Changes in Wage Structures over the Past Two Decades in Taiwan : Cross-sectional versus Cohort Analyses

by

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Declaration

This dissertation was written while I was studying at the Australian National University. The opinions expressed are my own unless otherwise indicated.

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Abstract

This thesis investigates changes in wage structures over the past two decades in Taiwan. Taiwan has experienced high economic growth and tremendous demographic changes, such as a declining fertility rate and the increased level of higher education among the population.

As is widely recognised in modern labour market analysis, the fast accumulation of human capital may have an important impact on wage structures. Most studies examine the evolution of wage structures over time on the basis of cross-sectional analysis. This thesis raises possible problems with cross-sectional estimations of returns to experience and returns to education caused by cohort and year effects, and develops methods to correct for those biases.

The theoretical analysis shows that the estimated cross-sectional returns to experience are biased by cohort effects, especially when an economy has been undergoing significant changes in cohort characteristics and economic structure, as has been the case for Taiwan. On the other hand, the returns to experience estimated by tracing cohorts over time is also biased by the effects of economic growth and cyclical fluctuations. The empirical evidence shows that cohort wage profiles are much steeper than cross-sectional wage profiles because of the rapidity of economic growth in Taiwan.

Four different models are employed to decompose the experience, cohort and year effects on wages in order to estimate the true returns to experience. The results show that there are significant differences in the experience–wage profiles estimated from the

four models. The advantages and disadvantages of the four models are also discussed at the end of the analysis.

The study reveals that cross-sectional returns to education are a combination of cohorts' returns to education in that year, while the cohort returns to education are the joint effects of returns to education for the same cohort at different points in time.

The empirical study follows the approach of investigating the returns to education over time and by cohort. The results reveal that returns to education for old cohorts are fairly stable over time. Most of the changes in returns to education appear in the young cohorts. The different patterns of changes in returns to education among different education levels imply that the changes are jointly driven by rapid educational expansion and structural shifts under conditions of high economic growth.

The contribution of this thesis is to address the wide applicability of the approaches and the importance of accurate estimates of the returns to human capital for policy making. The models developed in this study can be applied not only in studies on returns to human capital but also those on gender wage differentials, industry wage differentials or any other application of Mincerian wage equations.

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1 Introduction

Taiwan is known as one of the four Asian tigers, the miracle growth economies. During the period 1952–97, the average annual growth rate was as high as 8.5 per cent. Besides the high growth rate, the rapid increase in trade volume and the development of technology intensive industries also attracted worldwide attention. In 1997, the total trade volume accounted for 2 per cent of the global total, and the information industry ranked third in the world.

Alongside this outstanding economic performance, an interesting question arises — what are the consequences of rapid economic development for labour market outcomes? Did wage inequality expand as Kuznets (1955) predicted for rapid growing economies? Did the wage differentials between different skill levels increase with the increase in technology intensity?

There is a large literature on the importance of human capital for economic growth and wage structures (Uzawa 1965; Rosen 1976; Tan 1981; Mincer 1984; Lucas 1988; Romer 1989; Mincer 1989b; Mincer 1996; Polachek 1995). This thesis will investigate how the returns to human capital changed over time and how these changes affected wage inequality in Taiwan.

1.1 Human capital and economic development

The reciprocal relationship between human capital and economic growth has been widely recognised in the literature on both growth theory and labour market outcomes.

Human capital investment is not only regarded as an engine of economic growth, but it is also seen as an effect of economic growth. Human capital is incorporated in the models of Lucas (1988) and Romer (1989) to explain the endogenous technological change that drives economic growth. The importance of human capital accumulation in driving economic growth is also emphasised by Uzawa (1965) and Rosen (1976).

Tallman and Wang (1994) explore the idea that human capital evolution has played a crucial role in the extraordinary development of the Taiwanese economy. They argue that human capital is the engine of growth, while government policies, the improvement of financial markets, and the opening of international trade are the important factors motivating and supporting human capital accumulation. The endogenous enhancement in human capital generates a big push, allowing countries to industrialise successfully. Using simple growth accounting, they find that human capital alone accounts for about 45 per cent of output growth in Taiwan over the past three decades. On the other hand, increasing human capital investment is also a result of rapid technological change. New technologies cannot be implemented without the acquisition by workers of skills specific to those technologies. Hence, rapid technological change induces greater investment in human capital (Tan 1981). Tan argued that education is a long-term process, skills acquired in school may not be updated quickly enough for new technologies; on-the-job training therefore become an important instrument for adapting to new technologies.

However, investment in education may also increase with rapid technological change. Although knowledge accumulated in school may not directly relate to the skills later required in the workplace, it offers a foundation for learning new technologies

after school. Employers therefore tend to hire workers with higher education levels as industries shift toward greater technology intensity.

In Taiwan, not only has the demand for human capital embodied in skilled labour increased significantly over time, but the supply of human capital has also increased enormously through the rapid expansion of education. What has happened to the price of human capital? Have the wage differentials among different skill levels increased over time, or decreased? Kuznets (1955) suggested that, with economic development, the wage gap between skilled and unskilled labour increases and this leads inevitably to an increase in wage inequality. Whether this argument is supported by the wage outcomes in the Taiwanese economy will be examined in this thesis.

1.2 Cohort effects and measuring returns to human capital

Education and labour market experience are the characteristics that are most commonly used to define workers' skill levels. Hence, wage structures are usually examined on the basis of the returns to education and experience. These returns are regarded as proxies for skill prices.

In developed countries, such as the United States and the United Kingdom, the returns to both experience and education increased during the 1980s. A huge literature has suggested that the increasing skill premia can largely be explained by skill-biased technological change (Bound and Johnson 1992; Constantine and Neumark 1996; Johnson 1997; Juhn, Murphy and Pierce 1993; Katz and Murphy 1992; Mincer 1993; Schmitt 1995).

In contrast to the developed countries, the returns to education decreased in most developing countries during the 1980s. This was due to the widespread phenomenon of educational expansion (Psacharopoulos 1989). Taiwan is an exception, where returns to education have been fairly stable over time (Gindling, Goldfarb and Chang 1995).

Kim and Topel (1995) reveal that experience–wage differentials have been increasing in South Korea since the late 1970s. There is very little literature documenting the returns to experience over time in Taiwan.

The studies mentioned above all focus on changes in cross-sectional returns to education and experience over time. The Mincerian wage equation and the calculation of the difference in average wages between two comparable experience or education groups are the two most commonly used methods. No matter which method is applied, the returns to human capital are biased because individuals belonging to different cohorts[1] are compared in the estimation.

This bias comes from the fact that wages of old cohorts are compared with young cohorts with the same educational level despite the fact that college graduates today are very different from college graduates twenty years ago. Educational quality may differ over time, and individuals' relative ability may also differ greatly when there is significant educational expansion in a country. Hence, cross-sectional returns to experience do not purely reflect returns to post-school human capital investment; the effect of different cohort characteristics is captured as well.

[1] Cohort can refer to either birth cohort or labour market entry year. For further discussion of the term cohort, see Chapter 4.

Similarly, in a cross-sectional regression of a Mincerian wage equation, the returns to education are the combination of returns to education for different cohorts. The levels as well as the time trends of returns to education may be different across cohorts because of differences in educational quality, the distribution of education levels and labour market experience. When these differences are not considered, the apparent time trend of returns to education may not reflect the true one. Consider an extreme case: if the time trends of the returns to education for old and young cohorts go to different directions, i.e. one increasing and one decreasing, it is possible that the cross-sectional returns to education remain stable over time.

Thus, for a country such as Taiwan, where changes in cohort characteristics have been marked, cross-sectional returns to experience and education that are biased by cohort effects may provide a very misleading picture of the causes of the changes in wage inequality. To develop a method of estimating the true returns to experience and education is therefore a crucial aspect of this thesis.

1.3 Purpose of this study and its importance

The main purpose of this thesis is to investigate how the wage structures changed over the past two decades during Taiwan's rapid economic development. Methods of estimating returns to education and experience, which take into account cohort effects, will be developed in Chapters 5 and 6. The reasons for focusing on Taiwan's labour market are as follows:

1. The demand for and supply of skilled and unskilled labour have changed enormously due to shifts of industry structures, trade liberalisation, the increase in

educational levels among the labour force and the decrease in the fertility rate. It is interesting to understand how wage structures reflect such drastically changing economic conditions.

