then fall.

Although investments in human capital may be through additional education, on-the-job training, migration, health care, and so fortn, most studies of human capital treat human capital as a homogeneous factor embodied in human begins with a single rental price in the labor market. They ignore the fact that there are differences in the production activities of younger and older workers and in the demand for those activities. Therefore, these studies imply that all workers, regardless of age or experience, could easily be substituted for one another in production. In other words, the age-earnings profile would only depend on age or experience instead of the composition of labor force age or experience in the labor market.

In fact, some recent studies, for the United States by both Welch (1979) and Freeman (1979) and for Japan by Martin (1980), have indicated that the age-earnings profiles for these two countries were strongly influenced by the labor force age com-

position. In the United States, the large cohorts of the post-World War II baby boom experienced lower earnings relative to the earnings of other cohorts in the late 1960s and early 1970s. For Japan, Martin finds that small cohorts of young Japanese workers received higher relative wages from 1960 to 1970. These effects of labor force age composition on the age-earnings profile have been called cohort size effects.

This also suggests that conventional human capital theory might be incomplete as it ignores important demographic and demand factors in the determination of earnings. There are several possible approaches to explaining cohort size effects. The following ones will be discussed below: institutional, production function (both CES and translog), and human capital approaches.

A. Institutional Approach

What factors would relate the labor force age composition to age-earnings profiles? From the point of institutional view the answer is that organizational hierarchy in job assignment causes the malfunction of wage competition in the modern economy. Arthur (1979:16) points out defects in orthodox wage competition:

> It would be stretching reality to invent neoclassical mechanisms for the way society arranges its production into an organizational hierarchy, for the way it attaches salaries to levels of this hierarchy, and for the way it selects and promotes people to fill these levels. These days, by and large, industry, government and the service sector define and advertise job positions, they tag salaries to them, they select people to fill them, and they pay their employees usually not piece-by-piece, but by the week or month for the occupancy of their positions. This does not mean of course that individual productivity, initiative, and ability count for nothing. If productivity is rewarded in the promotional system an individual may advance rapidly, certainly without it he may not occupy his position for long.

The above implies that investments in human capital are not solely determined by an individual's decisions but also by the choice of the organizational hierarchy, and that workers in the labor market compete against one another on the basis of individual relative position in the organizational hierarchy rather than on the basis of wages. In this case, the number of people needed to fill the hierarchy then determines the number of job positions.

Here, we simplify Arthur's model to explain how demographic changes affect

the age-earnings profile in the hierarchy. In this model, seniority or age is the only criterion for an individual's job promotion. The roles of education and personal ability in the hierarchy are ignored here. At time t, the number of individuals in age-cohort x is given by the function L(x, t); the total labor force thus is L(t) at time t,

$$L(t) = \int_{15}^{R} L(x, t)\, dx \tag{2-1}$$

where R refers to the retirement age. Let j(h, t) represent the number of jobs of level h at time t. The total number of job positions at time t is J(t),

$$J(t) = \int_{\underline{h}}^{\bar{h}} j(h, t)\, dh \tag{2-2}$$

where $\bar{h}$ and $\underline{h}$ refer to the highest and the lowest position levels respectively.

Suppose that a person U at age t_u occupies a position at level a; therefore, there are J(a, t) positions no worse than his level, where

$$J(a, t) = \int_{a}^{\bar{h}} j(h, t)\, dh \tag{2-3}$$

On the other hand, there are also $N_u(t)$ members in the hierarchy at least with the same seniority to compete with person U for promotion, where

$$N_u(t) = \int_{t_u}^{R} L(x, t)\, dx \tag{2-4}$$

Since the seniority system ensures that all persons who are not junior to person U in the hierarchy should be placed in those positions no worse than person U's level, we get a fundamental accounting identity – that is,

$$J(a, t) \equiv N_u(t) \tag{2-5}$$

at any time t. By differentiation, the identity becomes

$$d[N_u(t)] - [\partial J(a, t)/\partial a]\, da = 0 \tag{2-6}$$

Having $\partial J(a, t)/a = j(a, t)$, by differentiating equation (2-3) with respect to a, allows us to predict changes in person U's position level with the following function:

$$d\,a = -d\,[N_u(t)]/j(a, t) \lesseqgtr 0 \quad \text{if } d\,[N_u(t)] \gtreqless 0 \tag{2-7}$$

Equation (2-7) indicates that an increase in the number of members of any older cohort or of person U's own cohort will slow his promotion in the hierarchy from his present age t_u to the age of retirement. Conversely, a decrease in the number of those who are not junior to the person will cause a faster promotion for him in the rest of his career. Changes in $N_u(t)$ in this simplified model are only due to changes in the labor force age composition – that is, $d[N_u(t)] = \int_{t_u}^{R} [d\,L(x, t)]\,dx$. Thus, equation (2-7) relates the labor force age composition to the job hierarchy,

$$d\,a = -\left\{ \int_{t_u}^{R} [d\,L(x, t)]\,dx \right\} /j(a, t) \tag{2-8}$$

The question arises here, "what would happen to the age-earnings profile if the age composition of the labor force changes?" The answer is that person U's age-earnings profile will deteriorate if his cohort group is large, and conversely. The reason is simple: the rate of promotion in his career directly influences his earnings, because hierarchial wages are simply a function of position level. The wage of person U at position level a is W(a, t) at time t. Differentiating his wage function W(a, t), we have

$$d\,[W(a, t)] = [\partial W(a, t) / \partial a]\ da \gtreqless 0 \qquad \text{if } da \gtreqless 0 \tag{2-9}$$

That is, workers at higher levels receive higher pay. Integrating equation (2-9) and (2-8), we find that changes in the age-earnings profile is a function of changes in the age composition of the labor force,

$$d\,[W(a, t)] = \left\{ -[\,W(a, t) / a\,] \cdot \int_{t_u}^{R} [d\,L(x, t)]\,dx \right\} \cdot$$

$$/j(a, t) \lesseqgtr 0 \text{ if } \int_{t_u}^{R} [d\,L(x, t)]\,dx \gtreqless 0 \tag{2-10}$$

Given the distribution of jobs in the hierarchy, this equation implies that a large cohort as well as some succeeding age-cohorts would all suffer lower age-earnings profiles in the labor market, because they all lose their seniority in the promotion process. Moreover, this model tells us that the cohort size effects would persist throughout the life-cycle as long as the organizational hierarchy fails to adjust its job positions to changes in the labor force age composition.

Arthur's proposition is also advocated by others. For example, it is similar to Thurow's theory of job competition (1972). Orthodox wage competition theory posits that workers in the labor market compete with one another with respect to wages and are paid their marginal products. Thurow's job competition theory, however, asserts that an individual's earnings are determined by his relative position in the labor queue and by the distribution of job opportunities in the economy. His theory is based on four major propositions: (1) the number of different types of job slots is technologically determined; (2) the workers' skills, i.e., human capital, and wage offers are nearly irrelevant in the determination of the number and type of job positions actually filled; (3) the queue of workers for jobs offered at fixed wages constitutes the labor supply, and the employer's assessment of workers' trainability and adaptability determines which workers are hired; and (4) fluctuations in macro policies will lead to changes in demand for labor and thus to changes in queue lengths.

Given macro-economic conditions, a large cohort constitutes a much longer queue of workers for job offers. There is only a small chance for gaining job positions with high pay. As a result, an average worker in a large cohort would tend to have a lower income.

B. CES Production Function Approach

The production function approach to the issue of cohort size effects is to test empirically how substitutable different age groups are in the production process. Constant elasticity of substitution (CES) production functions are characterized by constantly diminishing marginal rates of technical substitution (not all the elasticities of substitution are the same constant). In a function with two variable inputs, a direct elasticity of substitution is defined as

$$S_{ik} = S_{ki} = -\partial \ln (L_i / L_k) / \ln(W_i / W_k) = \text{constant} \qquad (2\text{-}11)$$

where i and k refer to the two factors in production respectively, L refers to the amount of input, and W refers to wages. Clearly, this elasticity measures the impact of relative wage changes on the substitution between these two factors and must be positive in the two-factor case. Thus, the impact of relative quantities on relative earnings can be obtained by integrating equation (2-11),

$$\ln (W_i / W_k) = - 1/S_{ik} \cdot \ln (L_i / L_k) + \text{constant} \qquad (2\text{-}12)$$

Suppose factors i and k denote young workers and older workers respectively in a simplified economy; equation (2-12) says that the wage ratio of young workers versus older workers is negatively affected by their labor force ratio if they are not perfect substitutes for each other, i.e., S_{ik} does not approach ∞.

In a multi-factor CES production function, this equation is still true if factors other than i and k do not affect the ratio of their marginal products or wages. The extension of the basic form of equation (2-12), which may include the business cycle and the time trend, has been applied to analyze the impact of changes in the labor force ratio of young workers versus older workers on their wage ratio for the United States (Freeman, 1979) and for Japan (Martin, 1980; 1982). The empirical results of these studies indicate that in production the young workers were not perfectly substitutable for older workers in the male labor force. Although cyclical variables had fairly strong effects on young workers' earnings, the labor force age composition was still considered as the most important determinant of the age-earnings profile for these two countries by using the CES production function approach.

C. Translog Production Function Approach

Griliches (1969) has found that older workers (skilled labor) are relatively more complementary with capital equipment than young workers (unskilled labor) in production, and Freeman (1979:310) has noted that "greater substitutability between women and young men than between women and older men is that women are more likely to be competing for entry-level or early career jobs than for senior positions in firm." Accordingly, changes in the male age-earnings profile cannot be explained only by changes in the male labor force age composition. However, the CES production function is incapable of handling problems that arise out of the variable substitutability among all factor pairs of young men, older men, women, and capital in produc-

tion. In this context, the translog production function provides a systematic examination of the effects of changes in the quantities of several inputs on the age-earnings profile.

Technically, a translog production function, unlike the CES production function which constrains some of the elasticities of substitution to be equal, can be used for the case of variable elasticities of substitution between factors. It is defined as

$$\ln Y = f(\ln L_1, \ln L_2, \ldots . \ln L_n) \tag{2-13}$$

Where output Y and any input L_1 are all in natural logarithms. Here, factor i can denote any male age group, female group, or capital. By using the Taylor series expansion to the second term, $F(X) \simeq F(X_0) + F'(X_0)(X - X_0) + F''(X_0)(X - X_0)^2/2$, around all L = 1, we obtain an approximation to the production function as follows.

$$\ln Y = A + \sum_i a_i \ln L_i + \tfrac{1}{2} \sum_i \sum_k r_{ik} (\ln L_i \ln L_k) \tag{2-14}$$

where

$$A = \ln Y \Big|_{\ln L = 0 \text{ for all } i} = \ln Y \Big|_0$$

$$a_i = \partial \ln Y / \partial \ln L_i \Big|_0$$

and $$r_{ik} = \partial^2 \ln Y / (\partial \ln L_i \partial \ln L_k) \Big|_0$$

The homogeneity of degree 1 (CRS) implies that

$$\sum_i r_{ik} = \sum_k r_{ki} \tag{2-15}$$

and

$$\sum_i a_i = 1 \tag{2-16}$$

At times too many factors are involved to use the direct regression analysis for the parameters in equation (2-14); an indirect method (via derived demand function) is applied to the problem by assuming that competitive equilibrium is always achieved. The derived demand function can be obtained by differentiating equation (2-14) with respect to $\ln L_i$,

$$\partial \ln Y / \partial \ln L_i = L_i Y_i / Y = L_i W_i / Y$$

$$= c_i$$

$$= a_i + \sum_k r_{ik} \ln L_k \qquad (2\text{-}17)$$

where W_i refers to wages or marginal products of factor i and thus, c_i refers to its share in the production cost. Obviously, equation (2-17) is applicable for linear regression analysis to attain the estimates of parameters (i.e., a_i and r_{ik}) of the translog production function.

Now, we can relate the parameters of the translog production function to the substitution among different factors. It is useful first to introduce the definition of partial elasticity of complementarity,

$$s_{ik} = (\partial \ln W_i / \partial \ln L_k) / c_k = Y \cdot Y_{ik} / Y_i Y_k = s_{ki} \qquad (2\text{-}18)$$

given a constant marginal cost of output Y. Here, c_k refers to the share of factor k in the production cost, and Y_i for all i refers to the partial derivative with respect to factor i. A positive s_{ik} indicates that factors i and k are (quantity) complements, because an increase in the quantity of factor k or factor i will lead to an increase in the marginal products (wages) of the other factor. Analogously, a negative s_{ik} implies that factors i and k are (quantity) substitutes for each other, because their marginal products (wages) will decline as the quantity of the other factor increases.

Differentiating equation (2-17) with respect to L_k, we get

$$Y_{ik} = (r_{ik} \cdot Y / L_i L_i) + (a_i + \sum_k r_{ik} \ln L_k) Y_k L_i$$

$$= (r_{ik} \cdot Y / L_i L_k) + Y_k (Y_i / Y) \qquad (2\text{-}19)$$

where

$$Y_i = Y(a_i + \sum_k r_{ik} \ln L_k) / L_i$$

from equation (2-17). Multipling both sides of equation (2-19) by $Y/Y_i Y_k$, we yield

$$YY_{ik} / Y_i Y_k = (r_{ik} Y / L_i L_k) Y / Y_i Y_k + (Y_i Y_k / Y)(Y / Y_i Y_k)$$

or in the form of elasticity,

$$s_{ik} = r_{ik}/c_i c_k + 1 \quad \text{for } i \neq k \tag{2-20}$$

Similarly, we also can derive

$$S_{ii} = (1/c_i)^2 (r_{ik} + c_i^2 - c_i) \tag{2-21}$$

Once we have the estimates of r_{ik} and c_i for all i and k from the regression specification as equation (2-17), the partial elasticities of complementarity for all pairs of inputs can easily be obtained by both equations (2-20) and (2-21).

As for the decomposition of all related effects on the relative wages between age groups, we have to rearrange the partial elasticities of complementarity into a discontinuous form.

$$\Delta \ln W_i = c_k s_{ik} (\Delta \ln L_k) \tag{2-22}$$

When all factors' quantities vary, the factor price determination must be rewritten as

$$\Delta \ln W_i = \sum_k c_k s_{ik} (\Delta \ln L_i) \tag{2-23}$$

To explain changes in relative wages between age groups or between any other two factors, a further transformation of equation (2-23) is indeed useful:

$$(\Delta \ln W_i - \Delta \ln W_j) = \sum_k c_k s_{ik} (\Delta \ln L_k) - \sum_k c_k s_{jk} (\Delta \ln L_k) \tag{2-24}$$

Moreover, the "own elasticity" of complementarity s_{ii} is also implicitly defined as

$$\sum_k c_k s_{ik} = 0 \text{ so that } s_{ii} = - \sum_{k \neq i} (c_k / c_i) s_{ik} \tag{2-25}$$

Finally, we obtain a formula for the decomposition of all related effects on the relative wages by integrating equations (2-24) and (2-25),

$$(\Delta \ln W_i - \Delta \ln W_j) = \sum_k c_k (s_{ik} - s_{jk})(\Delta \ln L_k) + c_i (s_{ii} - s_{ij})(\Delta \ln L_i) + c_j (s_{jj} - s_{ij})(\Delta \ln L_j) \qquad k \neq i \neq j \tag{2-26}$$

Using this formulation facilitates decomposition of a change in relative wages (or relative factor prices) into the contribution of each factor input change.

Here, we face another problem: how to disaggregate the labor force into age groups? Anderson (1978) after testing the separability of various age groups and capital, finds that there is no conclusive disaggregation of the labor force for the translog production function. He uses age groups 14 to 24, 25 to 54, and 55 and over, and argues that "to study properly the contribution of labor of different ages to production and substitution possibilities among labor age groups and capital, it seems wisest to use labor data disaggregated at least into the three age groups specified" (Anderson, 1978:18).

Using the translog production function Anderson also concludes that different age groups in the United States were not perfect substitutes for one another. For the period 1947 to 1976, young workers of age 14-24 and workers of age 25-54 were (imperfect) substitutes for each other (the partial elasticity of complementarity between these two groups, $s_{\underline{14\text{-}24,\ 25\text{-}54}}$, was negative) while young workers and older workers were complements for each other ($s_{\underline{14\text{-}24,55+}} > 0$). He also finds that capital had a vital impact on the age-earnings profile for the United States:

> While technical change does not appear to be biased in favor of one age group or capital, there is evidence that capital is more complementary to workers of the middle age group, age 25-54. The apparent deterioration in the relative earnings of young workers during the past two decades may be due as much or more to the effects of relatively rapid growth of capital inputs favoring middle workers as to the rapid growth of the numbers of young workers. (Anderson, 1978 : 28-29)

By using the same formulation as equation (2-26) but with a different disaggregation of the labor force (men of age 20-34, men of age 35-64, and women 20-64), Freeman (1979), however, finds that changes in the numbers of young male workers would explain the most variations in the earnings of young men relative to those of older men in the United States labor market from 1967 to 1978. He also shows that these two male groups are (imperfect) substitutes for each other, complements to women, and also complements to capital in production.

The specification of age groups in the labor force for either the translog or other production functions is not only difficult, but also easily leads to sharp differences in the estimates of production parameters and elasticities of substitution between

age group. That is the reason why Welch (1979) argues that the abrupt now-you-are-in-now-you-are-out implications of the imposed rigid age demarcations are unappealing from the point of view of human capital theory. He then suggests using a human capital approach, as discussed below.

D. Human Capital Approach

Welch illustrates the effects of labor force age composition on the age-earnings profile by assuming that work careers consist of a series of more or less distinct phases. He argues that

> A new job-market entrant arrives fresh from school and enters his profession as a trainee, apprentice, or learner . . . . first achieves junior membership, and somewhat later senior membership in the profession. (1979: s75).

Workers in different phases of their careers thus do different kinds of jobs or tasks – and therefore perfect substitution between different age groups in profession could not exist. Consequently, the number of workers of a particular type (characterized by age or experience level) functionally affects the marginal products or wages of that type of worker.

Welch begins with an aggregate production function,

$$Y = F(G(N_1, N_2, \ldots, N_m), Z) \tag{2-27}$$

where G denotes the total human effect of workers in the profession characterized by a certain education level, N_i refers to the number of the i^{th} type of workers, and Z is a vector of all other variables such as labor inputs in other education classes and capital. For simplicity, Z is assumed separable from all N_i so that it will not affect any marginal rate of substitution between different types of workers in the profession.

Since a career phase involves transition between two types of work, Welch assumes that a member with x years of experience devotes a proportion, p_j, of his working time to activity j and the rest of his time to activity j + 1. In the competitive market the wages he receives equal the marginal products.

$$W(x) = \partial F/\partial n_x = F_G[(\partial G/\partial N_j)(\partial N_j/\partial n_x) + (\partial G/\partial N_{j+1})(\partial N_{j+1}/\partial n_x)] \tag{2-28}$$

where n_x denotes the number of workers with x years of working experience, and N_j and N_{j+1} are the equivalent numbers of workers engaged in activities j and j + 1 respectively. With the assumption that $\partial N/\partial n = p$ and $\partial N_{j+1}/\partial n_x = p_{j+1} = 1 - p_j$, wages thus can be expressed as

$$[W(x)/F_G] = [p_j G_j + (1 - p_j) G_{j+1}] \tag{2-29}$$

Here F_G, the partial derivative with respect to G, does not affect the relative wages among different types of workers but affects the level of the earnings for the whole class at a given level of education. Changes in F_G are thus neutral across all experience groups. The effects of changes in age (experience) composition then can be obtained by differentiating equation (2-29) with respect to n_x.

$$\frac{\partial [W(x)/F_G]}{\partial n_x} = (p_j, 1 - p_j) \begin{bmatrix} G_{j,j} & G_{j,j+1} \\ G_{j,j+1} & G_{j+1,j+1} \end{bmatrix} \begin{bmatrix} p_j \\ 1 - p_j \end{bmatrix} < 0 \tag{2-30}$$

If G is a (quasi) concave function, the quadratic form of equation (2-30) is negative definitely, that is, large cohorts in the labor force would result in relative wage reductions and vice versa.

Based on group data of the Current Population Survev from 1967 to 1975, Welch, using the semi-logarithmic income equations, finds that own cohort size did have a strong negative impact on the age-earnings profile for workers in each male education group.

In brief, over the past decades, researchers using both production function and human capital approaches have found that changes in the labor force age composition influence the shape of the age-earnings profiles vigorously for both the United States and Japan. However, the hypothesis here is that in studying the effects of cohort size on the age-earnings profile in Taiwan it may be important to consider the development characteristics of the country. Before attempting to build a theoretical wage model for a developing country, we will survey the structural changes that have taken place in the labor force of Taiwan.

CHAPTER III

THE SURVEY OF TAIWAN'S LABOR FORCE

A. Demographic Changes and The Labor Force Age Composition in Taiwan

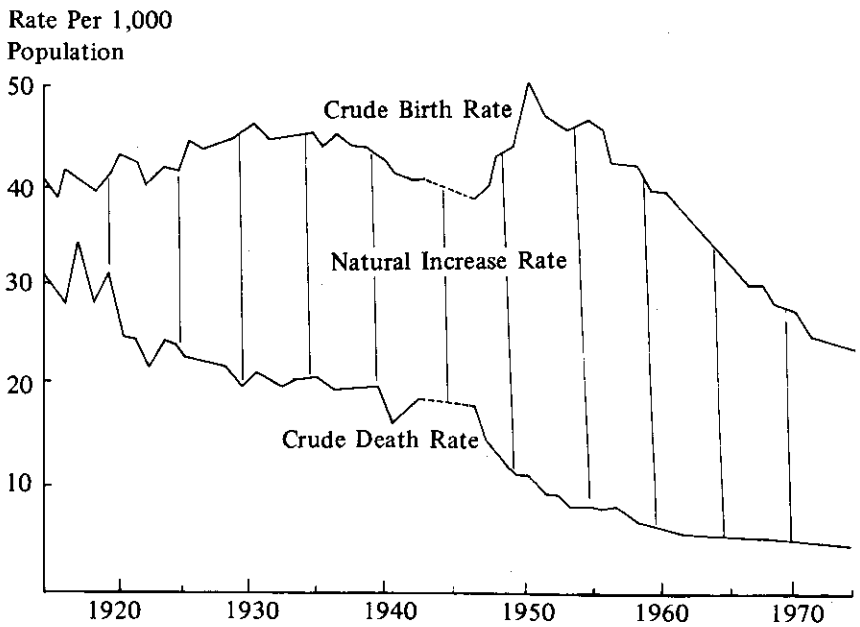
Because the labor force age composition is determined by both the size of various age groups in the population and their labor force participation rates, we shall first examine the demographic situation of Taiwan. We will then examine changes that have taken place in labor force participation rates.

In Taiwan, the rapid demographic transition in this century from high fertility and mortality to low fertility and mortality has resulted in considerable changes in the size of population, as well as its age composition. Concurrent with these changes, the labor force of Taiwan has grown and varied rapidly in the last three decades and will continue to change for some future decades.

Both size and age composition of a population are results of such factors as fertility, mortality, and migration. The vital rates of Taiwan's population are presented in Figure 3.1. Before 1920, the relatively slow growth rate of Taiwan's population was the result of a stable and high crude death rate (around 30.0/1,000).

Between 1920 and 1945, improvement of medical care and steady economic and social development under Japanese colonization resulted in a higher natural population growth rate in Taiwan. Specifically, there was a fairly steady decline in mortality rate, especially the infant mortality rate, and a slight increase in fertility.

After World War II, two critical population changes occurred. First, in the late 1940s, when it became apparent that the Nationalist government's position on the mainland China was unstable, a large number of mainlanders took refuge in Taiwan. From 1946 to 1950, more than one million mainlander refugees (military



Source: Cho, Lee-Jay, *Fertility Transition of the East Asian Populations* (Honolulu: University Press of Hawaii, 1979), p. 118.

Figure 3.1 Vital Rates in Taiwan, 1915-74

and civilian) arrived in Taiwan. This sudden influx contributed to an increase in population from 6 to 7 million over a short period of time.

Second, a large number of babies were born after the war. This "baby boom" lasted for over 15 years and is in sharp contrast to the size of earlier cohorts. Despite unfavorable economic conditions (production in 1945-46 was below one-half the peak reached in the colonial period. In addition, the (Taipei) wholesale price index increased 26 percent in 1946, 360 percent in 1947, 520 percent in 1948, and 3,500 percent in 1949 [Ho, 1978]), the fertility rate started to increase rapidly in 1946. The crude birth rate rose from the 38.1/1,000 in 1947 to a peak of 50.0/1,000 in 1950 and thereafter declined gradually in the years 1950-75 to about 23.0/1,000. The total fertility rate (TFR) was as high as 7.04, i.e., 7 children per mother, in 1951. By 1965, the fertility rate gradually declined to about 5 children per mother (TFR = 4.83). In the years 1965-75, the fertility rate decreased further to about 3 children per mother (TFR = 2.77).

Since the mid-1970s, more and more women born during the post-war "baby boom" period have reached child-bearing age. This ripple from the high post-war fertility rate significantly affects the current population age distribution. The total fertility rate suddenly rose to 3.08 in 1976, and the rate of decline in fertility has slowed down thereafter.

Selected age composition data of the male population ages 15-65 are also presented in Table 3.1. The figures in the table indicate the dynamic impact of the high post-war fertility rate on the age composition of the population. For instance, the proportion of males 15-19 in the male population of working age, 15-65 years, started to grow in 1964, reached its peak around 1969, sustained a high of 0.22 in the years 1969-74, and then declined. Thus, the entry of "baby boom" cohorts into the working age category reached its zenith around 1969 and was sustained to 1974.

Since the labor force, L, is determined by both the population size, P, and the labor force participation rate, r, changes in the labor force then can be expressed as

$$\Delta L = r \cdot \Delta P + P \cdot \Delta r + \Delta r \cdot \Delta P \qquad (3\text{-}1)$$

where Δ denotes the changes. $r \cdot \Delta P$ represents the effect of changes in the population size on the labor force, and $P\Delta r$ represents the effect of changes in the labor force

Table 3.1 Age Composition of Male Population of Age 15-65 in Taiwan, 1960-79

Unit: %

Age \ Year	1960	1964	1969	1974	1979
15-19	16.7	16.7	22.6	22.1	18.8
20-24	10.8	9.5	7.3	10.4	11.0
25-40	39.7	39.7	35.1	32.3	34.0
40-54	25.1	25.7	25.5	25.8	24.9
55-59	4.7	4.9	5.6	5.2	6.6
60-65	3.1	3.6	3.9	4.1	4.6
Total	100.0	100.0	100.0	100.0	100.0

Source: Directorate-General of Budget, Accounting & Statistics, Executive Yuan, the Republic of China, *Quarterly Report on the Labor Force Survey in Taiwan*, various issues.

participation rate on the labor force. $\Delta r \cdot \Delta P$ then refers to the interaction effect between changes in the population size and in the labor force participation rate. Table 3.2 presents the decomposition of changes in the labor force of different age groups for both sexes.

From 1964 to 1979, changes in the labor force age composition were primarily due to changes in the age composition of the population for those males in prime working ages, 25-54. Their labor force participation rates in the past have remained fairly high and steady, i.e., in the 89 to 99 percent range, depending on the particular age. This situation of high participation in the labor market is also likely to be maintained in the future. Participation rates for males 55-59 years have a slight but stable upward trend (see Figure 3.2). The steady decline in the participation rate for males 15-19 seems to be due to the increasing proportion of male junior high school graduates continuing their education. The same relation has been observed in the participation of females 15-19 years for the same reason since the mid-1970s. It is likely that the rate of labor force participation for these two groups will continue to decline in the coming decade as a result of a continuing rise in the educational attainment of youth. (The present participation rate for Taiwan's males of age 15-19 is still around 0.38 while the same rate for Japanese young men of the same age group has declined below 0.30 since 1970).

For males 20-24, participation in the labor market has remained at a level around 0.80 since 1970. Therefore the demographic change in the recent period has had a fairly important influence on the number of workers in this group. Its future path, however, could decline in the coming decades for several reasons. First, it is possible that the proportion of senior high school and vocational school graduates choosing to go to college could continue to increase as the economy continues to grow rapidly. Second, the past decline in labor force participation for the male 20-24 group has been linked with the increase in the proportion working in non-agricultural sectors, since labor force participation is higher in the agricultural sector. For this male group, the continuing growth of the proportion working in non-agricultural sectors seems likely to be sustained for the same period of time.