2. Taiwan's labour market is highly competitive (Chang and Wu 1983; Wu 1987). There is little government intervention in wage determination. This allows us to examine how the wage changes are driven by supply and demand in labour market.

3. There is a rich source of data for Taiwan. The dataset employed in this thesis contains information from 19 successive cross-sectional household surveys with a large number of observations in each cross-section. The consistent sampling method and variable coding enable the application of advanced techniques for cohort studies.

The importance of this study is reinforced by the potential for the broader application of the estimation methods it adopts. The returns to education and experience are considered to be the two main factors that explain wage inequality in an economy and they are also two key elements in any investigation of wage structures. They can also be applied to studies of gender wage differentials, ethnic wage differentials and industry wage differentials.

Accurate measurement of the returns to education and experience is also very important for policy making. Biased information may lead to inappropriate decisions about education, training and even industry policies.

1.4 Outline of the thesis

This thesis is structured as follows. Following the introduction, Chapter 2 provides an overview of labour market institutions over the past two decades in Taiwan. This chapter offers the background to an understanding of the empirical analysis presented in the next three chapters.

Chapter 3 presents a brief discussion of the literature on human capital theory, experience–wage profiles, the returns to education and cohort studies. In addition to a discussion of the economic intuition behind the Mincerian wage equation, (the basic instrument applied in the empirical analysis in Chapters 5 and 6), the concept of cohort effects is also discussed in this chapter.

Chapter 4 presents the evolution of wage structures over the past two decades. This chapter comprises two parts. The first discusses changes in cross-sectional wage structures. This analysis is comparable with what may be found in the existing literature. The second part explores wage profiles for different cohorts and compares them with cross-sectional wage profiles.

The objective of Chapter 5 is to estimate the true returns to experience using the stacked cross-sectional data. Four different models are used to decompose the experience, cohort and year effects in wages. The first three models estimate the true experience–wage profile by removing year effects from the cohort wage profile, while the fourth model estimates true experience–wage profile by removing cohort effects from cross-sectional experience–wage profile. The results show that returns to experience estimated from the four models are very different. The advantages and restrictions of each model are discussed in the final section of this chapter.

Chapter 6 presents an empirical analysis of the returns to education for different cohorts over time. In this chapter, individuals are grouped into cells by cohort, survey year and education level. The returns to education are calculated from the differences in cell means between different educational groups. The results show that older and younger cohorts exhibit very different patterns of returns to education over time.

2 The Taiwanese labour market

The objective of this chapter is to provide background information on the changing Taiwanese economy and labour market. This chapter begins by presenting the economic growth rate, industrial structure, labour force statistics and employment statistics to give a broad picture of labour market conditions and structural changes over the past two decades.

Besides the high economic growth and rapid changes in demographic features, labour market institutions may also be factors of wage determination. The impacts of institutional changes on wage structures have been addressed in a number of studies on developed countries (Blau and Kahn 1996; Fortin and Lemieux 1997). Empirical investigation of the impacts of institutional change on wage structures is beyond the scope of this thesis. Nevertheless, this chapter offers a brief description of Taiwan's labour market institutions in order to provide a basic understanding of how its labour market operates. Labour Standard Law, minimum wages, payment systems and unions are described in this second section.

2.1 Economic growth, structural change and the labour force, 1978–96

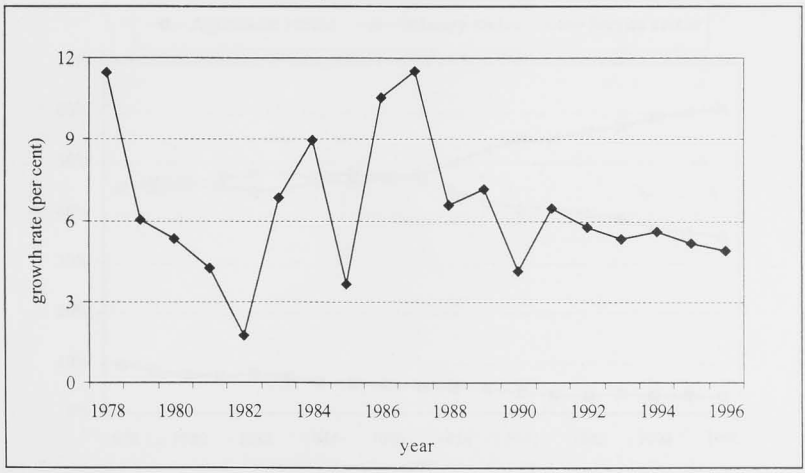
This section presents indicators of economic growth and labour force statistics in order to draw a broad picture of changes in general economic conditions and labour market structures in Taiwan over time.

2.1.1 Economic growth

Figure 2.1 shows the annual growth rate of real gross domestic product (GDP) per capita in the period 1978–96. The average growth rate in this period fluctuated between 11.5 and 1.7 per cent, with an average rate of 6.38 per cent. The average growth rate in this period was about 1 per cent lower than that in the previous ten years, but still higher than in most countries in the world.

Due to the influence of the global recession caused by the second oil crisis, the GDP growth rate decreased significantly after 1978 and reached its lowest point in 1982. The boom in the late 1980s was referred to as the Taiwanese 'bubble economy' caused by high returns in the stock and real estate markets. After 1990, economic growth slowed and did not fluctuate as much as was the case in the pre-1990 period.

Figure 2.1: Taiwan: growth rate of real GDP per capita, 1978–96



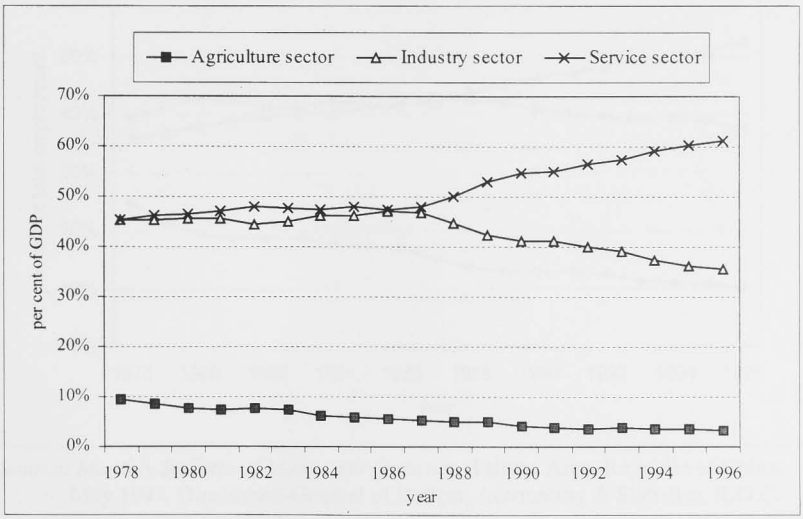
Source: *Taiwan Statistical Data Book*, 1997.

2.1.2 Structural Change

In addition to rapid economic growth, Taiwan also experienced significant structural changes over the past two decades. Both production and employment have shifted towards service industries and technology-intensive manufacturing industries.

As illustrated in Figure 2.2., the percentage contribution to GDP from the agricultural sector has decreased over time. The service sector grew slowly before 1988 but rapidly thereafter. The significant growth in service sector reflects the liberalisation of financial market in the late 1980s. The share of the industrial sector remained stable in the first half of the period, but decreased in the second half because of the strong growth of the service sector.

Figure 2.2: Taiwan: structure of production (% of GDP by sector), 1978–96

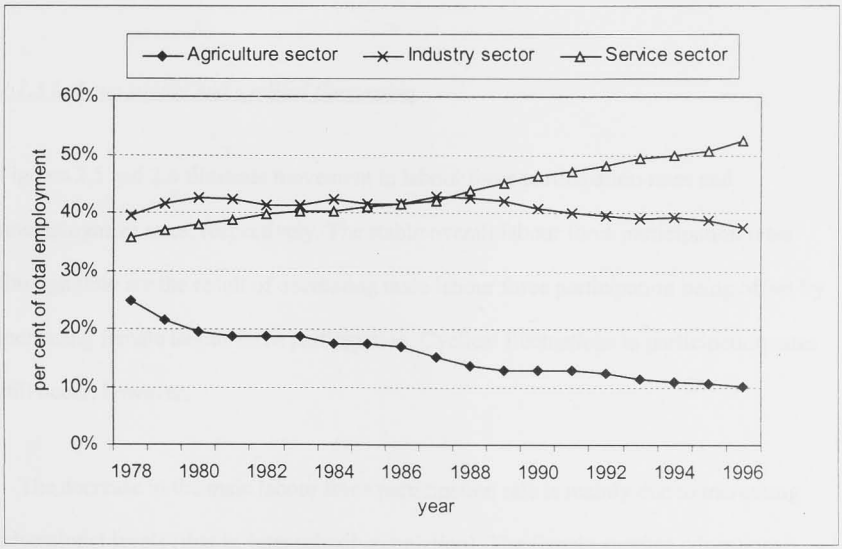


Source: *Taiwan Statistical Data Book*, 1997.