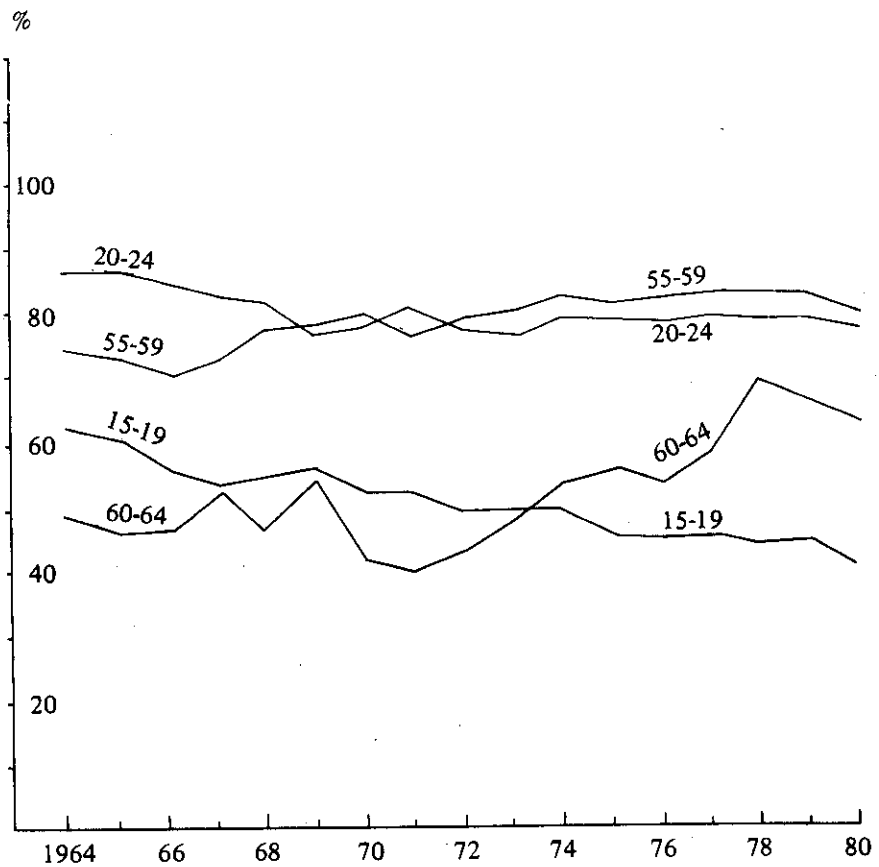
For the older males, 60 years and over, despite a considerable amount of fluctuation, participation in the labor market has increased during the past. Future labor force participation could be significantly affected by the availability of pensions,

Table 3.2. Changes in the Labor Force Age Composition by Sex, Taiwan 1964-79

	1964-69				1969-74				1974-79			
	ΔL*	rΔP*	PΔr*	ΔrΔP*	ΔL*	rΔP*	PΔr*	ΔrΔP*	ΔL*	rΔP*	PΔr*	ΔrΔP*
Males												
15-19	130	181	−33	−18	18	83	−56	−9	−124	−4	−120	0
20-24	−17	10	−26	−1	165	149	9	7	70	86	−14	−2
25-29	18	16	1	1	23	26	−3	0	309	315	−3	−3
30-34	60	57	3	0	45	44	1	0	11	13	−2	0
35-39	55	50	4	1	70	68	2	0	−11	−13	2	0
40-44	75	73	2	0	81	77	3	1	−41	−39	−2	0
45-49	67	62	4	1	66	63	3	0	45	41	4	0
50-54	7	3	4	1	57	57	0	0	128	121	5	2
55-59	39	36	2	1	31	18	13	1	92	93	1	0
60-64	20	13	5	2	19	20	−1	0	56	30	20	6
Females												
15-19	141	134	5	2	60	53	7	0	−46	44	−82	−8
20-24	25	0	25	2	176	125	32	19	110	107	2	1
25-29	28	3	24	1	29	13	15	1	154	115	23	16
30-49	183	53	113	17	189	85	90	14	22	16	6	0
50-64	20	6	13	1	37	14	19	4	65	32	26	7

*ΔL = change in the labor force of each age group (in thousands) = $r\Delta P + P\Delta_r + \Delta_r\Delta P$, Where P and r refer to the (civilian) population size and the labor force participation rate, respectively. Thus, ΔP and Δ_r refer to changes in the population size and in the labor force participation rate, respectively.

Source: *Quarterly Report on the Labor Force Survey*, various issues.



Source: *Quarterly Report on the Labor Force Survey*, various issues.

Figure 3.2 Male Age-Specific Labor Force Participation Rates in Taiwan, 1964-80

retirement policies of firms and the government, business cycles, and many other socio-economic variables. However, variations in the labor force of males in the 60 and over group have not and will not pose any severe problem for the labor market, because the labor force of Taiwan is still relatively young.

For females 20 years and older, the decision to seek paid jobs depends on family obligations, wages offered, workplace location, etc. Despite a noticeable upward trend, the labor force participation rate for these groups has shown larger fluctuations in the past. Table 3.2 indicates that demographic change seems to be most pronounced after the early 1970s. This is explained in part because of fewer fluctuations in labor force participation for females of age 20 and older after the early 1970s, as compared to before.

What will happen to the labor force age composition for Taiwan in the 1980s and beyond? We find that several demographic and economic factors are very likely to cause a much tighter supply of young workers in the labor market of Taiwan, as compared to the relatively abundant supply of young workers in the 1950s, 1960s and 1970s. By the early 1980s, the large "baby boom" cohorts that provided a dependable supply of relatively cheap and young labor in fueling the rapid expansion of Taiwan's labor-intensive industries in the past will reach middle age – 30 and over.

Meanwhile, the much smaller population cohorts born in the period from the late 1960s to the mid-1970s will begin to reach working age. Moreover, labor force participation for both males and females in the age group of 15-19 may continue to decline, and participation for males in the age group of 20-24 could slightly decline due to the extension of the period of schooling. Thus, in the 1980s young workers (both male and female) will become less abundant, and also become much more expensive if the cohort size effects on wages by age exist in Taiwan.

A population projection by Avery and Freedman (1970) also suggests that the number of young workers relative to the number of older workers may continue to decline in the future. The projection of variations in the population age composition and the population size, based on the assumption that the fertility rate will reach the replacement level (two children per mother) by 1988, is presented in Table 3.3. This fertility assumption seems reasonable because the current total fertility rate of Taiwan is about 2.7 children per mother with a declining trend. These projections

Table 3.3 Projected Age Composition and Total Population for Taiwan on the Assumption that Taiwan's Total Fertility Rate Will Converge to 2 by 1988

Ages \ Year	Percent Age Distribution for 1988	2008	2028	2048 & over
0- 9	20.1	15.1	13.7	13.5
10-19	18.1	15.2	14.1	13.5
20-29	19.7	16.2	13.5	13.5
30-44	21.6	22.1	20.6	20.0
45-64	15.4	23.8	24.8	24.7
65+	5.1	7.6	13.3	14.8
Population Size*	19.6	23.8	26.1	26.4

*In millions.

Source: Avery, R. and Freedman, R. "Implications of Fertility at Replacement Levels for Taiwan," Taiwan Population Studies Working Paper No. 5, University of Michigan, 1970 : 9.

suggest the need for a reevaluation of the strategy of industrialization via the expansion of labor-intensive industries.

In summary, the post-war baby boom has strongly influenced the age composition of the population and the labor force since the early 1960s. The 1980s will see the aging of the "baby boom" cohorts. This factor, plus the relatively small number of population cohorts born during the years 1965-75 and a likely decline in the labor force participation rate for young people will lead to a severe reduction in the number of younger workers relative to the number of older workers in the labor market. This represents quite a change from the situation common in the 1950s, 1960s and 1970s which was characterized by a relatively large number of young workers in the labor force.

B. The Labor Force and The Development Process in Taiwan

The post-war changes in both the population and the labor force have been associated with rapid economic development in Taiwan. Dramatic structural changes in labor force composition reflect the character of Taiwan's economic growth. Since the early 1950s, labor absorption in the industrial sector (including mining, manufacturing, public utilities, transportation, communication, and construction) has continued at a high rate, about 6-7 percent annually, allowing Taiwan, unlike most developing countries, to avoid the build-up of a large urban services sector characterized by low productivity. By 1980, Taiwan had achieved a labor force distribution that, if examined on the basis of its employment status, more closely resembled that of a developed than a developing country.

The sectoral employment series are presented in Table 3.4. In the 1950s, successful land reform programs made large increase in yields per hectare possible without an increase in acreage of arable land. This was accomplished via the greater use of labor, better cultivation practices, increased use of chemical fertilizers, improvement in the irrigation system, increased use of insecticides, and, above all, multi-cropping and inter-cropping. Thus, the agricultural sector not only solved the problem of under-employment but also absorbed roughly one-third of the increase in the total labor force during the 1950s (Ho, 1978). During this period, about 75 percent of male entrants in the labor market were absorbed by the agricultural sector.

In the following decade (1960-70), the increasing productivity of the agricultural

Table 3.4 Time-Series Distribution of Employed Persons by Sector in Taiwan, 1964-80

Unit: %

Year	Agriculture	Industry	Service Sector	Total
1964	48.5	28.2	23.3	100
1965	46.9	28.9	24.2	100
1966	45.6	29.7	24.7	100
1967	42.8	30.0	27.2	100
1968	49.7	30.0	30.3	100
1969	38.9	31.2	29.9	100
1970	36.8	33.7	29.5	100
1971	35.1	35.6	29.3	100
1972	33.0	37.3	29.7	100
1973	30.5	39.5	30.0	100
1974	30.9	39.9	29.2	100
1975	29.9	41.2	28.9	100
1976	29.1	43.3	28.6	100
1977	27.1	44.0	28.9	100
1978	24.9	44.8	30.3	100
1979	22.3	46.4	31.3	100
1980	20.0	47.1	33.1	100

Source: *Statistical Yearbook of the Republic of China,* various issues.

labor force and growing employment opportunities in non-agricultural sectors caused out-migration from farms; only about 38 percent of male labor-market entrants took agricultural jobs to replace the agricultural labor force. With rising per hectare yields for grain crops and low elasticities in the demand for food, fewer and fewer workers have found employment in the agricultural sector since the late 1960s. Consequently, the percentage of agricultural workers in the total labor force dropped rapidly from 50 percent in 1950 to 20 percent in 1980.

Along its course of development, Taiwan's industrial sector has provided abundant employment opportunities without sacrificing economic growth possibilities by adopting a labor-intensive production technology. Much of this has been due to the desire of foreign and local firms to take advantage of the supply of low cost labor in Taiwan, rather than as a result of a planned choice by the government (Kuo, 1975; Galenson, 1976).

During the 1950s, the industrial sector of Taiwan absorbed at least 38 percent of the increase in the labor force, according to an estimate made by Oshima and Lai in 1976. The absorption rate of labor accelerated during the 1960s to 47 percent. In the last decade, almost 80 percent of the labor force increase in Taiwan was employed in the rapidly growing industrial sector. By 1980, this sector had absorbed almost half of Taiwan's total labor force.

The service sector has grown only moderately in Taiwan, partly because in the 1950s much of the service output in both rural and urban areas was family produced and consumed at a near-subsistence income level and partly because industrial employment opportunities have swiftly expanded since 1950 (Ho, 1978; Galenson, 1976; Oshima and Lai, 1976). In the years 1960-80. the service sector grew somewhat faster than before, as rapid growth of per capita income resulted in an increasing demand for services.

This development process suggests that employment distribution by sector for each age group in the labor force would change extensively over time. Table 3.5 presents the cross-sectional distribution of employed persons by sector for each age group in 1980. For older people, we find a higher proportion working in the agricultural sector and a lower proportion working in the industrial sector. The reverse situation is found for young people. Finally, a fairly stable proportion of workers employed in the service sector has been sustained for all age groups except the 15-19

Table 3.5 Cross-Sectional Distribution of Employed Persons by Sector in Taiwan, 1980

Unit: %

Age	Agriculture	Industry	Service Sector	Total
15-19	9.15	70.66	20.19	100
20-24	9.83	58.95	31.22	100
25-29	12.13	51.93	35.94	100
30-34	15.58	47.98	36.44	100
35-39	20.27	44.02	35.71	100
40-44	27.95	38.27	33.78	100
45-49	34.19	33.27	32.54	100
50-54	33.33	31.78	34.88	100
55-59	33.62	30.48	35.90	100
60+	40.45	21.35	38.20	100

Source: *Monthly Bulletin of Labor Force Statistics*, April 1980, p. 18.

group. This cross-sectional pattern is quite consistent with the dynamic development process revealed by Table 3.4. Both numbers in Table 3.4 and Table 3.5 indicate that the age-earnings profile may be affected by the employment distribution by sector for each age group in Taiwan. This is usually the case in developing countries where large wage differentials are normally observed between agricultural and non-agricultural workers. In the next chapter, we will show that ignoring the structural characteristics of a developing economy could lead to an improper analysis of the cohort size effects on the earnings by age.

Another remarkable characteristic of the changing pattern of labor force distribution is the progress of urbanization over a short period of time. Although population of Taiwan has always been concentrated in the coastal plains, by 1960 only 20 percent of the population lived in metropolitan areas (with at least 250,000 residents). During the 1960s, the annual metropolitan population growth rate was high, around 5.6 percent. Since 1970, this rate has remained at about 5 percent. By 1980, the metropolitan population was expected to be much more than the official 38 percent of the total population (based on the household register data), because many young or recent migrants from rural areas failed to register as "mobile residents" in large cities.

Migration studies usually find that young adults of both sexes are much more mobile than people of other ages (Weeks, 1978). More and more young adults would tend to live in urban areas. This tendency could inflate the average wages of young workers relative to those of older workers. Other characteristics of workers held constant, wages would be lower in the rural areas where living costs are much cheaper (Wu, 1976). Again, it is important to take the location variable into account in the determination of age-earnings profiles.

The occupational structure of the labor force has shown a less rapid change in Taiwan. The pattern of change in occupational structure is presented in both time series data and cross-sectional data by Table 3.6 and Table 3.7 respectively. In the past, the proportion of individuals in the category of administrative and managerial personnel has declined, suggesting the existence of substantial economies of scale in the employment of this manpower (Galenson, 1976). Although the reduction in professional and technical personnel for some years was caused by the expansion of the labor-intensive production, there are indications that the growing specialization

Table 3.6 Time-Series Distribution of Employed Persons by Occupation in Non-Agricultural Sectors, Taiwan 1964-80

Unit: %

Year	Professional and Technical	Administrative, Managerial, and Executive	Clerical, Sales, and Service	Craftsman and Laborers in Production and Transportation
1964	8.2	5.2	41.5	45.1
1965	7.5	4.5	41.6	46.4
1966	9.0	6.7	43.2	41.1
1967	8.8	6.9	42.3	42.0
1968	8.3	5.5	42.2	44.0
1969	7.2	5.3	39.9	47.8
1970	6.5	4.9	40.2	48.4
1971	6.3	4.7	39.6	51.6
1972	6.8	2.9	39.6	50.7
1973	6.6	3.4	38.4	51.6
1974	6.3	2.6	38.6	52.5
1975	7.0	2.8	37.9	52.3
1976	7.3	3.3	36.8	52.6
1977	6.7	3.8	37.1	52.4
1978	6.8	1.1	39.6	52.5
1979	6.8	1.1	40.3	51.8
1980	7.6	1.3	41.3	49.8

Source: *Statistical Yearbook of the Republic of China*, various issues.

Table 3.7 Cross-Sectional Distribution of Employed Persons by Occupation in Non-Agricultural Sectors, Taiwan 1980

Unit: %

Age	Professional and Technical	Administrative, Managerial, and Executive	Clerical, Sales, and Service	Craftsman and Laborers in Production and Transportation
15-19	0.74	–	19.38	79.88
20-24	5.79	0.12	38.84	55.25
25-29	10.00	0.61	40.61	48.78
30-34	8.88	1.81	40.08	45.23
35-39	9.79	1.69	43.88	44.44
40-44	8.29	2.53	43.55	45.62
45-49	8.03	2.49	46.53	42.94
50-54	8.93	2.59	53.03	35.73
55-59	8.54	2.56	59.83	28.63
60+	8.49	1.89	67.92	22.64

Source: *Statistical Yearbook of the Republic of China*, various issues.

and complexity of Taiwan's economy would tend to demand an increase in these high levels of labor. The remainder of the labor force in other occupations outside of the agricultural sector shows relatively little fluctuation over time (see Table 3.6).

This change in the occupational structure, however, has had a strong influence on the occupational choice for new labor-market entrants with lower levels of education. For example, the proportion of non-college graduates in the categories of professional and technical workers and administrative and managerial workers declined from 0.49 and 0.74 in 1975 to 0.24 and 0.52 in 1980, respectively. In Table 3.7 we also find that there is a high proportion of young workers in those occupations demanding little specialized knowledge and skills, such as laborers. In work careers an individual's job promotion sometimes leads to changes in "occupations" (defined here); therefore, the average earnings for young workers could be depressed if we do not control for occupations.

The educational attainment of the labor force has been rising quickly during the rapid economic and social development of Taiwan, as shown in Table 3.8. That proportion of the labor force with only a primary school education decreased rapidly from 84 percent in 1964 to 51 percent in 1980. The proportion of workers with a junior high school education rose from 7 percent to 18 percent over the same period.

That part of the labor force with higher education has been expanding the most rapidly; college graduates (from both junior and four-year colleges) increased from 2 percent to 11 percent of the total labor force. Senior high school and senior vocational school graduates also rose from 7 percent to 21 percent in the same 16-year period. These figures also imply that, at any time during the process of industrialization, the educational attainment of young workers has been increasing faster than that of older workers. Therefore, at least for Taiwan, it is also important to control for the education variable in the analysis of the age-earnings profile. (For this reason, we plan to disaggregate the labor force by education level by assuming that each education class of the labor force constitutes a separable production branch in the economy and to examine the cohort size effects on the age-earnings profile for each of these education classes in our study).

In brief, rapid socio-economic development in Taiwan has led to great changes in the distribution of the labor force by industry, locality, occupation and education. It is then important to take structural changes in the economy into account in the

Table 3.8 Time-Series Distribution of Educational Attainment of the Labor Force, Taiwan 1964-80

Unit: %

Year	Primary School	Junior High School	Senior High School*	College and Over	Total
1964**	83.68	7.35	6.92	2.04	100
1966**	73.89	8.66	12.29	5.17	100
1968**	71.12	10.49	13.00	5.40	100
1970**	70.76	11.15	13.20	4.89	100
1972**	57.85	13.88	19.49	8.78	100
1974**	53.58	15.61	21.28	9.53	100
1980***	51.19	18.11	19.74	10.96	100

*Includes Senior Vocational School.

**Source: Chiang, S. H. and Hu, C. T. *Attributes of Gini Coefficients of Wage Rates* (Taipei: Academia Sinica, 1979), pp. 3-8.

***Source: *Monthly Bulletin of Labor Statistics*, April 1980, p. 8.

determination of the effects of demographic changes on the age-earnings profile for Taiwan.

C. Taiwan's Labor Market Institutions

As discussed in the review of literature, some economists argue that large labor cohorts would tend to depress their earnings within a system that generates jobslots or positions that are arranged institutionally by different seniority levels. Taiwan's labor market, however, is not characterized by such a system of seniority in the determination of wages and promotion. Taiwan differs from many developing countries in that there has been little government intervention in the determination of wages, and, additionally, the impact of trade union on wages has been minimal in the labor market.

In general, Taiwan's employers have good information about wages and benefits offered by their competitors and thus a considerable degree of standardization prevails, despite the absence of any significant trade union influence (Galenson, 1976). However, wage administration varies a great deal; some have formal systems, some operate informally. Merit seems to be the primary factor in determining wage increases among employees, even though some firms have begun to pay attention to seniority in order to retain their skilled workers.

Thus, Taiwan does not practice any system comparable to that of the life-employment commitment model in Japan. Even so, the lay-off of employees has been rare if the employees' performance in production is reasonable. This seems to be attributed to the rapid growth of firms in Taiwan, rather than the practice of a permanent employment system.

There are only a few large firms in Taiwan. By 1980, enterprises with less than 100 employees hired 90 percent of the total labor force in the private sector. Furthermore, about 70 percent of the labor force in the private sector was employed by those firms with only 1 to 9 workers. As a result, the demand side of Taiwan's labor market seems to be highly competitive.

On the supply side of the labor market, trade unions are entitled to enter into collective agreement with management covering conditions of work other than wages by law. Strikes have been forbidden by law. However, trade unions are still capable of exerting a substantial influence on the working conditions in industries.

This influence is likely due to the labor shortage since the mid-1970s. The definitive answer to the question of the trade union being dominated or influenced by employers or government under the present law awaits further study.

In general, Taiwan is very much a market economy in terms of the manner in which job placements and wage determinations are made. Thus, institutional factors in Taiwan's labor market seem to be less important in the determination of wages, as compared to Japan's labor market.

CHAPTER IV

THE THEORETICAL FRAMEWORK

In this chapter, we link human capital theory and the conventional production function in an effort to specify the relationship between cohort size and earnings in Taiwan. When the labor force of different age groups is taken as exogenously determined by demographic changes, our model predicts that the greater the substitutability between age groups in production then the smaller the changes in the (relative) age-earnings profile will be. In addition, we include the development characteristics of developing countries in the determination of earnings.

A. The Substitutability Among Labor Force Age Groups and Wage Ratios

The model of career phases by Welch (1979) suggests that in a profession there are a series of more or less distinct worker types in production. Workers progress along their career path from raw recruits or learners up to a position of senior membership in the profession. Different types of workers with varying levels of experience, do different kinds of jobs or tasks and, vis-a-via aggregate product, these jobs or tasks might not be perfect substitutes for one another. Thus, the marginal productivities of each worker type are determined by the number of workers involved in that type of production activity.

Consider an aggregate production function of the form:

$$y = y(L_1, L_2 \ldots L_r, \ldots L_m, Z) \tag{4-1}$$

where L_r refers to the productive effort of the r^{th} activity by workers of a given education level, and Z refers to all other factors that are not included in any L_r of

these workers. Thus, those variables contained in Z include other schooling composites, and Z is also assumed to be strongly separable from any L_r in the production function. By the definition of strong separability, we have

$$\frac{\partial}{\partial z}\left[\frac{\frac{\partial y}{\partial L_r}}{\frac{\partial y}{\partial L_s}}\right] = 0 \quad ; \qquad z \in Z$$

That is, the marginal rate of substitution between any two L_r and L_s (i.e., their wage ratio) is independent on the quantity changes in those variables contained in Z. If this is true, then Z can be omitted in the following discussion.

In the optimal life-cycle configuration suggested by Rosen (1972), a worker solves for an optimal sequence of position progress rates by recognizing that each position level corresponds to learning options that affect performance in sequential position levels. Thus, a worker at any sequential career phase is involved in the process of transition from lower toward senior worker activities. For simplicity, we characterize career phases by experience levels, i.e., the i^{th} career phase is denoted by the i^{th} year of working experience. At the i^{th} career phase, a worker distributes his total working time to the productivities related to his current position. Of the general form, the distribution of workers' time in production is

$$\begin{aligned} x_i &= p_{il}\,x_i + p_{i2}\,x_i + \ldots + p_{im}\,x_i \\ &= \sum_{r=1}^{m} p_{ir}\,x_i \quad \text{with} \quad \sum_{r=1}^{m} p_{ir} = 1 \text{ and } 1 \geqslant p_{ir} \geqslant 0 \end{aligned} \tag{4-2}$$

where x_i denotes the number of workers in their i^{th} career phase or i^{th} year of experience, and p_{ir} denotes the part of their working time spent in activity r of the profession. Although the value of each p_{ir} is related to how an individual transits between worker types, it seems obvious that a more experienced worker is more likely to devote more of his time to senior production activities. To highlight the cohort size effects on earnings, we assume that each p_{ir} is exogenously determined by experience levels.

The productive effort in each activity, L_r, is a function of working time devoted

by related workers at various experience levels. It also can be expressed in a general form,

$$L_r = L_r(p_{1r} x_1 , p_{2r} x_2 , \ldots p_{ir} x_i , \ldots p_{nr} x_n) \tag{4-3}$$

where $1 \geqslant p_{ir} \geqslant 0$ for all i, and n denotes the length of working life.

The marginal product of workers in the i^{th} career phase is the combination of marginal products of all related activities in the profession,

$$\frac{\partial y}{\partial x_i} = \sum_{r=1}^{m} p_{ir} \frac{\partial y}{\partial L_r} \frac{\partial L_r}{\partial x_i} > 0 \tag{4-4}$$

The wage of these workers under competition is W_i ,

$$W_i = \phi \frac{\partial y}{\partial x_i} \tag{4-5}$$

where ϕ denotes the marginal cost or competitive price of output y. Changes in ϕ are neutral across experience groups and ϕ determines levels but not shapes of the (relative) age-earnings profile.

Effects of (own) cohort size on the relative wages are given by

$$\frac{\partial \ln \left[\frac{W_i}{W_j}\right]}{\partial \ln x_i} = \frac{\partial \ln \left[\frac{\partial y}{\partial x_i}\right]}{\partial \ln x_i} - \frac{\partial \ln \left[\frac{\partial y}{\partial x_j}\right]}{\partial \ln x_i}$$

$$= \frac{x_i \frac{\partial y}{\partial x_i} \frac{\partial^2 y}{\partial x_i^2} y}{y \frac{\partial y}{\partial x_i} \frac{\partial y}{\partial x_i}} - \frac{x_i \frac{\partial y}{\partial x_i} \frac{\partial^2 y}{\partial x_i \partial x_j} y}{y \frac{\partial y}{\partial x_i} \frac{\partial y}{\partial x_u}}$$

$$= c_i (s_{ii} - s_{ij}) \tag{4-6}$$

where c_i refers to the share of experience group i in the production cost, and s_{ii} and s_{ij} refer to own and cross partial elasticities of complementarity between experience groups respectively (see p. 18). Here, we have to examine the value of s_{ii} and s_{ii} so

that we can determine the sign of the cohort size effects.
Here we have

$$s_{ii} = \frac{\frac{\partial^2 y}{\partial x_i^2} \cdot y}{(\frac{\partial y}{\partial x_i})^2}$$

$$= \frac{y}{(\frac{\partial y}{\partial x_i})^2} \left\{ \sum_{r=1}^{m} p_{ir}(\frac{\partial y}{\partial L_r})(\frac{\partial^2 L_r}{\partial x_i^2}) + [\, p_{1i}(\frac{\partial L_1}{\partial x_i}), \ldots p_{mi}(\frac{\partial L_m}{\partial x_i})] \right.$$

$$\left. \cdot [\, K_{rs}\,] \cdot [\, p_{1i}(\frac{\partial L_i}{\partial x_i}), \ldots p_{mi}(\frac{\partial L_m}{\partial x_i})\,]' \right\} < 0 \qquad (4\text{-}7)$$

where $\frac{\partial^2 L_r}{\partial x_i^2} < 0$ and

$$K_{rs} = \begin{bmatrix} \frac{\partial^2 y}{\partial L_1 \partial L_1} & \frac{\partial^2 y}{\partial L_1 \partial L_2} & \cdots & \frac{\partial^2 y}{\partial L_1 \partial L_m} \\ \frac{\partial^2 y}{\partial L_2 \partial L_1} & & & \\ \vdots & & & \\ \frac{\partial^2 y}{\partial L_m \partial L_1} & & & \frac{\partial^2 y}{\partial L_m \partial L_m} \end{bmatrix}$$

= Hessian determinant

If output y is a (quasi) concave function of L, the quadratic form of K_{rs} must be negative definitely. Thus, the own partial elasticity of complementarity in the model of career phases must be negative.

The sign of the cross partial elasticity of complementarity, s_{ij}, is determined by the degree of substitutability or complementarity between two factors. By defini-

tion, a positive s_{ij} indicates that workers at experience levels i and j are (quantity) complements, since an increase in the number of one experience group will lead to an increase in the marginal products of the other group. Therefore, the (own) cohort size effects on the relative wages must be negative if experience groups are complements for one another.

At this point, we cannot infer from equation (4-6) that the cohort size effects must be negative if experience groups are (imperfect) substitutes for one another. However, if all experience groups are perfect substitutes for one another, we will have $s_{ii} = s_{ij}$, i.e., zero cohort size effects on the age-earnings profile.

By the definition of perfect substitution between two factors, we have

$$\frac{W_i}{W_j} = \frac{\sum_{r=1}^{m} \frac{\partial y}{\partial L_r} \frac{\partial L_r}{\partial x_i} p_{ir}}{\sum_{r=1}^{m} \frac{\partial y}{\partial L_r} \frac{\partial L_r}{\partial x_j} p_{jr}} = k_{ij} = \text{constant} \qquad (4\text{-}10)$$

Thus, the necessary condition for perfect substitution between experience groups in this human capital model is that

$$\frac{\frac{\partial L_r}{\partial x_i}}{\frac{\partial L_r}{\partial x_j}} = k_{ij} \text{ with } p_{ir} = p_{jr} \quad \text{for all } r \qquad (4\text{-}11)$$

That is, the two experience groups must have a constant marginal rate of substitution in every production activity of the profession (i.e., the homogeneous human capital are embodied in workers of these two groups) as well as the same schedule of working time distributed to the same types of work. Even though two workers have the "units" of human capital embodied in them with the same efficiency, they are still not perfectly substitutable for each other if they cannot be engaged in the same production activities with the same working schedule because of market barriers.

In the case of imperfect substitutability between experience groups, an assumption of homotheticity in production function is needed here to ensure negative cohort size effects. The only mathematical property of a homothetic production function

is that the ratios of factor prices depend only on the ratios of factor quantities, i.e.,

$$\frac{W_i}{W_j} \quad \frac{\frac{\partial y}{\partial x_i}}{\frac{\partial y}{\partial x_j}} = g^{ij}\left(\frac{x_1}{x_i}, \frac{x_2}{x_i}, \ldots, \frac{x_n}{x_i}\right) \tag{4-11}$$

where

$$\frac{\partial g^{ij}}{\partial x_i} < 0 \tag{4-12}$$

if the isoquants between experience groups are convex. Equation (4-12) can be rewritten in terms of elasticity and related to equation (4-6),

$$\frac{\partial \ln\left[\frac{W_i}{W_j}\right]}{\partial \ln x_i} = \frac{x_i}{\left[\frac{W_i}{W_j}\right]} \frac{\partial g^{ij}}{\partial x_i} = c_i(s_{ii} - s_{ij}) < 0$$

$$\text{complements if } s_{ii} > 0$$

$$\text{substitutes if } s_{ij} < 0 \tag{4-13}$$

i.e., $|s_{ii}| > |s_{ij}|$ in the case of imperfect substitutability between experience groups in production.