Figure 2.3 shows the distribution of employment by sector. The pattern is very similar to that observed for production. The agriculture sector shrank over time while the service sector expanded rapidly. The proportion of employment in the industrial sector was relatively stable compared with the other two sectors.

To provide further insight into the development of high-technology industries, Figure 2.4 presents the ratio of employment in high-technology industries[2] to total employment in manufacturing industries. The trend of increasing employment in high-technology industries may also suggest increasing demand for human capital in Taiwan.

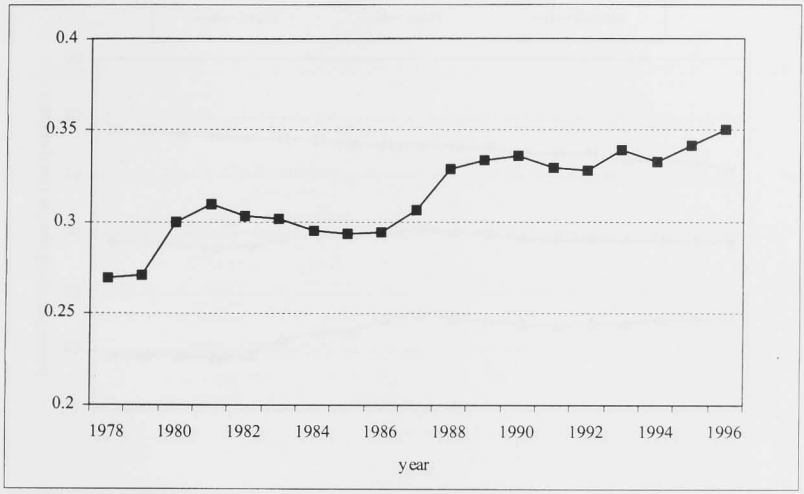
Figure 2.3: Share of employment by sector, Taiwan, 1978–96



Source: *Monthly Bulletin of Manpower Statistics*, Taiwan Area, Republic of China, May 1997, Directorate-General of Budget, Accounting & Statistics, R.O.C.

[2] Including chemical products, electronic, electrical machinery and equipment, and precision instruments and machinery industries.

Figure 2.4: Proportion of employment in high-technology industries to total employment in manufacturing industries, 1978–96



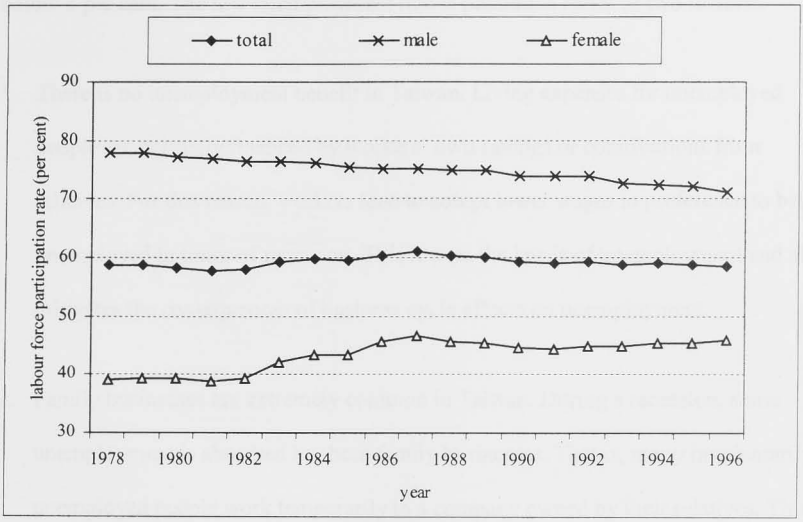
Source: *Monthly Bulletin of Manpower Statistics*, Taiwan Area, Republic of China, May 1997, Directorate-General of Budget, Accounting & Statistics, R.O.C.

2.1.3 Labour supply and cyclical fluctuation

Figures 2.5 and 2.6 illustrate movement in labour force participation rates and unemployment rates, respectively. The stable overall labour force participation rates through time are the result of decreasing male labour force participation being offset by increasing female labour force participation. Cyclical fluctuations in participation rates still occur, however.

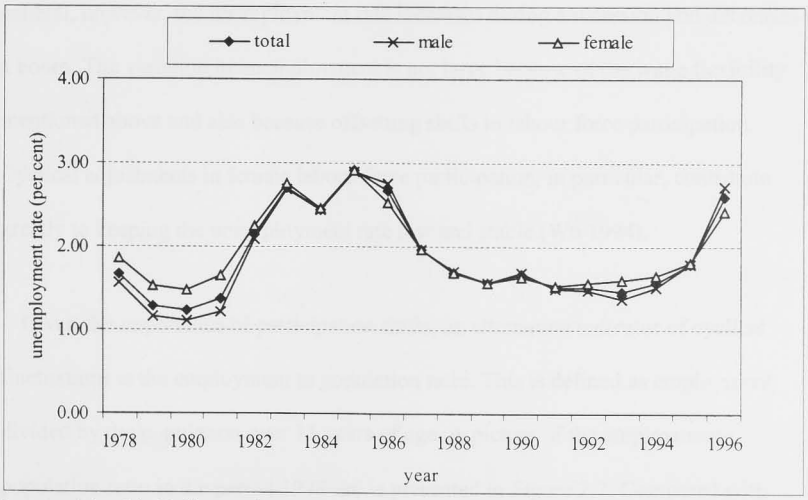
The decrease in the male labour force participation rate is mainly due to increasing educational levels (that is, later school completion). The female average educational level is also increasing, but the principle reason for the growth in the female labour force is the significant increase in the participation of married women in the labour market.

Figure 2.5: Labour force participation rates, 1978–96



Source: *Monthly Bulletin of Manpower Statistics*, Taiwan Area, Republic of China, May 1997, Directorate-General of Budget, Accounting & Statistics, R.O.C.

Figure 2.6: Taiwan: unemployment rates, 1978–96



Source: *Monthly Bulletin of Manpower Statistics*, Taiwan Area, Republic of China, May 1997, Directorate-General of Budget, Accounting & Statistics, R.O.C.

As shown in Figure 2.6, the unemployment rates over this the whole period were all below 3 per cent. The low unemployment rate is possibly a result of two factors:

1. There is no unemployment benefit in Taiwan. Living expenses for unemployed people are normally financed by workers' own savings or contributions from relatives. For this reason, workers tend to accept lower wages in preference to being unemployed in times of recession. This lowers the levels of unemployment and also mitigates the consequences of business cycle effects on unemployment.

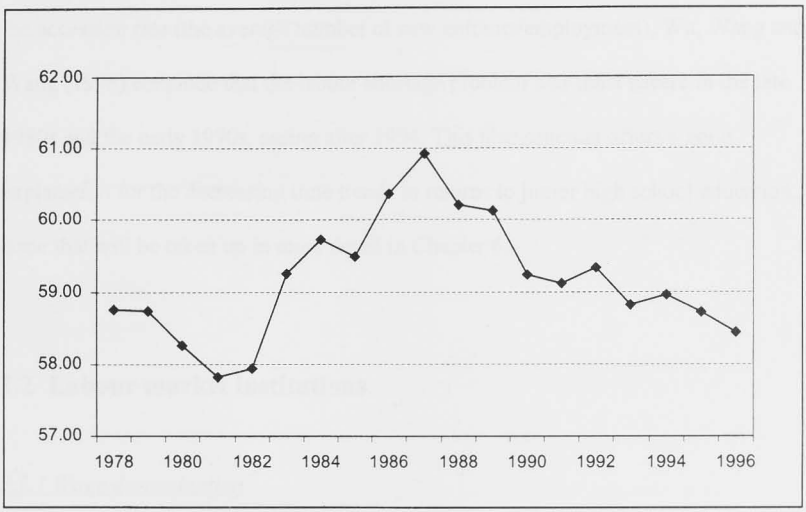
2. Family businesses are extremely common in Taiwan. During a recession, some unemployment is absorbed by these family businesses. That is, many involuntarily unemployed people work temporarily in a company owned by their relatives. This group represents hidden unemployment.