The above discussion implies that negative cohort size effects on relative wages approach to 0 as the degree of substitutability between experience groups mounts and become more negative as the degree of complementarity ascends. If positive cohort size effects on relative wages are obtained, then the concavity of production function no longer holds. This suggests the existence of either non-decreasing returns to the labor inputs of experience groups with imperfect substitutability between them (i.e., $s_{ii} > 0$ and $s_{ij} < 0$) or increasing returns with complementarity between them while $s_{ii} > s_{ij} > 0$ in production.

B. The Effects of Development on Wage Ratios

Aggregate production functions such as equation (4-1) usually neglect sharp differences in the structure of a developing country by sector, industry, level of urbani-

zation, and occupation. In the course of industrialization, a developing country may adapt various production processes, less advanced or advanced, while operating side by side with traditional production processes.

Using a simple Edgeworth box diagram, we will show that changes in the structure of an economy lead to changes in the labor force structure in the economy and consequently changes in the age-earnings profile.

Suppose there are two sectors in the economy, A and B, and two types of workers, i and j. A and B refer to traditional sector and modern sector, respectively. The agriculture and service industries usually are included in the traditional sector, and the major industry in the modern sector is manufacturing. Therefore, A represents traditional (manual) production technology, and B represents modern (skill-intensive) production technology. Labor factors i and j denote unskilled (young) and skilled (older) workers, respectively. In Figure 4.1, the number of workers of type j is measured on the vertical axis, and the number of workers of type i is measured on the horizontal axis. The homogeneous production functions of sectors A and B are illustrated by two sets of isoquants. An isoquant is the locus of the combination of worker types i and j that produce a given level of output. We measure A's output from the lower left-hand corner and B's output from the upper right-hand corner. Combining all points in the box where A's isoquants and B's isoquants are tangent to each other, we obtain the contract curve (curve AB in Figure 4.1), which indicates not only the efficient market structure between A and B (the degree of industrialization), but also the efficient distribution of labor factors i and j between sectors A and B.

Suppose the initial equilibrium point is E on the contract curve. The corresponding marginal rate of substitution (MRS) or the wage ratio between workers is presented by the MRS_E between factors i and j in Figure 4.1. An attempt to increase the share of traditional sector A to new production point S would create excess demand for young workers at the initial wage ratio. Therefore, to maintain the output level of traditional sector A at point S, the wage ratio must rise to absorb young workers working in sector B. Meanwhile, wages for older workers become relatively cheaper; modern sector B then will employ some more older workers and release some young workers from its production. This adjustment process ensures a new market equilibrium, say point E', where $MRS_{E'}$ must be greater than the initial MRS_E

as traditional sector A expands its output. An analogous process also tells us that the expansion of the modern sector would raise the wages of older workers relative to those of young workers.

Next, we will use the same Edgeworth box diagram to show that the age-earnings profiles may not necessarily change as the labor force age composition varies, if the structure of the economy is also changing at the same time. In Figure 4.2, the number of young workers increases as a result of some demographic change, and the number of older workers is unchanged. Corresponding to this demographic change, the contract curve moves to AB'. Obviously, the wage ratio of young workers versus older workers does not have to change as long as traditional sector A simultaneously expands its new output level to point N. Moreover, any equilibrium point beyond point N on the new contract curve would lead to an improvement in the earnings of young workers, even though the relative number of young workers has increased.

This analysis thus implies that growth of the labor-intensive sector in a developing country would tend to offset the effects of large cohort size of young workers on their earnings relative to the earnings of older workers. Conversely, the rapid expansion of the skill-intensive sector would tend to reinforce the negative cohort size effects on the relative earnings of young workers. That is, there could be a specification error due to omitting the structural variables in the economy from the regression analysis.

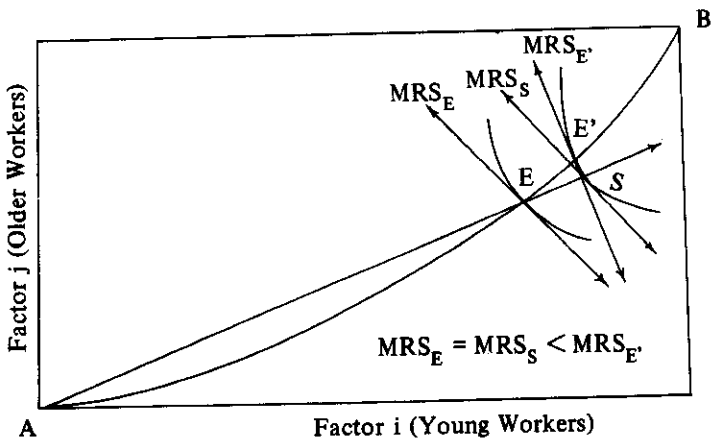


Figure 4.1 Economic Structures and Wages

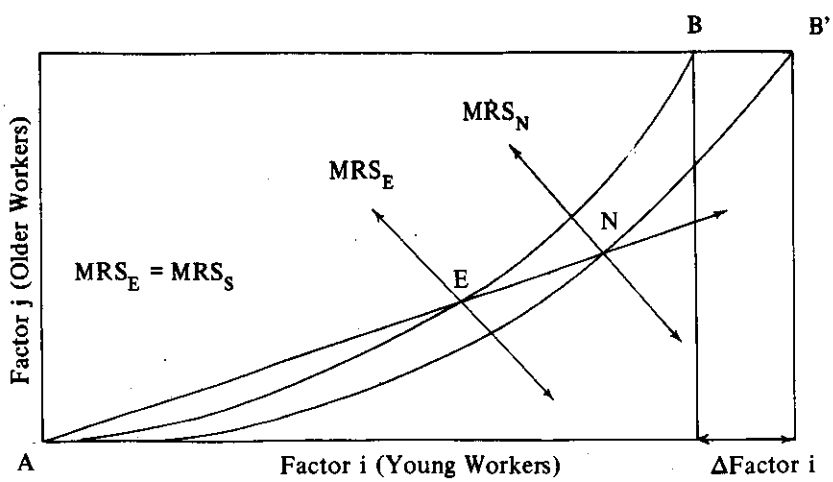


Figure 4.2 Labor Force Growth, Economic Structures, and Wages

CHAPTER V

THE EMPIRICAL RESULTS

A. The Data

To test the hypothesis of cohort size effects on age-earnings profiles in Taiwan, we use both cross-sectional individual worker data and time-series data on groups of individuals. Since cross-section data alone might be questioned with respect to the adequacy of the information on structural changes in an economy, they are supplemented by time-series analysis.

Data on 8,397 male full-time workers 15 to 65 are analyzed here. They are extracted from the 1976 Survey of Family Income and Expenditure conducted by the Department of Budget, Accounting and Statistics of the Taiwan Provincial Government and the Department of Budget, Accounting and Statistics of the Taipei City Government. Also used are group data, including both sexes, for 1964, 1966, 1968, 1970, 1972, 1974, and 1976. These group data are based on the same survey as the individual data. The 1976 group data are derived from the official publication, *Report on the Survey of Personal Income Distribution in Taiwan District,* 1976. Data for the other years are from Chiang and Hu, *Attributes of Gini Coefficients of the Wage Rates,* 1979.

The Survey of Family Income and Expenditure is a systematic, stratified, radom sample of all households in Taiwan. For 1976 the sampling ratio was 3/1,000 and for earlier years was 1/1,000 with a sample error of less than 5 percent.

The individual data include the six most important labor characteristics – sex, age, education, occupation, industry, and job location – as well as individual earnings

from the labor market. Education is classified into 5 groups: primary school (0-6 schooling years); junior high school (7-9 schooling years); senior high school (10-12 schooling years); senior vocational school (10-12 schooling years but in a vocational training program); and college (13 schooling years and over). The occupation variable in the non-agricultural sector is divided into 3 categories: (1) managers, administrators, and professionals; (2) laborers; and (3) clerks, salesmen, service workers, and members of the armed services.

Job location is classified in three categories: cities, towns, and rural villages. The classification is according to the following criteria: (1) for a city or a town the percentage of population employed in non-agricultural activities is 50 percent or more; (2) population density is 1554-5180 per square mile for a town and 5180 or more for a city; and (3) for a town the minimum population size is 20,000 and for a city it is 30,000. A locality that cannot meet all of these criteria is classified as a rural village by the survey. The variable of job location thus serves as a measure of the degree of urbanization of a locality.

The categories of industry are as follows: (1) agriculture, including farming, forestry, fishing, and hunting; (2) services, including wholesale trade, retail trade, import and export agencies, and restaurants and hotels; and (3) manufacturing, including mining and quarrying, manufacturing, electricity and gas, water, construction, and transport and communication.

The recorded annual earnings of individual workers from the labor market include gross cash receipts (salaries, professional subsidies, working subsidies, and wages), wages and salaries in kind (the conversion values of food, housing, water, electricity, uniform and other aids subsidized by employers), overtime payments, transportation allowances, various bonuses, education allowances, marriage and family allowances, etc.

In the time-series group data, there are 4 age groups: 15-24, 25-44, 45-59, and 60 and over. For each group which includes both sexes, there is information of annual earnings from the labor market (defined as above) and the number of workers in the group. Unfortunately, data on years of schooling and other variables are not available.

B. The Cross-Sectional Specification

To examine the relation between the age-earnings profile and the labor force age composition across education groups in Taiwan, we estimate, using the following equation, relative earnings for each of the education groups of male workers:

$$\ln \frac{W_x}{W_d} = a_0 + a_1 \ln L(x) + a_2 S \ln L(x) + a_3 x + a_4 x^2 + a_5 DA_1 + a_6 DA_2 + a_7 DU_1 + a_8 DU_1 + a_9 DO_1 + a_{10} DO_2 + a_{11}(DA_1)x + a_{12}(DA_2)x + a_{13}(DU_1)x + a_{14}(DU_2)x + a_{15}(DO_1)x + a_{16}(DO_2)x + \text{error} \qquad (5\text{-}1)$$

where

W_x = annual labor earnings in New Taiwan Dollars for those who have x years of potential labor market experience

W_d = annual earnings of a particular experience group which serve as the numeraire for all wage levels (which can be omitted here)

x = years of potential labor market experience

$L(x)$ = weighted cohort size of workers having x years of potential labor market experience

S = 0 if $x < \alpha$
$(1 - {}^{x}/_{\alpha})$ if $x < \alpha$

DA_1 = 1 if a worker is employed in agriculture
= 0 otherwise

DA_2 = 1 if a worker is employed in manufacturing industries
= 0 otherwise (The reference group refers to those who are employed in services industries, as $DA_1 = DA_2 = 0$)

DU_1 = 1 if a worker's job location is a town
= 0 otherwise

DU_2 = 1 if a worker's job location is a rural village
= 0 otherwise (Workers who are employed in cities are the reference group as $DU_1 = DU_2 = 0$)

DO_1 = 1 if a worker's occupation is a manager, administrator, or professional

= 0 otherwise

DO_2 = 1 if a worker's occupation is a laborer

0 otherwise (The reference occupations are clerks, salesmen, service workers, and members of the armed forces as $DO_1 = DO_2 = 0$)

An additional dummy variable D_c that equals 1 if a worker only received junior college education and 0 if a worker received 4-year college education, and its interaction with experience, $D_c x$, are also introduced in the equation for the college educated to control potential differences in the two different types of workers in the college group. The reference group within each education group are those for whom $DA_1 = DA_2 = DU_1 = DU_2 = DO_1 = DO_2 = 0$. By "those" we are referring to clerks, salesmen, service workers, and members of the armed services who are employed by the services industry in cities.

Cohort size refers to the number of workers entering the labor market in the same calendar year. It is necessary for an inter-group comparison to normalize absolute cohort sizes by the total number of workers in an education group. Furthermore, Welch (1979) points out that wages of a particular cohort may be affected not only by its own size but also by surrounding cohorts, since they might be highly substitutable for each other in production. There is also the possibility of sampling errors resulting from the calcultation of proportions of cohorts within each education group, because the age was not a continuous variable included in the sample design.

Hence, the proportion of group members at each experience level is smoothed by computing a moving average with inverted V weights. That is,

$$L(x) = \sum_{i=-2}^{2} (w_i \; n_{x+i}) \qquad (5\text{-}2)$$

where n_x is the fraction of those in the group who are in their x-the year of potential labor market experience. Following Welch's work, the w weights are: w = (1/9, 2/9, 3/9, 2/9, 1/9), except for recent entrants where succeeding cohort fractions are not defined. In this case, the w distribution is truncated and remaining weights are scaled accordingly so as to sum to 1.

In order to allow the wage elasticities with respect to cohort size to vary over experience levels, the interaction term between S, the early career spline function, and (ln L(x)) is included in equations, since effect of cohort size of very young workers in their early careers could be greater. That is, their substitutability for older workers to production might increase as their experience grows. The wage elasticities hence are formulated as follows:

$$\frac{\partial \ln \left(\frac{W_x}{W_d}\right)}{\partial \ln L(x)} = \begin{cases} a_1 + a_2 S & \text{if } x \leqslant \alpha \\ a_1 & \text{if } x > \alpha \end{cases} \qquad (5\text{-}3)$$

where S is the early-career spline function and is equal to max (0, 1 − x/α). The elasticity begins with a value of $(a_1 + a_2)$ at the entry level (x = 0) and then declines linearly at a rate of $(-a_2/\alpha)$ to the permanent level of a_1 in the x-the year of experience. The spline function captures the differences in the wage elasticities for different career stages, which otherwise would have to be represented by many dummy variables. After trying alternative values of α (the duration of the initial effects of cohort size) for the five education groups of Taiwan's male labor force, we find that the best estimates of α, according to the t-value of estimated of a_2, are 4, 6, 8, 9, and 11 for the primary school, junior high school, senior high school, senior vocational school, and college groups respectively.

The (relative) age-earnings profiles are captured by x and x^2. The variable x is estimated as age minus years of schooling minus 6. It is common to assume that labor market experience is continuous after the completion of schooling for males age 15 and over, because the highly competitive and restricted entrance examinations beyond junior high schools make difficult to return to school after having once left.

In conventional human capital semi-logarithmic wage equations, x and x^2 are both used to approximate the concavity of the age-earnings profiles. Because the optimal pattern of human capital investments for individuals suggests that later investments are less profitable than earlier ones, intensive human capital investments would be expected at the early stage of life. The investments would then decline after this stage. Corresponding to changes in the human capital investments over the life cycle, the observed earnings of the individual workers rise initially with experience, peak,

and fall thereafter. Thus, the coefficient a_3 is expected in theory to be positive and the coefficient a_4 negative.