Fluctuations in unemployment rates lag slightly behind movements in output; in general, however, the unemployment rate increases during a recession and decreases in a boom. The variation in unemployment is not large because of the wage flexibility mentioned above and also because offsetting shifts in labour force participation. Cyclical adjustments in female labour force participation, in particular, contribute greatly to keeping the unemployment rate low and stable (Wu 1994).

Given the importance of participation shifts, an alternative indicator of cyclical fluctuations is the employment to population ratio. This is defined as employment divided by the population over 15 years of age. A picture of the employment–population ratio in the period 1978–96 is presented in Figure 2.7. Compared with Figure 2.4, we can see that the employment–population ratio almost always moves in the same direction as the GDP growth rate. Nevertheless, the employment–population

ratio may incorporate a time trend because of the increase in female labour force participation. Hence the employment–population ratio does not capture only cyclical fluctuations.

Figure 2.7: Employment–population ratio, 1978–96



Source: Author's calculation based on employment and population (15+) data from *Monthly Bulletin of Manpower Statistics*, Taiwan Area, Republic of China, May 1997, Directorate-General of Budget, Accounting & Statistics, R.O.C.

Accompanying the process of economic growth, the large levels of labour surpluses reflected by underemployment in the agricultural sector during the 1950s and 1960s no longer exist. The labour supply curve has been elastic since the late 1960s.[3] Since the mid-1980s, the labour shortage problem has become an important issue in the Taiwanese labour market.

The labour shortage problem refers to the excess demand for unskilled labour. Unfortunately, there are no reliable vacancy /unemployment ratio data available in

Taiwan. Using information such as unemployment rate by education and the vacancy rate[4] (the number of vacancies/employment by firms), Wu (1992) demonstrates that excess demand for labour does exist in the manufacturing and construction industries. Most of this excess demand is for labourers. Supplemented by the separation rate (the number of workers who leave the firms voluntarily or involuntarily/employment) and the accession rate (the average number of new entrants/employment), Wu, Wang and Wang (1998) conclude that the labour shortage problem was most severe in the late 1980s and the early 1990s, easing after 1994. This phenomenon offers a good explanation for the decreasing time trends in returns to junior high school education, an issue that will be taken up in more detail in Chapter 6.

2.2 Labour market institutions

2.2.1 Wage determination

It is well accepted that the Taiwanese labour market is very close to being a competitive labour market. Several studies show that wages are determined by market forces in Taiwan (Chang and Wu 1983; Wu 1987). Besides describing the lack of non-competitive factors in the Taiwanese labour market, these studies also employ empirical analysis to reach their conclusion.

Using semi-aggregate data in the manufacturing sector, Chang and Wu (1983) demonstrate that wage inertia does not exist in the Taiwanese labour market. Shifts in labour demand and supply as reflected in wage adjustment are more sensitive and more

[3] 1968 is generally regarded as a turning point. Since 1968, the average wage has increased significantly.

rapid than shifts in employment. Wu (1987) made an extensive examination of the period to 1985. However, few studies on this topic have been undertaken recently.

The determination of wages in Taiwan differs from that in most developing countries, because of the low level of government intervention in Taiwan. Although minimum wage legislation was established as early as 1956, it has been largely disregarded due to the lack of effective implementation and the fact that real wages tended to overtake the minimum wage frequently, with the result that the minimum wage is usually much lower than actual wages in the labour market. Minimum wage regulation was not implemented seriously until the establishment of the Labour Standard Law in 1984.

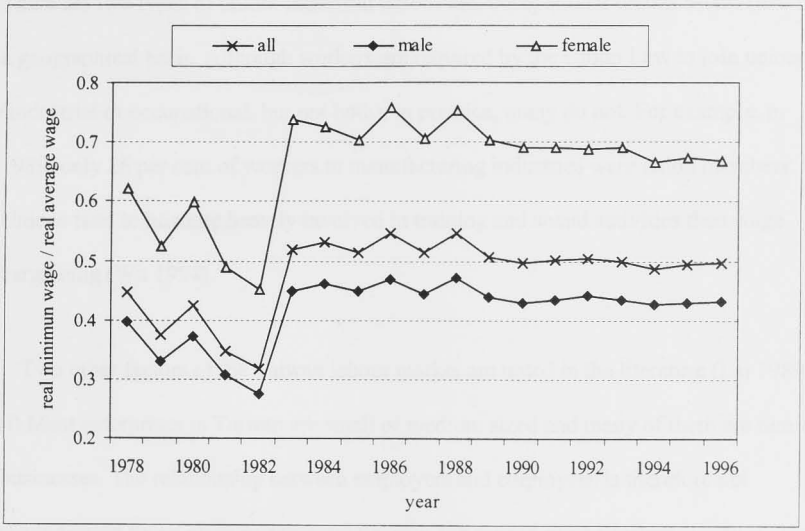
The Labour Standard Law is the basic legislation regulating the rights and responsibilities of employers and employees. It includes rules governing working hours, overtime payment, leave, retirement, compensation for industrial injury and apprenticeships. While the Labor Standard Law specifies that wages cannot be lower than the minimum wage, it does not cover all industries. It covers all of the primary and secondary industries, but among the service industries, only the media industry is covered.

The level of the minimum wage has also been updated more regularly since the responsibility for determining minimum wages was transferred from the Ministry of Interior Affairs to the Council of Labour Affairs in 1987. It is now updated every year on the basis of general living standards and average wages. The ratios of minimum

[4] These data are from a supplement to the Labour Mobility Survey, for which only around 900 firms are interviewed.

wages to average wages[5] for males, females and all workers are presented in Figure 2.8. As can be seen, they have remained fairly stable since 1989.

Figure 2.8: Ratios of minimum wages to average wages, 1978–96



Source: Author's calculations based on data from MUS, 1978–96.

Several studies (Jiang and San 1987; Huang 1995; Shin 1995) suggest that only employment in young age groups (15–19 and 20–24) is negatively influenced by minimum wages, and that even among these groups, the magnitude of the effect is very small. Neither did the increase in the minimum wage lead to general wage increases. The number of workers who earn less than the minimum wage does not differ greatly between those industries covered by the labour standard law and industries not covered. The minimum wage has not been effectively implemented and penalties for violating the regulations range from NT $2,000 to $20,000, a mere drop in the ocean to

[5] Average wages are for industries covered by the Labour Standard Law. The media industry is not included because it is not possible to separate it from the service industry in the Manpower Utilisation Survey.

employers. These are the main reasons that the minimum wage has had little influence on wage setting (Huang 1995; Shen 1998).

Trade unions in Taiwan play an insignificant role in the determination of wages. There are two types of union: industrial unions and occupational unions established on a geographical basis. Although workers are required by the Union Law to join unions (industrial or occupational, but not both), in practice, many do not. For example, in 1989, only 26 per cent of workers in manufacturing industries were union members. Unions tend to be more heavily involved in training and social activities than wage bargaining (Wu 1994).

Two other factors of the Taiwan labour market are noted in the literature (Lai 1989): (i) Most enterprises in Taiwan are small or medium sized and many of them are family businesses. The relationship between employers and employees is therefore not characterised by an overt power struggle, as is the case in most Western societies. The close relationship between employers and employees and a cultural preference for harmonious relationships tend to mitigate conflicts in the Taiwanese workplace. Problems are usually solved by negotiation between employers and employees rather than through public channels. (ii) The power of unions was restricted by the government until 1987 when the ban on striking was lifted. Recently the number of strikes has been increasing, but there has been little research on the impact of unions on wages after 1990.

2.2.2 Compensation Mix

In Taiwan, salaries are paid in a number of ways. In general, basic salaries are paid on a monthly basis. Besides the basic salary, significant amounts are paid in the form of

bonuses and fringe benefits, which are considered part of the total salary package. Table 2.1 shows the average pay package for employed workers. Regular salary includes basic salary, regular monthly allowances, and other regular monthly payments.[6] Overtime payments, one-off bonus payments and other allowances are included in non-regular salary. Fringe benefits encompass a wide range of payments, for example insurance paid by employers, superannuation, retrenchment packages, school fees, bereavement payments and payments on the birth of a child, to name a few.

Table 2.1: The structure of pay of employed workers, 1984–95

	overtime & bonus payment	fringe benefit	regular salary	total
1984	9.97	6.06	83.97	100
1985	12.24	6.87	80.89	100
1986	9.48	7.50	83.02	100
1987	9.94	7.79	82.27	100
1988	12.38	6.43	81.19	100
1989	10.29	6.70	83.01	100
1990	10.40	6.69	82.91	100
1991	12.01	6.83	81.16	100
1992	11.65	7.53	80.82	100
1993	12.14	7.26	80.60	100
1994	12.70	7.55	79.75	100
1995	11.80	9.91	78.29	100

Source: Report of occupational salary survey, 1985–95, DGBAS.

Table 2.1 shows that, on average, regular salary is only around 80 per cent of total earnings, and the percentage has decreased slightly over time. Because salaries reported in this survey are only for July, the most important bonus payment, the New Year bonus, is not included in this report. As mentioned in the literature (Chang and Wu 1983), this payment is an important instrument for the cyclical adjustment of

[6] For workers in some industries, the basic salary is supplemented by an additional payment or commission that is calculated according to productivity. These can take the form of payments on the basis of piece rates or production or sales achievements, for example.

compensation. The New Year Bonus is paid before the Chinese New Year, usually according to both the profitability of the company and individual performance in the year.

Unfortunately, information on bonus payments (including the New Year bonus) is usually unavailable from the national household survey. When information on bonus payments is collected, it is at an aggregate rather than a unit record level. Thus, the effects of cyclical fluctuation on wages reported in Chapter 5 are underestimated because the data employed in this thesis only offer information on regular monthly earnings.

Chapter 3 Theoretical background and literature review

The hypothesis that an individual's wage increases with his/her labour market experience and that well-educated workers have higher wages than less educated workers is well supported by empirical evidence. Many theories have been developed to explain experience–wage and education–wage differentials. Great attention has been paid to human capital theory due to its broad application in explaining labour market outcomes. Therefore, the bulk of the discussion in this chapter is on human capital theory and the development and application of the Mincerian wage equation, the most widely applied method in the literature for estimating the returns to human capital.

3.1 Experience–wage differential

3.1.1 Theory

The basic assumption of human capital theory is that, in a competitive labour market, workers are paid according to their productivity (Becker 1975). The upward-sloping lifetime earnings profile implies that a worker's productivity increases with the accumulation of labour market experience. Although workers' productivity can be raised through investment in physical capital or technological change, investment in human capital is a major source of an individual workers' rising productivity.

The broad definition of human capital investment refers to the activities that influence future income by increasing the resources invested in (or accumulated by) people such as schooling, on-the-job training, medical care, and migration. In this

thesis, human capital is restricted to knowledge and skills that are acquired through training, including schooling and on-the-job training, the common definition used in literature. As in much of the literature, on-the-job training is approximated by labour market experience and not observed directly.

This section focuses on post-school human capital investment. The present analysis refers to individuals who have the same level of education. On-the-job training, taking the form of formal training or learning-by-doing, is very difficult to measure. Since investment in human capital is time-consuming, Mincer (1974) developed a human capital earnings equation that has been widely applied to estimate returns to human capital investment by assuming that investment costs are time costs. The direct cost of on-the-job training is ignored in his analysis. The procedure of deriving the equation is as follows:

$$E_t = E_{t-1} + rC_{t-1} \qquad (3.1)$$

where E_t is gross earnings in the period t, C_{t-1} is the dollar value of net investment in the period t-1 and r is the average rate of return on the individual's investment in human capital. If the ratio of investment expenditure to gross earnings, C_t / E_t denoted by k_t, is given by viewing investment in time-equivalent units, equation (3.1) can be rewritten as:

$$E_t = E_{t-1}(1 + rk_{t-1}) \qquad (3.2)$$

By recursion,

$$E_t = E_0 \prod_{i=0}^{t-1} (1 + r_i k_i) \qquad (3.3)$$

Assuming $k \leq 1$, and r is relatively small, a logarithmic approximation of $\ln(1 + sk) \approx rk$, the gross earnings function becomes:

$$\ln E_t = \ln E_0 + \sum_{i=0}^{t-1} r_i k_i \qquad (3.4)$$

Based on equation 3.4, the empirical earnings function can be written as a function of labour market experience for individuals with the same level of education. The proper functional specification for experience depends on the form of the life-cycle investment function. If the investment ratio is assumed to decline linearly, then the earnings equation includes experience (*EXP*) and its quadratic terms (*EXPSQ*), the most widely applied specification (see Mincer 1974 or Borland and Suen1994):

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ \qquad (3.5)$$

Economic theory provides no guidance about the specific form of the investment ratio besides the fact that it declines over the life cycle. That is, the best specification of the experience term is not suggested. Hence, in Chapter 5, a set of experience dummies is used to let the data determine the form of the experience effect on wages, and the results do suggest a quadratic functional form. The experience effects

$\partial \ln W / \partial EXP = \beta_1 + 2\beta_2 EXP$) on wages are explained as returns[7] to post-school human capital investment.[8]

3.1.2 Empirical estimation: cross-sectional vs cohort

Since the concept of returns to experience is longitudinal, the ideal way to estimate the earnings equation is to trace individuals' life-time earnings through time and then correct for effect of changing general economic conditions. Unfortunately, the scarcity of panel data forces most studies to use cross-sectional data to estimate the earnings equation.

In cross-sectional data, individuals with different years of experience belong to different cohorts[9] as they have entered the labour market at different point of time. They have been subject to very different economic conditions and their educational quality can also differ significantly. Hence, their wage differences are arrived at not only as a result of differences in experience but also differences in cohort characteristics. Put simply, the initial value of human capital stock for different cohorts can differ even when they have the same years of schooling. It is therefore too strong a conclusion to attribute experience–wage differentials solely to the returns to human capital investment. This can be explained by the following mathematical analysis.

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[7] This is different from 'rate of return'. In equation 3.5, the coefficient of experience is not referred to the rate of return (r) in equation 3.4 (see Mincer 1974: 87).

[8] Tan and Chapman (1980) distinguished the effects of experience and tenure as the returns to general and specific training. Here, these two effects are not distinguished. The increase in wages with experience is a result of both general and specific human capital investment.

[9] The cohort in this thesis is defined by labour market entry year as opposed to birth year, as is generally adopted in the literature. However, for individuals who have the same level of education, birth cohort and labour market entry year, the cohort amounts to the same thing. These two definitions only make a difference when analysing individuals whose education levels are different. See Chapter 4 for further discussion.

Assume that wages equal the sum of a worker's starting wage, the experience–wage premium and the wage premium arising from economic growth experienced in the period after the worker began employment. This can be represented as follows:

$$\ln W_t^c = \ln \alpha^c + (t-c)\beta + \ln \gamma_t \qquad (3.6)$$

Where W_t^c is the wage of c cohort workers at year t ; c denotes the cohort, defined as a worker's labour market entry year in this thesis. γ_t represents the wage premium from economic growth. β is the returns to experience.[10] The equation is expressed in a log linear form for consistency with the empirical model for the wage equation.

Calculating the experience–wage differentials between levels of experience 0 and n from cross-sectional data in year t, the equation becomes:

$$\ln W_t^{t-n} - \ln W_t^t = \ln \alpha^{t-n} - \ln \alpha^t + n\beta \qquad (3.7)$$

For the cross-sectional data surveyed in year t, individuals who have n years of experience entered the labour market at year t-n, so they belong to cohort t-n. Similarly, new labour market entrants in year t belong to cohort t.

While most studies (Mincer and Polachek 1978; Tan 1981; Mincer 1993) attribute all of the estimated wage differentials to experience, it is obvious from equation 3.7 that the log wage differences contain both returns to experience and cohort effects.