Dummy variables for industry, job location and occupation and their interaction with experience are introduced to control for structural changes in the economy. The characteristics of jobs in different markets (characterized by industry, location, and occupation) may lead to different patterns of demand for human capital investments and thus of age-earnings profiles. Wages for those workers who are employed in non-agricultural, urban areas, and in some occupations, e.g., managerial and professional workers, are indeed much higher than the wages for others in Taiwan, given the same level of experience and education. Thus, these dummy variables are used to control for differences in the values of the intercept of age-earnings profiles, and their interactions with experience years are used to control for the shape of age-earnings profiles for workers in the different labor markets. Specification error due to the omission of relevant explanatory variables, such as structural variables of a rapidly growing economy like Taiwan, from the regression equation could lead to biased estimates of the cohort size effects on the (relative) age-earnings profile. Given that true coefficients of structural variables in an economy are not all different from zero, omitting these variables would make the least squares estimator of a_1, i.e., the estimated impact of cohort size on the (relative) age-earnings profiles, biased and inconsistent unless the correlations between each of the omitted structural variables and cohort sizes are all equal to zero. Moreover, the estimated variance of a_1 would also contain an upward bias, so that the usual tests of significance and confidence intervals for a_1 would tend to reject the null hypothesis of cohort size effects more frequently than is justified by the given level of significance.

In order to capture the importance of structural variables in the determination of the age-earnings profiles, two types of regression equations are used for comparison. The first one does not include structural variables, and the second one includes all related structural variables in the economy. The regression results are displayed in Table 5.1. All equations are estimated using the ordinary least squares method and pass the F-test at the 5 percent level. Significant coefficients are indicated with an asterisk. A two-tailed test at the 5 percent level is employed. The relative (i.e., the "percentage") effect of dichotomous variables on earnings is expressed in square

Table 5.1 Cross-Sectional Regression Results

PRIMARY SCHOOL

Explanatory Variable	Coefficient	Standard Error	Percentage Effect
ln L(x)	−0.11436	0.08986	−
S · ln L(x)	−0.12201*	0.03454	−
x	0.05278*	0.01257	−
x^2	−0.00110*	0.00027	−
Constant	10.73306		
R^2 = 0.04176			
F = 43.04398			
n = 3956			
ln L(x)	−0.11397	0.06782	−
S · ln L(x)	−0.12030*	0.02601	−
x	0.05561*	0.01000	−
x^2	−0.00115*	0.00021	−
DA_1	−0.57695*	0.07757	[−0.44008]
DA_2	−0.15994*	0.05956	[−0.14932]
DU_1	−0.14293*	0.05532	[−0.13451]
DU_2	−0.32053*	0.04897	[−0.27511]
DO_1	0.40142*	0.20029	[0.46428]
DO_2	0.00085	0.07924	[0.00229]
$DA_1 x$	−0.00611*	0.00265	[−0.00609]
$DA_2 x$	0.00517*	0.00222	[0.00518]
$DU_1 x$	−0.00144	0.00190	[−0.00144]
$DU_2 x$	−0.00161	0.06782	[−0.00390]
$DO_1 x$	0.00170	0.00638	[0.00168]
$DO_2 x$	0.00229	0.00273	[0.00229]
Constant	11.12263		
R^2 = 0.46269			
F = 211.99906			
n = 3956			

Table 5.1 (continued)

JUNIOR HIGH SCHOOL			
Explanatory Variable	Coefficient	Standard Error	Percentage Effect
ln L(x)	−0.00816	0.04652	−
S · ln L(x)	−0.05639*	0.02863	−
x	0.06226*	0.00750	−
x^2	−0.00099*	0.00016	−
Constant	10.22963		
R^2 = 0.31636			
F = 159.88124			
n = 1387			
ln L(x)	−0.02911	0.04182	−
S · ln L(x)	−0.07153*	0.02568	−
x	0.05993*	0.00801	−
x^2	−0.00101*	0.00015	−
DA_1	−0.43569*	0.10472	[−0.35672]
DA_2	−0.02742	0.07184	[−0.02956]
DU_1	−0.08809	0.06613	[−0.08632]
DU_2	−0.17544*	0.05610	[−0.16223]
DO_1	0.27621	0.18303	[0.29623]
DO_2	0.02608	0.09193	[0.02210]
$DA_1 x$	−0.01473*	0.00467	[−0.01463]
$DA_2 x$	−0.00172*	0.00308	[−0.00172]
$DU_1 x$	−0.00136	0.00301	[−0.00136]
$DU_2 x$	−0.00154	0.00250	[−0.00154]
$DO_1 x$	0.00319	0.00629	[0.00318]
$DO_2 x$	−0.00050	0.00358	[0.00051]
Constant	10.51915		
R^2 = 0.46229			
F = 73.61560			
n = 1387			

Table 5.1 (continued)

SENIOR HIGH SCHOOL			
Explanatory Variable	Coefficient	Standard Error	Percentage Effect
ln L(x)	−0.03082	0.04370	−
S · ln L(x)	−0.25534*	0.04764	−
x	0.04326*	0.00992	−
x^2	0.00079*	0.00021	−
Constant			
R^2 = 0.34167			
F = 108.98915			
n = 845			
ln L(x)	−0.01838	0.03885	−
S · ln L(x)	−0.25083*	0.04303	−
x	0.03963*	0.00903	−
x^2	−0.00078*	0.00019	−
DA_1	−0.37326*	0.16157	[−0.32044]
DA_2	0.00797	0.06402	[0.00777]
DU_1	−0.26648*	0.07604	[−0.23614]
DU_2	−0.22049*	0.06510	[−0.19957]
DO_1	0.19182	0.07012	[0.20848]
DO_2	0.08793	0.07604	[0.08876]
$DA_1 x$	−0.03325*	0.01173	[−0.03277]
$DA_2 x$	−0.00042	0.00284	[−0.00042]
$DU_1 x$	0.00348	0.00334	[0.00348]
$DU_2 x$	0.00031	0.00309	[0.00031]
$DO_1 x$	−0.00410	0.00389	[−0.00410]
$DO_2 x$	−0.00929*	0.00356	[−0.00925]
Constant	11.02471		
R^2 = 0.49186			
F = 50.09237			
n = 845			

Table 5.1 (continued)

SENIOR VOCATIONAL SCHOOL			
Explanatory Variable	Coefficient	Standard Error	Percentage Effect
ln L(x)	0.03469	0.09837	–
S · ln L(x)	−0.11967*	0.03660	–
x	0.05570*	0.01146	–
x^2	−0.00100*	0.00033	–
Constant			
R^2 = 0.33757			
F = 104.97447			
n = 829			
ln L(x)	0.04544	0.09086	–
S · ln L(x)	−0.13046*	0.03511	–
x	0.05666*	0.01097	–
x^2	−0.00096*	0.00031	–
DA_1	−0.27741	0.14632	[−0.25032]
DA_2	−0.01711	0.06564	[−0.01908]
DU_1	−0.06857	0.06854	[−0.06846]
DU_2	−0.13732*	0.06379	[−0.13008]
DO_1	0.21277*	0.09765	[0.23122]
DO_2	0.07830	0.07284	[0.07858]
DA_1 x	−0.01443	0.00923	[−0.01436]
DA_2 x	0.00356	0.00374	[0.00356]
DU_1 x	−0.00223	0.00383	[−0.00223]
DU_2 x	−0.00987*	0.00367	[−0.00983]
DO_1 x	−0.00082	0.00463	[−0.00083]
DO_2 x	−0.01342*	0.00459	[−0.01334]
Constant	10.64018		
R^2 = 0.45120			
F = 41.72486			
n = 829			

Table 5.1 (continued)

COLLEGE			
Explanatory Variable	Coefficient	Standard Error	Percentage Effect
ln L(x)	0.10414	0.05405	–
S · ln L(x)	–0.06475	0.04456	–
x	0.04814*	0.01277	–
x^2	–0.00097*	0.00029	–
Constant			
R^2 = 0.11611			
F = 39.70546			
n = 1214			
ln L(x)	0.13199*	0.05218	–
S · ln L(x)	–0.04243	0.04317	–
x	0.04853*	0.01251	–
x^2	–0.00097*	0.00028	–
D_c	–0.18609*	0.06086	[–0.17134]
$D_c x$	0.00156	0.00303	[–0.00156]
DA_1	1.44438	0.09502	[1.81468]
DA_2	0.15213*	0.06571	[0.16180]
DU_1	–0.01768	0.08015	[–0.02068]
DU_2	–0.38460	0.08495	[–0.32295]
DO_1	0.08464	0.06070	[0.08632]
DO_2	0.02097	0.11107	[0.01491]
$DA_1 x$	–0.34157*	0.15705	[–0.29806]
$DA_2 x$	–0.00022	0.00372	[–0.00023]
$DU_1 x$	–0.00573	0.00394	[–0.00572]
$DU_2 x$	0.00808	0.00447	[0.00810]
$DO_1 x$	0.00535	0.00295	[0.00536]
$DO_2 x$	–0.02348*	0.00728	[–0.02323]
Constant	10.52290		
R^2 = 0.22619			
F = 19.30477			
n = 1214			

brackets in the final column.[1]

In the following discussion, we will first start from the results of the estimation of wages using only cohort size and experience as explanatory variables. Unlike other studies of the cohort size effects, the empirical results here show that the impact of cohort size on earnings is not negative and significant at all levels of experience for all of the male groups. The coefficient on the term of (ln L(x)) is not significantly different from zero for any of the male education groups, but for the college group of male workers the coefficient is positive and close to the significant level. On the other hand, the estimates of a_2, the coefficient of (S ln L(x)), are all negative, and significantly different from zero for those male groups without college education. After including the structural variables in regression equations, we find that the coefficient of the (ln L(x)) terms is still positive but becomes significantly different from zero for the male college group. For those male groups without a college ecudation, this inclusion of structural variables leads to no changes in the signs of coefficients on the terms of (ln L(x)) and (S ln (x)) but the elevation of t-values.

Thus, from the regression results we find that for the male college group, there are significant but positive cohort size effects on the (relative) earnings of those who have already passed the early stage of their careers. For those male groups without a college education, we find that the cohort size does negatively affect workers who are in the early stage of their careers.

Variations in wage elasticities with respect to cohort size at different experience levels are presented in Table 5.2 for each male education group. In the table, estimated standard errors and t statistics (absolute) are enclosed in parentheses and square brackets, respectively. For males without college education, wage elasticities decline linearly during the early career stage toward a persistent level that is not significantly different from zero. For the male college group, wage elasticities are not significantly different from zero during the early career stage. Conversely, the persistent wage elasticities for the male group are positive and significantly different from zero.

The significant test at the 5 percent level also shows that the negative cohort size effects on the (relative) age-earnings profiles, indicated by the wage elasticity with respect to cohort size, are significantly different from zero for those workers who only have less than 5, 3, 7, and 1 years of experience in primary school, junior high school, senior high school, and senior vocational school groups, respectively.

Table 5.2 Wage Elasticities with Respect to Cohort Size[a]

x[b]	Primary School	Junior High School	Senior High School	Senior Vocational School	College
0	−0.23427* (0.07259) [3.2275]	−0.10064* (0.04896) [2.0555]	−0.26921* (0.05790) [4.6497]	−0.08502* (0.03185) [2.6692]	0.08956 (0.06695) [1.3378]
1	−0.21021* (0.07090) [2.9650]	−0.09042* (0.04129) [2.1898]	−0.24134* (0.05448) [4.4325]	−0.07052 (0.04120) [1.7117]	0.09342 (0.06456) [1.4470]
2	−0.18615* (0.06956) [2.6761]	−0.08020* (0.04055) [1.9776]	−0.21347* (0.05121) [4.1684]	−0.05603 (0.04910) [1.1412]	0.09727 (0.06233) [1.5607]
3	−0.16209* (0.06859) [2.3631]	−0.06998 (0.04014) [1.4916]	−0.18560* (0.05166) [3.5628]	−0.04156 (0.05616) [0.7400]	0.10113 (0.06027) [1.6780]
4	−0.13803* (0.06801) [2.0296]	−0.05977 (0.04070) [1.4916]	−0.15773* (0.04556) [3.4619]	−0.02704 (0.06268) [0.4314]	0.10499 (0.05840) [1.7977]
5	−0.11397 (0.06782) [1.6805]	−0.04955 (0.04033) [1.2287]	−0.12986* (0.04326) [3.0020]	−0.01254 (0.06880) [0.1823]	0.10885 (0.05675) [1.9181]
6		−0.03933 (0.04092) [0.9612]	−0.10199* (0.04137) [2.4649]	0.00196 (0.07462) [0.0263]	0.11270* (0.05532) [2.0373]
7		−0.02911 (0.04182) [0.6963]	−0.07412 (0.03998) [1.8537]	0.03094 (0.08021) [0.2051]	0.11656* (0.05414) [2.1530]
8			−0.04566 (0.03913) [1.1669]	0.03094 (0.08561) [0.3614]	0.12042* (0.05322) [2.2625]
9			−0.01838 (0.03885) [0.4731]	0.04544 (0.09086) [0.5001]	0.12488* (0.05259) [2.3633]
10					0.12813* (0.05224) [2.4530]
11+					0.13199* (0.05218) [2.5295]

[a]The calculation of the wage elasticities for each experience level is according to the formula: Var (Y + cZ) = Var (Y) + c^2 Var (Z) + 2cCov (Y , Z) where c is constant.

[b]x denotes the experience year.

For each of the four groups, these results imply that: the substitutability of new recruits for older workers increases when experience exceeds that accumulated during the early career stage, with the result that workers who have passed their early careers tend to be excellent substitutes for each other in production.[2] Consequently, an increase in the number of those workers who still remain in their early career would lead to a decrease in their earnings relative to the earnings of older workers. Also, a change in the number of any age group of experienced workers will not lead to any change in the wage ratio of that group versus another age group of experienced workers even at different experience levels. (Two factors are perfect substitutes for each other if and only if they have a constant factor price ratio everywhere.)

This phenomenon is also consistent with human capital theory when applied to a developing country. Since jobs for those with lower education in the labor market of a developing country usually do not call for much proficiency in decision-making and problem-solving areas, the scope for "on-the-job" learning after the initial period of training consequently does not extend very far. Dhesi (1979) points out that the process of development usually is accompanied by increases in the number of sophisticated machines in the economy implying an upward shift in the hierarchical structure of machines; a corresponding quantitative and qualitative upward shift in the skill profile of the labor force can be expected.

However, the development policy for expansion of the labor-intensive sector in Taiwan has led to a slow transition from professions with low skills to professions with high skills in the past. We can thus expect that professions for those workers without a college education in Taiwan will generally not require high skills or a long period of "on-the-job" learning. This is not to suggest that an individual's further experience does not benefit his productivity, but it does indicate that there may be only a few different production activities for these workers to learn in Taiwan. For many manual jobs in Taiwan, workers may do the same tasks everyday since they have learned the work routine. In this case, workers would tend to be perfect substitutes for one another in spite of thieir differences in experience levels. Unfortunately, this situation is popular for those workers without a college education in their professions in Taiwan.