[10] Workers in different cohorts may not be perfectly substitutable because of different experience, education quality, etc. Therefore, productivity growth at any point of time may not be distributed equally across cohorts because of their different abilities to adapt to new technologies. Hence, β is not necessarily the same across cohorts. To simplify the analysis in this section, β is assumed to be the same across cohorts. This assumption can be relaxed in future studies.

The effects of cohort size on earnings growth have been examined in many studies (Welch 1979; Berger 1983; Berger 1985; Lin and Chu 1985). The evidence supports the idea that rapid increases in the proportion of young workers due to the entry of peak baby-boom cohorts into the labour market are associated with a reduction in the wages of those cohorts relative to the starting wages of their counterparts in older cohorts. However, cohort size and changes in labour force age composition, account for only part of the cohort effect on wages. Cohort effects caused by different educational quality and the different unobserved ability of various cohorts with the same level of education are not taken into account in these studies. (See Chapter 5 for further discussion of the sources of these effects.)

Although the effect of cohort quality has not been addressed in those studies on earnings of natives, this issue has been widely discussed in literature of immigrants' earnings. Borjas (1985) stresses that cross-sectional studies of immigrant earnings growth confound the true assimilation impact with immigrant cohort quality. Cross-sectional growth in the relative earnings of immigrant cohort can be decomposed into within-cohort growth and across-cohort growth. Using 1970 and 1980 US census, the study shows that the across-cohort earnings differentials are consistent with the secular decline in the quality of immigrants admitted to the United States.

Since educational quality and unobserved ability are very difficult to measure, Meghir and Whitehouse (1996) and Beaudry and Green (1997) estimated age–wage profiles[11] separately for different birth cohorts using stacked cross-sectional data in order to completely remove cohort effects. The idea is that, for example, individuals

[11] When the information on actual labour market experience is not available, potential experience is usually employed as a proxy. Since *potential experience = age - years of schooling - 6*, when the sample is restricted to workers who have the same years of schooling, estimating age–wage profiles for birth

who were 20 years old in 1970, must be 21 years old in 1971, and 22 years old in 1972. Following this rule, we can estimate a cohort wage equation by tracing the same cohort over time.

However, the experience–wage differential within the same cohort does not represent a pure return to human capital investment. It contains both returns to human capital and wage increases due to the effects of economic growth. The wage differential between levels of experience 0 and *n* within cohort *t-n* becomes:

$$\ln W_t^{t-n} - \ln W_{t-n}^{t-n} = n\beta + \ln \gamma_t - \ln \gamma_{t-n} \qquad (3.8)$$

The individuals in cohort *t-n* are observed to have *n* experience in year *t*, if they were new labour market entrants in year *t-n*. Equation 3.8 shows that the coefficient of experience in a Mincerian wage equation estimated from cohort data cannot be attributed to the returns to experience without removing year effects (effects of economic growth and business cycle).

In Borjas (1985), in order to control for year effects, the earnings growth of immigrant cohorts relative to the native cohorts were analysed instead of earnings growth of immigrant cohorts itself. Since the wage equations are still estimated by cross-sectional data, cohort effects of natives are not taken into account. The estimate of cohort earnings growth is still biased.

However, this thesis does not distinguish natives and immigrants. Year effects have to be removed by other methods, which are presented in Chapter 5.

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cohorts is the same as estimating experience–wage profiles for cohorts defined by workers' labour market entry year.

3.1.3 Empirical studies on returns to experience over time

As discussed above, there are two different approaches, cross-sectional and cohort analysis, to investigate changing experience–wage differentials, but most studies apply the former. Experience–wage differentials are presented in the form of experience–wage profiles estimated from Mincerian wage equations or the wage ratios of earnings between experienced workers and new entrants.

Using synthetic cohorts from the Survey of Consumer Finances over the period 1971–93, Beaudry and Green (1997) show that the slope of age–earnings profiles of Canadian men has been decreasing for more recent cohorts compared with older cohorts. This finding runs counter to the hypothesis that increased skill premiums explain the observed increase in the dispersion of male weekly earnings in Canada. Clearly, the slope of cross-sectional experience–wage differentials is decreasing over time, but the slope of cohort experience–wage differentials is not. This result can be generated by the low starting wage of young cohorts. When the wages of new entrants in a year is low, the cross-sectional returns to experience would be higher. But, in fact, the wages of those new entrants increase much in the next year, so that their returns to experience is higher than the earlier cohort. This provides a good example of the differences between cross-sectional and cohort estimations.

Although the year effects are not removed from their estimation, the returns to experience are still comparable between cohorts since they are all observed in the same period, unless economic growth has had very different influences on wages for old and young cohorts. One possible problem in this comparison is that different cohorts are observed at different stages of their working lives. According to the theory of

optimising behaviour, workers tend to invest more in their early life; age–wage profiles, therefore, are steeper when they are younger. In this sense, even if the returns to experience are the same across cohorts, the age–wage profiles estimated from data on younger workers would be steeper than profiles estimated from data on older workers'. However, this does not change the direction of changing cohort's wage profiles in Canada. It merely implies that the age–wage profile is even flatter for young cohorts in reality.

Wage ratios between high and low experience groups calculated from cross-sectional data are often used as an indicator of skill premium (Katz and Murphy 1992; Bound and Johnson 1992; Juhn, Murphy and Pierce 1993; Mincer 1993). As discussed previously, this measure of experience–wage differentials contains cohort effects on wages. Differences in the labour supply across cohorts are used to explain such changes, yet this can only explain part of the cohort effect embodied in cross-sectional experience wage differentials. Apart from cohort size, other cohort characteristics, such as educational quality, are not considered in these studies.

Katz and Murphy (1992) and Mincer (1993) are typical examples of this type of study. Katz and Murphy explain the increasing experience–wage differentials before the mid-1970s as being generated by the increased supply of young workers relative to old workers. The increase in supply of new entrants lower their starting wages and leads to a steeper cross-sectional experience-wage profile. However, the increasing experience-wage differentials in the mid-1970s and 1980s cannot be explained in this way since the baby boom cohorts had gained experience during that period. The smaller cohort size of new entrants in these years, theoretically, should have generated flatter experience–wage profiles. This contradicts the reality of increasing experience–wage

differentials. This phenomenon is explained by skill-biased technological change which has favoured experienced workers. The overall college/high school wage ratio is used as a proxy for the shifts of relative demand in skilled to unskilled labour in their studies.

Mincer (1993) used the ratio of young workers to total workers in the same educational level (RNE) to capture the effects of cohort size on the calculated experience–wage premium. However, RNE only reflects the size of the young cohort, not the size of the old cohort. Since both the wages of the old and the young cohort affect the experience–wage premium, only including the size of the young cohort as an explanatory variable merely captures part of the cohort size effect.

3.2 Education–wage differential

3.2.1 Theory

Education is regarded as an important process of human capital investment. The knowledge accumulated in educational institutions increases individuals' productivity later, and they receive higher wage rates than their counterparts with less education.

An alternative explanation for the higher wages of more educated individuals is that education has a screening effect. The knowledge acquired in educational institutions may not be directly useful to the occupations that individuals are engaged with in the future. Yet employers believe that well-educated workers have higher unobserved ability, so higher wages are paid for their higher expected productivity (Spence 1973).

These two theories are not exclusive. It is likely that both these mechanisms co-exist in the labour market. According to screening theory, the wage gap between higher-educated and lower-educated workers does not represent a 'return' to education since the higher earnings are due to higher unobserved ability. In this thesis, both theories are employed to explain the changing education–wage differential; human capital theory, however, is more closely followed.

The Mincerian wage equation has been widely used in estimating the wage effects of education. The equation is as follows:

$$\ln W = \alpha + \beta_1 S + \beta_2 EXP + \beta_3 EXPSQ \qquad (3.9)$$

where S denotes years of schooling. EXP and $EXPSQ$ are experience and its square term. β_1 denotes the percentage earning increase due to an additional year of schooling. This does not represent rate of return to schooling since forgone earnings and direct costs are not taken into account. In this thesis, β_1 is called the returns to schooling in order to distinguish it from rate of return to schooling.

The rate of return to education refers to the internal rate of return, that is, the discount rate that equals the present value of the costs and benefits of education. There are two types of internal rate of return, private and social. For private rate of return, costs includes direct costs, such as tuition and books, and forgone earnings. The benefit refers to the expected earning differences between an individual and a counterpart with one educational level less.

For the social internal rate of return to education, government expenditure and tax differences have to be considered in the cost and benefit function. Nevertheless, the

social benefit is generally underestimated because the externalities generated by education are ignored due to measurement difficulties. Hence, the private rate of return to education appears more often in the literature.

No matter what type of return to education is investigated, the Mincerian wage equation is an important instrument for summarizing wage differences between education groups. The differences of the present value for workers' life-time earnings between two educational groups are usually calculated on the basis of coefficients estimated from a Mincerian wage equation. The following discussion of empirical methods focuses on estimating the returns to education by means of the Mincerian wage equation.

3.2.2 Empirical estimation: cross-sectional vs cohort

In equation 3.9, the increment of log wage is assumed to increase linearly as years of schooling increase. This assumption seems artificial in reality. Different levels of education may have a very different effect on wages so that the effects of schooling will not be linear in the logarithm of wages. Whether a level of education is completed can make a big difference. Hence, a set of education dummies instead of years of schooling is usually applied in empirical work to capture the non-linearity of the schooling effect.

Generally, the returns to education are estimated from a single cross-section. In a cross-sectional study, although observations belong to different cohorts, education–wage differences are calculated from a comparison of the same cohort, since experience is included in the regression. Because cohort is defined as survey year

minus experience in this thesis, controlling for experience is equivalent to controlling for cohort.

The problem with cross-sectional estimation is that the coefficient of the education variable is determined jointly by the education–wage differentials for different cohorts. When we compare two cross-sections, the oldest cohort in the first year is not present in the second year's data, while the youngest cohort in the second year is not present in the first year's data. This means that the difference in returns to education between two cross-sections is likely to be driven by differences in education–wage differentials across cohorts and the changing cohort composition of the cross sections.

Taking an extreme case, when the returns to education for different cohorts are unchanged in the second year, the estimated cross-sectional returns to education can change only because the returns to education are different between the oldest cohort in the first cross-section and the youngest cohort in the second one. Moreover, the difference between the coefficients in the two years will be smaller than the difference in the education–wage differential between the two cohorts since the effects are averaged. The empirical results in Chapter 6 provide evidence for this argument.

3.2.3 Empirical studies on returns to education over time

In studies that explore returns to education over time, two different methods are commonly applied to estimate returns to education. One is to compare educational–wage differentials for the same experience group, and this is the method generally employed in the literature on wage inequality (Murphy and Welch 1992; Juhn, Murphy and Peirce 1993; Mincer 1993). The two experience groups that are often

analysed are new entrants, with 1–5 or 1–10 years of experience, and peak wage earners, with 25–30 or 25–35 years of experience.

The other method is to calculate the returns to education from the coefficients of education dummies using a cross-sectional Mincerian wage equation (Ryoo, Nam and Carnoy 1993; Schmitt 1995; Gindling, Goldfarb and Chang 1995). The thinking behind these two methods is the same. They both employ cross-sectional analysis, but the former assumes that the returns to education may be different according to experience group while the latter assumes returns to education are the same across different experience groups. (That is, the typical Mincerian wage equation does not allow for interaction of the education and experience effects, a restriction which is implicitly relaxed in the alternative group average approach).

An estimation of internal rates of return to schooling is also worth considering since the expected benefit is normally calculated from the regression results of cross-sectional Mincerian wage equations. Using wage data from the Manpower Utilisation Survey in the period 1978–91, Gindling, Goldfarb and Chang (1995) estimate both private and social internal rates of return to education in Taiwan. Using cross-sectional data to estimate life-time earnings implies that a combination of education-wage differentials for all cohorts is used as a proxy for the education–wage differential of a particular cohort, but the direct cost is specific to that cohort. If there is great difference in education–wage differential across cohorts, the estimated internal rate of return is meaningless because other cohorts' benefits are applied to compare with a particular cohort's cost. In this sense, life-time earnings estimated from a single cohort data is a better means of estimating an internal rate of return.

Similar research has been undertaken by Ryoo, Nam and Carnoy (1993) for South Korea. The same problem was also encountered in their study. Since Taiwan and Korea have experienced rapid economic growth and rising educational levels among their populations, the bias caused by cohort effects tends to be more serious. This underscores the necessity to reinvestigate the returns to education by means of cohort data.

Unfortunately, there do not appear to have been any studies that focus on returns to education by cohort. Therefore, in Chapter 6, returns to education over time by cohorts are investigated to expose the trends over the past two decades and compare them with the results from cross-sectional estimations.

4 Male Wage Structures in Taiwan — Evidence from Micro Data

4.1 Introduction

There is a rich source of data on wage structures and changes in wage structures over the period 1978–1996 in Taiwan, assembled through the Manpower Utilisation Survey (MUS). Answers to questions about the determinants of the pattern of wages ultimately require careful econometric analysis. But a great deal of information can be garnered, and the direction of analysis appropriately set, by first examining the raw data and summarising the main trends and patterns observed.

Thus, this chapter provides an overview of wage structures using MUS micro-data, a series of stacked cross-sections for the years 1978 to 1996. Without resorting to complicated econometric methods, the chapter simply employs tables and charts, allowing the actual data to reveal the wage outcomes in Taiwan's labour market over this 19-year period.

Studies in developed countries reveal increasing wage inequality in the 1980s and 1990s as a result of expanding educational and experiential wage differentials (Bound and Johnson 1992; Katz and Murphy 1992; Murphy and Welch 1992; Juhn, Murphy and Pierce 1993; Schmitt 1995). These increasing inequalities are not observed in several newly industrialised countries (NICs) such as Taiwan and South Korea. Wage inequality has been fairly stable over time in Taiwan and has been decreasing in South Korea (Kim and Topel 1995; Hsu and Chen 1998).

Kim and Topel (1995) argue that the enormous increase in educational level of the workforce is the main reason for the reduction in wage inequality in Korea. The average education level of the workforce also increased tremendously in Taiwan. Since the increase in the average education level of workforce is mainly caused by the increase in the average education level of labour market new entrants, an analysis of wage structures by cohort is a more direct method for investigating the wage effects of increases in human capital. Although there has been considerable discussion of the effects of increasing education levels of younger cohorts on wage structures, there have been very few studies which systematically analyse wage structures by cohort, and this will be taken up here.

This chapter investigates two different aspects of wage structures. In addition to wage inequality, educational wage differentials and experience–wage differentials (the traditional focuses in the literature) and the evolution of cohorts' wage paths are also presented. Since stacked cross-sectional data are employed, the wage trends of different cohorts can be tracked in order to understand the evolution of wages. Because a cross-section is a combination of individuals from different cohorts, investigating cohorts' wage paths is helpful in terms of understanding how a cross-sectional wage structure is formed. Furthermore, a comparison of cross-sectional and cohort experience–wage differences helps us to analyse the true returns to experience and education. This idea is taken up more formally in subsequent chapters.

This chapter is arranged as follows: section 4.2 presents a discussion of existing studies of wage structures that have been undertaken in developed countries and newly industrialised countries. Section 4.3 describes the data. In section 4.4, changes in wage structures over time are examined using commonly accepted methods from the

literature. Section 4.5 presents the cohorts' wage trends and a comparison of cross-sectional and cohort wage profiles. Section 4.6 offers a brief conclusion and a discussion of remaining issues.

4.2 Literature review

There are a number of well-known studies of changes in wage structures in developed countries. Using the Current Population Survey from the early 1960s to the late 1980s, studies in the United States report that the level of wage inequality declined slightly in the 1960s and increased rapidly after 1980 (Bound and Johnson 1992; Katz and Murphy 1992; Murphy and Welch 1992; Juhn, Murphy and Pierce 1993). Increasing wage dispersion is often attributed to an increase in skill prices[12], that is, educational and experience–wage differentials. Shifts in demand and changes in the age and education structures of the population (i.e. shifts in supply), are considered to be the main factors affecting skill prices, although shifts in demand elicit more attention than supply side factors in the literature.