This situation can be explained by labor-intensive production processes that tend to avoid the use of sophisticated machines and skills in production in such a

way that the substitutability of new recruits for older workers can be quickly raised by a short period of "on-the-job" learning. Obviously, this is the reason why workers in each of the male groups except the college group tend to be perfect substitutes for each other after the initial period of learning.

Among these four groups, we also find that the duration of the cohort size effects for the senior vocational school group is the shortest one. This is not surprising, because the education offered by senior vocational schools focuses on the knowledge and skills required by the various jobs in Taiwan. This school training is usually accompanied by practical working experience for students in firms during the schooling period. As a result, these graduates can become fully skilled workers in their professions (that are also usually characterized by a low skill profile) within a very short time. On the other hand, new graduates from senior high schools are subject to military service after a short time of working and employers may be less willing to train these graduates for jobs before they leave for military service.[3] This leads to new graduates from senior high schools having a lesser number of opportunities to become fully skilled workers in a short time. Consequently, the duration of the cohort size effect on the senior high school group would tend to be longer.

Although further data are needed to confirm our estimates of cohort size effects for the male college group, we will try here to explain the results based on the information we have. The significance test on wage elasticities with respect to cohort size for the male college group suggests that: (1) there are no significant cohort size effects on the earnings of those who have less than six years of experience, i.e., these workers tend to be perfectly substitutable for each other; and (2) there are significant and positive cohort size effects on the earnings of those who have passed the early stage of their careers, i.e., the substitutability between these experience groups tend to be imperfect in production. For experienced workers in this group, we are able to say that they are not perfect substitutes for each other, but we are not able to determine whether they are (imperfect) substitutes or complements for each other (see equation (4-6)).

It seems quite reasonable to say that the entrants with a college education are more capable and flexible in learning the various beginning jobs in their professions. Thus, these young workers would tend to be easily substituted for each other in the job market. This seems the reason why the cohort size effects are not significantly

different from zero for them.

However, jobs for this high-level manpower of college graduates usually require workers to accumulate knowledge and skills throughout their entire careers for decision-making and problem solving during which time experience gradually builds up their individual proficiency. It is common to observe that different levels of decision-making and problem-solving in professions demanding high-skills profiles are usually specialized and are performed by appropriate workers with compatible proficiency. Consequently, a worker of this group would devote more of his time to the higher level of decision-making and problem-solving as his experience increases, i.e., a worker in the male college group tends to do different kinds of jobs or tasks during different stages of his career.

If this case is true, it suggests that cohort size effects on the relative earnings, using the earnings of workers around the entry level as a base, would exist for those workers who have passed the entry level of their careers in the male college group. The negative cohort size effects are based on the assumption of a concave production function with the convex isoquants (see equation (4-13)). However, the positive persistent wage elasticity for the male college group may not be necessary to indicate that increasing returns exist in this group.

There are several other possible reasons that could result in an over estimation of the coefficient of the cohort size term, (ln L(x)), in the regression analysis. The first possible reason is that we cannot control for qualitative changes in the college education of younger workers. Since cohort sizes of younger workers in the college group have been increasing over time, there could be a highly positive correlation between the cohort size and continuing improvement in the college education. This positive correlation might cause an over-estimated coefficient on the cohort size term.

The second possible explanation is that there might be continuing improvement in post-college on-the-job training. Analogously, this positive correlation would also lead to the over-estimated cohort size effects.

We do recognize that we cannot exclude the possibility of increasing returns in the male college group. This conclusion would be correct if our regression specification is correct. In a rapidly growing economy such as Taiwan there could be increasing returns to high-level production activities, since labor inputs of the college

educated workers in production could lead to modern entrepreneurship which promotes better planning, organization, staffing, leadership and control of the various resources comprising the production process. Most of the enterprises in Taiwan are fairly young and have experienced rapid growth. Increases in the number of workers in the category of highly skilled manpower, such as managerial and professional workers, might effectively raise the efficiency of production at the current stage of Taiwan's development. This point seems particularly important when we consider that almost half of the college graduates are engaged in such managerial and professional jobs. Increasing returns to the labor inputs of college graduates in production, therefore, is likely. Of course, to understand what factors are actually responsible for the positive cohort size effects on the earnings of those experienced workers with a college education, further data and study are indeed necessary.

The estimates of coefficients on variables concerning labor market experience, i.e., x and x^2, have the expected sign and are significantly different from zero. This suggests that the age-earnings profiles for Taiwan are quite similar to those for developed countries in terms of the curvature. As elsewhere, the peak age for earnings from labor market activities is around 45 to 50.

Let us now turn to the structural variables in the determination of age-earnings profiles for Taiwan. Not all of the coefficients on the structural variables are significantly different from zero, but we find that the introduction of structural variables contributes to the power of explanation by an F test.[4]

In general, the variables of industrial structure, DA_1, and DA_2, and their interaction with experience have especially significant effects on the wages of groups with lower educational attainment. The dummy variable of agricultural employment, DA_1, and its interaction with experience have significant, negative, and large effects on the earnings for those individuals in the primary school, junior high school, and senior high school groups. In other words, the more agricultural workers there are, the lower and flatter will be the age-earnings profiles for these three male groups. For the senior vocational school group, wages appear to be independent of changes in DA_1 and its interaction with experience. For the college group, changes in DA_1 do not influence the level of the age-earnings profile, but do affect its curvature ($DA_1 \cdot x$ is negative and significantly different from zero for this group).

The coefficients of manufacturing variable, DA_2, and its interaction with experi-

ence, $DA_2 \cdot x$, indicate that, as opposed to the service sector, having a job in the manufacturing sector has less effect than having a job in the agricultural sector. For the primary school group, workers in the manufacturing sector have a lower but steeper age-earnings profile, as compared to workers in the service sector; however, they have a much higher and steeper age-earnings profile, as compared to workers in the agricultural sector. For the junior high schoor group, workers in the manufacturing sector have a less steep age-earnings profile than workers in the service sector, but workers in these two sectors all have a higher and steeper age-earnings profile, as compared to workers in the agricultural sector.

For both senior high and vocational school groups, there is no significant difference in wages at all levels or experience for workers between manufacturing and service sectors. For the college group, working in the manufacturing sector leads to a higher level of earnings profile in comparison with working in the service sector. However, the age-earnings profiles for workers in these two sectors are much steeper than that for workers in the agricultural sector.

Job location also has a strong effect on the age-earnings profiles for all male education groups in the labor force. For all groups, the coefficient of the rural variable, DU_2, is significant different from zero and ranges from -0.14 and -0.38. In towns, according to the significance test of the coefficients of DU_1 and $DU_1 x$, only workers in the primary school and senior high school groups receive significantly lower earnings than those workers with the same level of education in cities. These results imply that the level of urbanization is also an important determinant of the age-earnings profiles in Taiwan.

Among the structural variables in Taiwan's economy, occupational variables have the least effect on the age-earnings profile for each education group in the labor force. This is partly because the education level to some extent limits the choice of occupations. Only within the primary school group and senior vocational school group, did having a managerial, administrative, or professional job significantly and positively affect wages. Especially for the primary school group, the occupations of professionals, administrators, and managers are the very important variable to raise wages; however, the chances of being hired in such occupations for young primary school graduates have been reduced rapidly in recent years. The significance test of the occupation variables also suggests that there are fewer differences in the earnings

of laborers, clerks, salesmen, and service workers, even though the age-earnings profiles tend to be a little flatter for those having a job as a laborer in each of the college, senior high school, and senior vocational school groups.

In brief, negative effects of cohort size on the earnings tend to occur for those workers with less experience and no college education, but the slightly positive cohort size effects on the earnings of the college educated workers beyond and early career stage call for further study. We also find that the structural variables in the economy of Taiwan, such as the industrial structure, degree of urbanization, and occupational structure are indeed important determinants of the age-earnings profiles for Taiwan.[5]

C. The Specification for The Pooled Group Data of Cross-Section and Time-Series

The aggregate age-earnings profile for Taiwan over time could be affected by some related aggregate variables in addition to the age-composition of the labor force. Such variables include the business cycle, structural changes in the economy, sex composition of the labor force, and improvements in the education of young workers. However, the group data do not provide sufficient information for a regression analysis of the effects of each of the above-mentioned variables on earnings. Thus, we must use a time trend to control for any of the variety of variables – other than those accounting for the business cycle and labor force age-composition – that might influence the age-earnings profile.

The data used are group data, including both sexes, for 1964, 1966, 1968, 1970, 1972, 1974 and 1976. For each of these years, we have four age groups, i.e., 15-24, 24-44, 45-59, and 60 and over. Thus, we get 28 observations for the regression analysis.

The earnings of young workers might, on the average, be more sensitive to the business cycle than those of older workers, because firms usually have more human capital (specific training) invested in older workers through "on-the-job" learning. On the other hand, the time trend could have either positive or negative effects on the earnings of young workers. This is because the time trend used here is a proxy for those variables which are not included in the regression equation and could twist the age-earnings profile. Some of these variables might have a positive effect on the earnings of young workers. For example, educational improvement in the young labor force or the expansion of labor-intensive industries might have positive effects.

Those factors producing negative effects over time could include increases in the number of young female workers in the labor force (if young workers in the female labor force are better substitutes for young male workers than for older male workers) and the expansion of the capital intensive industries (older workers by experience could accumulate more specific human capital and could be relatively more complementary with capital).

The specification of semilogarithmic earnings is of the form:

$$\ln\left[\frac{W_r}{W_{25-44}}\right] = a_0 + a_1 \ln\left[\frac{L_r}{L_T}\right] + a_2 A_r + a_3 A_r^2 + a_4 D_i B + a_5 D_j T + \text{error} \qquad (5\text{-}4)$$

where

W_r = annual earnings from the labor market of age group r
L_r = number of workers in age group r
L_T = total labor force
A_r = mean age of age group r
D_i = 1 if age under 25
= 0 if otherwise
D_j = 1 if age under 45
= 0 if otherwise
B = business cycle indicator which is measured by the deviation from the trend of real GNP growth rate
r = 15-24, 25-44, 45-59, and 60 and over
T = time trend

The interaction terms, $D_i B$ and $D_j T$, are included to control for the asymmetrical effects of the business cycle and the time trend on the earnings of different age groups.

Four different specifications of the regression equation were tried and the results are displayed in Table 5.3. (Because the data here provide insufficient information, the estimates of coefficients may be biased and inefficient. However, the results in all four forms are fairly stable.)

In all four specifications, coefficients of the experience variables have the correct signs and are significantly different from zero. Thus, we have captured the concavity

Table 5.3 Time-Series Regression Results

Equation	(1)	(2)	(3)	(4)
Explanatory Variable				
$\ln\left[\frac{L_r}{L_\tau}\right]$	−0.07120 (0.05838)	–	–	−0.02756 (0.33413)
A	0.12577* (0.01770)	0.10569* (0.00539)	0.10512* (0.00480)	0.11347* (0.01833)
A^2	−0.00136* (0.00025)	−0.00106* (0.00006)	−0.00103* (−0.00006)	−0.00116* (0.00027)
$D_1 B^{\#}$	–	−0.00371 (0.00640) [−0.00372]	–	−0.00236 (0.00605) [−0.00238]
$D_2 T^{\#\#}$	–	–	0.01614* (0.00677) [0.01627]	0.01454* (0.00742) [0.01465]
Constant	−2.8098	−2.4328	−2.4976	−2.6493
k^2	0.9750	0.9738	0.9785	0.9789
F	311.944	297.493	364.649	203.736
n	28	28	28	28

*Significant at the 5 percent level. Estimated standard errors are expressed in parentheses and corrected percentage effects are presented in square brackets.

$^{\#}D_1$ = 1 if age under 25, otherwise 0

$^{\#\#}D_2$ = 1 if age under 45, otherwise 0

of the aggregate age-earnings profile for Taiwan. In none of the regression specifications is the coefficient of the relative cohort size significantly different from zero. These results are not contradictory to the results from the cross-sectional analysis for several reasons. First, the negative cohort size effects for the majority of workers in the prime age are not significant in both the cross-sectional and the pooled analyses. Second, the negative cohort size effects for the majority of workers during the early career stage cannot be rejected by the results from group analysis, since we are not able to introduce the early career spline function to capture the variations in cohort size effects by age. Without the early career spline function, the variation in cohort size effects by age could lead to an inefficient estimated variance and to the rejection of the hypothesis of cohort size effects. Third, in the cross-sectional analysis the positive cohort size effects for the male college group, 15 percent of the male labor force in 1976, do not necessarily hold for the aggregate labor force over time.

Alternative definitions of D_i and D_j were tried and we find that: (1) in all cases the interaction of the business cycle and D_i is not significantly different from zero, indicating that the business cycle has not twisted the aggregate age-earnings profile in the past; and (2) the definition of D_j that is equal to 1 if under 45 years of age and equal to 0 otherwise, leads to a significant estimate of the coefficient on D_jT. The latter indicates that the earnings of workers under age 45, relative to older workers, have improved by about 20 percent in the period 1964-76.

One possible factor that would help to explain this situation would be an increase in the average schooling years of young workers in this period. Another possibility is that structural changes in Taiwan's economy, such as changes in the industrial structure, increased degree of urbanization, and changes in the occupational structure, have favored those workers under age 45. The final possibility is that technological progress has not been neutral to different age groups and has increased the relative earnings of young workers via the improvement in the quality of "on-the-job" training.

Unfortunately, here we are not able to distinguish the effects of qualitative and quantitative changes in human capital from the effects of structural changes on the earnings of young workers. However, the results from cross-sectional analysis dc clearly point out the importance of structural changes in the determination of the age-earnings profile for Taiwan.

In brief, from the group data we find that the age composition of the labor

force tends to have a negative but insignificant effect on the aggregate age-earnings profile for Taiwan. However, for very young workers around the entry level, the negative effects of cohort size on their (relative) earnings still cannot be firmly rejected. The improvement in the earnings of workers under age 45 relative to the older workers over time, can be attributed to the qualitative and quantitative change in young workers' human capital, as well as the structural change in the economy.

NOTES TO CHAPTER V

1. Kennedy (1981) demonstrates that it is incorrect to measure the relative effects of a dummy variable on earnings by the size of the regression coefficient in semilogarithmic equations. Thus he suggests that the correct measure of the relative effect is $[\exp(a_i - 1/2\ V(a_i)) - 1]$ if a_i is the estimated coefficient of the dummy variable and $V(a_i)$ is its estimated variance.
2. Consider the following relation between the relative wages or the MRS for different experience groups,

$$\frac{W_x}{W_\alpha} = \frac{\frac{\partial Y}{\partial L(x)}}{\frac{\partial Y}{\partial L(\alpha)}} = \begin{cases} K(\psi)\ \left(\frac{L(x)}{L(\alpha)}\right)^{-a(x/\alpha - 1)} & \text{if } x \leqslant \alpha \\ K(\psi)\ \left(\frac{L(x)}{L(\alpha)}\right)^{-a \cdot 0} = K(\psi) & \text{if } x > \alpha \end{cases}$$

where W denotes the wage, L denotes the cohort size of workers, x denotes the year of experience, Y is the output, $(x/\alpha - 1)$ for $x \leqslant \alpha$ is the early career spline function, α denotes the duration of early careers, a is a positive constant, and finally $K(\psi)$ is the function which is not affected by the cohort size. This equation implies that the substitutability of new recruits for older workers increases as their experience level rises and that workers tend to become perfect substitutes for each other when beyond the early career stage, because

$$\frac{\partial \ln \frac{W_x}{W_\alpha}}{\partial \ln L(x)} = \begin{cases} -a(x/\alpha - 1) \quad 0 & \text{if } x \leqslant \alpha \\ 0 & \text{if } x > \alpha \end{cases}$$

Thus, we expect a zero coefficient on the cohort size and a negative coefficient on the interaction of cohort size with the early career spline function in the regression analysis.

3. A male usually starts his military service at age 20 for 2 to 3 years.
4. $$F_{q, N-K} = (R_b^2 - R_a^2)\ (N - K) / (1 - R_b^2)q$$

where R_a^2 and R_b^2, respectively, are the coefficients of determination before and after including the additional explanatory variables in regression analysis; q refers to the number of explanatory variables added to the initial regression specification; N denotes the number of observations; and $(K - 1)$ is the total number of explanatory variables after the inclusion of the additional explanatory variables.

From the coefficients of determination in Table 5.1, we obtain the following statistics for the F test:

$F_{12,3939} = 257.15584$ (for the primary school group)

$F_{12,1370} = 30.83222$ (for the junior high school group)

$F_{12,828} = 20.39444$ (for the senior high school group)

$F_{12,812} = 13.90971$ (for the vocational high school group)

$F_{12,1197} = 11.16858$ (for the college group)

These F statistics are much greater than $F_{0.05,12,\infty}(\cong 1.75)$; therefore, we cannot accept the null hypothesis that the inclusion of structural variables in the regression specification does not improve the power of explanation.

5. We have also run different forms of the wage equation. For the primary school group, we have

$$\ln(W_x/W_d) = \underset{}{10.45569} - \underset{(0.08905)}{0.06855}\ \ln L(x) + \underset{(0.01254)}{0.05653}x - \underset{(0.00027)}{0.00114}x^2$$

$$R^2 = 0.03873 \qquad F = 53.07858$$

$$\ln(W_x/W_d) = \underset{}{10.84728} - \underset{(0.06723)}{0.06693}\ \ln L(x) + \underset{(0.01000)}{0.05877}x - \underset{(0.00021)}{0.00118}x^2$$

$$- \underset{(0.07770)}{0.56145}DA_1 - \underset{(0.05971)}{0.16420}DA_2 - \underset{(0.05546)}{0.14530}DU_1 - \underset{(0.04905)}{0.33035}DU_2$$

$$+ \underset{(0.20080)}{0.39391}DO_1 + \underset{(0.07945)}{0.00264}DO_2 - \underset{(0.00265)}{0.00674}DA_1x + \underset{(0.00223)}{0.00540}DA_2x$$

$$- \underset{(0.00211)}{0.00136}DU_1x - \underset{(0.00120)}{0.00120}DU_2x + \underset{(0.00639)}{0.00192}DO_1x + \underset{(0.00273)}{0.00216}DO_2x$$

$$R^2 = 0.46269 \qquad F = 211.99906$$

where estimated standard errors are presented in parentheses. For the junior high school group, we have

$$\ln(W_x/W_d) = \underset{}{10.24028} - \underset{(0.04197)}{0.04786}\ \ln L(x) + \underset{(0.00441)}{0.07422}x - \underset{(0.00010)}{0.00124}x^2$$

$$R^2 = 0.3144 \qquad F = 211.44155$$

$$\ln(W_x/W_d) = \underset{}{10.52515} - \underset{(0.03796)}{0.07857}\ \ln L(x) + \underset{(0.00587)}{0.07516}x - \underset{(0.00010)}{0.00131}x^2 - \underset{(0.10462)}{0.41149}DA_1$$

$$-\underset{(0.07196)}{0.03598}DA_2 - \underset{(0.06627)}{0.09218}DU_1 - \underset{(0.05622)}{0.17952}DU_2 + \underset{(0.18348)}{0.27803}DO_1$$

$$+ \underset{(0.09205)}{0.03828}DO_2 - \underset{(0.00467)}{0.01573}DA_1x - \underset{(0.00308)}{0.00132}DA_2x - \underset{(0.00302)}{0.00127}DU_1x$$

$$- \underset{(0.00251)}{0.00132}DU_2x + \underset{(0.00630)}{0.00306}DO_1x - \underset{(0.00359)}{0.00084}DO_2x$$

$$R^2 = 0.45925 \qquad F = 77.62325$$

For the senior high school group, we have

$$\ln (W_x/W_d) = \underset{}{10.62098} - \underset{(0.05324)}{0.08442}\ \ln L(x) + \underset{(0.00593)}{0.08628}x - \underset{(0.01640)}{0.00163}x^2$$

$R^2 = 0.33808$ $\quad F = 107.2597$

$$\ln (W_x/W_d) = \underset{}{10.73056} - \underset{(0.03870)}{0.06690}\ \ln L(x) + \underset{(0.00615)}{0.07876}x - \underset{(0.00014)}{0.00155}x^2$$

$$- \underset{(0.016400)}{0.46311}DA_1 - \underset{(0.06528)}{0.00018}DA_2 - \underset{(0.07753)}{0.26041}DU_1 - \underset{(0.06628)}{0.24176}DU_2$$

$$+ \underset{(0.10431)}{0.22991}DO_1 + \underset{(0.07119)}{0.05003}DO_2 - \underset{(0.01192)}{0.02765}DA_1x + \underset{(0.00289)}{0.08046}DA_2x$$

$$+ \underset{(0.00340)}{0.00316}DU_1x + \underset{(0.00315)}{0.00134}DU_2x + \underset{(0.00395)}{0.00264}DO_1x - \underset{(0.00361)}{0.00752}DO_2x$$

$R^2 = 0.47101$ $\quad F = 49.20941$

For the senior vocational school group, we have

$$\ln (W_x/W_d) = \underset{}{10.33035} + \underset{(0.00621)}{0.01991}\ \ln L(x) + \underset{(0.00026)}{0.08725}x - \underset{}{0.00167}x^2$$

$R^2 = 0.32897$ $\quad F = 134.81970$

$$\ln (W_x/W_d) = \underset{}{10.38499} + \underset{(0.09884)}{0.02977}\ \ln L(x) + \underset{(0.00621)}{0.08779}x - \underset{(0.00026)}{0.00166}x^2 - \underset{(0.14711)}{0.31490}DA_1$$

$$- \underset{(0.06610)}{0.00692}DA_2 - \underset{(0.06896)}{0.00835}DU_1 - \underset{(0.00370)}{0.00935}DU_2 + \underset{(0.09755)}{0.16427}DO_1$$

$$+ \underset{(0.07107)}{0.01056}DO_2 - \underset{(0.00929)}{0.01293}DA_1x + \underset{(0.00377)}{0.00292}DA_2x - \underset{(0.00384)}{0.00083}DU_1x$$

$$- \underset{(0.00370)}{0.00935}DU_2x + \underset{(0.00463)}{0.00132}DO_1x - \underset{(0.00450)}{0.00952}DO_2x$$

$R^2 = 0.44180$ $\quad F = 46.01817$

For the college group, we have

$$\ln (W_x/W_d) = \underset{}{10.58257} + \underset{(0.05255)}{0.85629}\ \ln L(x) + \underset{(0.00640)}{0.06420}x - \underset{(0.00018)}{0.00130}x^2$$

$R^2 = 0.11457$ $\quad F = 52.18864$

$$\ln (W_x/W_d) = \underset{}{10.45002} + \underset{(0.05061)}{0.11950}\ \ln L(x) + \underset{(0.00661)}{0.05896}x - \underset{(0.00017)}{0.00118}x^2 + \underset{(0.90401)}{1.4074}DA_1$$

$$+ \underset{(0.06564)}{0.14922}DA_2 - \underset{(0.08014)}{0.01664}DU_1 - \underset{(0.08495)}{0.38551}DU_2 + \underset{(0.06046)}{0.09001}DO_1$$

$$+ \underset{(0.11098)}{0.01678}DO_2 - \underset{(0.15694)}{0.33568}DA_1x + \underset{(0.00371)}{0.00010}DA_2x - \underset{(0.00394)}{0.00588}DU_1x$$

$$+ \underset{(0.00447)}{0.00811}DU_2x + \underset{(0.00294)}{0.00515}DO_1x - \underset{(0.00728)}{0.02325}DO_2x$$

$R^2 = 0.20447$ $\quad F = 20.52792$

When we impose a persistent wage elasticity with respect to cohort size throughout the life-cycle by excluding the interaction of the (relative) cohort size, ln L(x), with the early career spline function, S, from the regression equation, the significance test indicates (1) that the wage elasticity for each of the male groups, except the college group, is not significantly different from 0, and (2) that the cohort size effects on the earnings of college graduates are still positive and significantly different from 0. Moreover, excluding the interaction of structural variables with the experience level, x, from the above regression equations, or from equation (5-1), does not lead to different results for the significance test on the cohort size effects for each of the male groups.

CHAPTER VI

CONCLUSION

A. Summary of the Findings

1. Individual Cross-Sectional Analysis.

For those male workers in Taiwan who have not received a college education and are still at an early stage of their careers, the research presented here indicates that the effects of cohort size on their earnings are significantly negative. The analysis also shows that as experience increases the cohort size effects decrease to a persistent level that is not significantly different from zero.

This result implies that: (1) there are fewer production techniques for these workers to learn throughout their work careers and thus, they tend to do the same things or tasks after the initial period of learning in spite of their differences in experience; (2) the substitutability of new recruits for older workers is rapidly raised by experience during the early career; and (3) all workers beyond the early career stage tend to be perfect substitutes for each other, given a certain level of education (except the college education).

It was also noted that the cohort size effects for the college group are not significantly different from zero at the early stage of their careers, but after that period do increase to a significantly positive, persistent level. The implication is that production activities for the college group tend to be differentiated and to be performed by appropriate workers with compatible proficiency. Jobs for these workers usually require the accumulation of knowledge and skills throughout the

entire careers for decision-making and problem-solving in which experience gradually builds up individual proficiency. Therefore, the degree of substitutability between experience groups decreases as the difference in experience increases.

The positive cohort size effects on the earnings of those experienced workers with a college education require further study. Here, we have provided some explanations that clearly require further verification. The first possible explanation is that if our regression specifications do not miss any important explanatory variables in the analysis, then there are increasing returns to high-level production activities such as planning, organizing, staffing, leading and controlling. This results in better coordination and utilization of various resources in the rapidly growing economy of Taiwan where most firms are relatively and are expanding quickly. The second possible explanation could be specification error in the earnings equation for the college group. For example, our earnings equation cannot control for the qualitative changes in the human capital embodied in different cohorts of the labor force. If the quality of a college education and post-college on-the-job training have greatly improved over time, there would be a positive correlation between qualitative changes in human capital and cohort size for the college group in Taiwan. Therefore, an over-estimated coefficient of the cohort size effect would be attained.

The cross-sectional analysis also indicates that the industry dummy variables and their interaction with experience have a particularly strong impact on the age-earnings profiles for all male education groups in the labor force. The dummy variables of job location also have a fairly strong effect on the age-earnings profiles for all male education groups. The impact of occupational dummy variables decreases as the workers' education level increases. Thus, development characteristics of Taiwan, such as industrialization, urbanization, and occupational structure are important determinants of the age-earnings profiles.

2. Pooled Time-Series Analysis of Group Data.

The analysis of the group data shows that in aggregate the age-earnings profile is independent of the labor force age composition by broad age specification and is independent of the business cycle also. Since the broad now-you-are-in-now-you-are-out age specification may cause a highly inefficient estimated variance of the coefficient on cohort size, the negative cohort size effects (obtained from the cross-

sectional analysis) on the earnings of workers around the entry level cannot be firmly rejected here.

This analysis also suggests that since the earnings of workers under age 45 have improved by about 20 percent since 1964, factors such as the economic structure of Taiwan and the continuing improvement in young workers' schooling and on-th-job training have much more influence on the aggregate age-earnings profile than the aggregate age composition of Taiwan's labor force.

B. The Policy Implications

This study not only presents how the welfare of the different age groups of the labor force are affected by labor force age composition, but also indirectly indicates the degree to which young workers are substitutes for older workers at each educational level in the labor market. Our cross-sectional analysis suggests that young workers at their early career stage are not perfect substitutes for older workers for each of the male education groups.

The smaller size of young cohorts in the labor force would lead to higher (relative) earnings at least around the entry level of their careers, and conversely. This effect is particularly significant for those workers without a college education. This effect also provides further support for policies of population control that do not lead to severe disruptions in the age distribution.

Although the age-specific unemployment rates in Taiwan are all fairly low, higher unemployment for younger workers has been observed in the past. If a policy to reduce the unemployment rate for young workers is chosen, then some selective employment policies are needed. Tax credits for employment that subsidize some fraction of the employment cost of young workers would stimulate firms to employ more youth when the substitutability of youth for older workers is high. Our study indicates that this substitutability is relatively high in Taiwan for those workers without a college education; therefore, tax credit for employment would help the employment of those youth with a lower level of education. The current labor policy of keeping quite a low minimum wage would also contribute to the relatively low unemployment rate for young workers in Taiwan. On the other hand, current investment tax credits in Taiwan decrease the demand for labor, assuming capital and raw labor are substitutes, but their effects on demand for some experienced or highly

educated types of labor may be positive if capital is more complementary with them in production (Hamermesh and Grant, 1979). Further studies on substitution between capital and different types of labor in Taiwan should be carried out to discover the effect of capital deepening on labor demand by age or experience level or by education level during its path of growth.

The labor force of Taiwan generally is still young, compared with most developed countries. However, the decline in the size of population cohorts born in the period 1965-75 and the decline in the labor force participation rate for young people (especially the males under age 25 and females under age 20) due to a trend of increasing years of schooling will begin to have a severe impact on the labor market by the mid-1980s. A large supply of relatively cheap workers, which was undoubtedly a major factor in fueling Taiwan's expansion of the labor-intensive sector from the 1950s to the 1970s, would gradually vanish in the future. Moreover, the negative cohort size effects imply that the wages for new recruits would also gradually increase. The labor constraint in the 1980s and beyond brings to an end of the era of abundant unskilled young workers in Taiwan.

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