Schmitt (1995) uses data from the General Household Survey (GHS) to examine developments in the British wage structure during the same period. Unlike the

[12] Following human capital theory, higher educated and more experienced workers are paid more because of their higher human capital embodied in higher productivity. Therefore, educational and experience–wage differentials are considered as the prices of skills. Strictly speaking, educational and experience–wage differentials represent the 'value' of human capital. Because human capital is intangible, it is impossible to distinguish whether changes in wage differentials are a result of changes in quantity or changes in prices. Thus, to consider educational and experience–wage differentials as skill prices implies that workers with the same years of schooling and years of experience are assumed to have the same amount of human capital. Nevertheless, it is unrealistic to assume that workers with the same years of schooling and education but in different cohorts have the same amount of human capital because of differences in education quality and economic conditions they have faced. This reinforces the importance of the cohort analysis in this thesis.

increasing wage inequality observed over both decades in the United States, earnings inequality in the United Kingdom fell slightly during the 1970s, but rose rapidly during the 1980s. Borland and Kennedy (1998) explore wage inequality in Australia and finds that it rose in the early 1980s, fell in the late 1980s and rose again in the early 1990s.

In newly industrialised countries such as South Korea and Taiwan, the patterns of changes in wage structures are very different from those in developed countries. Using the Occupational Wage Survey (OWS) for South Korea, 1971–89, Kim and Topel (1995) report that wage distribution became more equal in the late 1980s than it was in the 1970s. The log wage differences (90th percentile – 10th percentile) decreased from 1.683 in 1971 to 1.219 in 1989. Using the Manpower Utilisation Survey (MUS), 1978–96, Hsu and Chen (1998) show that wage inequality has been fairly stable over the past 19 years in Taiwan. The log wage differences between 90th and 10th percentiles fluctuated between 0.92 and 1.03; it was 0.94 in 1972 and went up to 1.03 in 1986 and fell back to 0.94 in 1996.

Since the education level of the population increased dramatically between 1970 and 1990 in Korea, Kim and Topel (1995) suggest that the supply factor, the educational composition of the work force, dominated demand factors and led to decreasing skill prices. Following the decomposition method introduced by Juhn, Murphy and Pierce (1993), Hsu and Chen (1998) reveal that the increment of wage over the past two decades was constantly attributed to the increment of returns to education and experience rather than the quantity changes.

The purpose of the method developed by Juhn, Murphy, and Pierce (1993) is to decompose price and quantity effects on wage growth in order to examine the source of

changing wage inequality. The method assigns the estimated returns to experience and education from a pooling of cross-sectional data to be the fixed price and the estimated returns from every single cross-section to be prices for those years. The price effect is defined as the product of quantity and differences in price. This is based on the assumption that workers with the same education and the same years of experience have the same amount of human capital.

Following the discussion of cohort and year effects on wages in Chapter 3, it is clear that without removing cohort and year effects, the fixed prices, returns to education and experience estimated from pooled data are affected by cohort and year effects. Thus, in the case of Taiwan, under conditions of high economic growth and enormous changes in cohorts' characteristics, it is likely that the price effects are dominated by cohort and year effects.

Investigating another aspect of wage structures, Meghir and Whitehouse (1996), Deaton (1997) and Hsu and Chen (1998) estimate age–wage profiles for different birth cohorts.[13] The wage paths for different cohorts in Taiwan display patterns that are more similar than is the case in the United Kingdom. Deaton's pictures also show that cohort age–wage profiles are much steeper than cross-sectional profiles. Younger cohorts always have higher wages than older cohorts at the same age. In this chapter, both the cohort experience–wage profiles and cross-sectional wage profiles will be illustrated separately by education level. The relationship between cross-sectional and cohort wage profiles will also be addressed in detail in what follows.

[13] The data employed in Meghir and Whitehouse (1996) are from the U.K. Family Expenditure Survey, 1968–86. Both of the datasets used in the other studies are from Taiwan: the Personal Income Survey 1967–1994 in Deaton (1997) and the Manpower Utilisation Survey 1978–1996 in Hsu and Chen.

As mentioned, most studies either focus on cross-sectional wage structures or cohorts' wage structures. Very few of them bring these two approaches together and compare the differences as will be done in this chapter. Although Deaton (1997) shows that the shape of cross-sectional wage profiles can be seen by connecting the data points for different cohorts observed at the same year in a set of cohorts wage profiles, the data employed in his study do not provide information on individuals' education and working hours. With the addition of information on individuals' education and working hours, the structures of hourly wages can be investigated by education and potential experience, which more clearly reflects the effects of human capital on wages. Detailed discussion of the data is presented below.

4.3 Data

4.3.1 The Manpower Utilisation Survey

The data employed in the thesis are from the Manpower Utilisation Survey (MUS) conducted by the Directorate-General of Budget, Accounting and Statistics (DGBAS), Taiwan between 1978 and 1996. This is an annual, national, household survey of individuals 15 years of age and older.

The survey started in May 1978 and has been repeated annually. On average, 18,000 households (45,000–60,000 individuals) are surveyed, and each household is surveyed over two consecutive years, but individual identification codes are not available for reasons of privacy.[14] The dataset contains most of the important information that is

[14] This prevents the exploration of the panel nature of the data. In addition, standard errors must be calculated without correcting for correlations within individual entries.

commonly used in estimating wage equations, including sex, education level, marital status, working hours in the survey week, employment status, tenure (experience in the current company), industry, occupation and regular monthly earnings.

Data from the MUS have been widely used in Taiwan to study wage profiles, wage differentials and wage inequality. For example, Zveglich, Rodgers and Rodgers (1997) use data from 1978 to 1992 to study gender earnings' differentials. They estimate cross-sectional earnings profiles and undertake comparisons over time. The results suggest that wage discrimination against female workers has increased over time. As well as cross-sectional comparisons, we can also use the dataset to perform a cohort analysis because of the nature of the MUS dataset — large sample size, consistent sampling methods and the long running period of the survey.

The large sample size ensures every single cross-section has enough observations in every cohort and the consistent sample method minimises the possible bias caused by the different samples for different cross-sections. With these two characteristics, individuals in the same cohort can be selected from every single cross-section for the analysis of the cohort's wage profiles, the main approach adopted this thesis to avoid the biases inherent in traditional cross-sectional estimation. Most importantly, the long-running period generates more variation in potential labour market experience for a given cohort so that the cohort's life-time wage profile can be estimated. Furthermore, the cyclical effect on wages for different cohorts can be examined as the survey period captures different stages of business cycle.

In the absence of a large-scale and long-running panel survey, this stacked cross-sectional data (MUS) is excellent for the analysis of cohorts' life-time earnings as well

as the decomposition of the experience, cohort, and year effects on wages. This possibility will be taken up in the following three chapters.

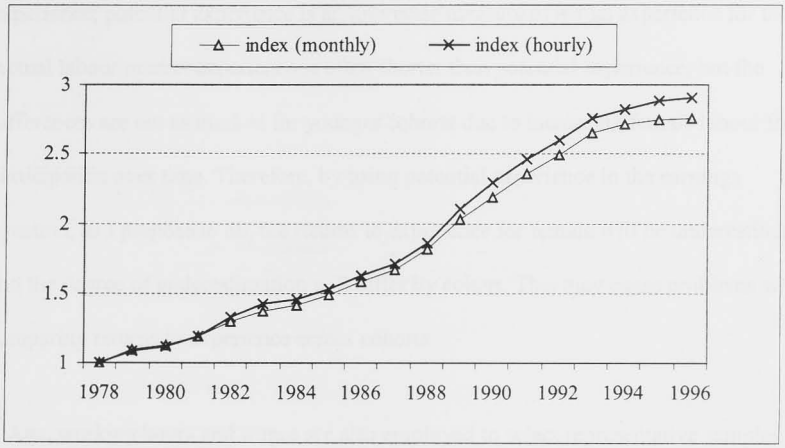
4.3.2 Earnings measure

The survey reports workers' regular monthly earnings including overtime and bonus payments. Earnings in the month before the survey week are reported if workers have stable monthly earnings; otherwise average monthly earnings in the past 12 months are reported. Unfortunately, only working hours in the survey week are reported and this causes problems in constructing hourly wages. For the purpose of studying changes in skill prices over time, hourly wages are a better measure than monthly wages, since average weekly working hours have been decreasing over the past twenty years, from 50.3 hours in 1978 to 47.6 hours in 1996 (see Table 4.1 below).

As shown in Figure 4.1, hourly wages have increased at a rate greater than monthly earnings because the decrease in working hours over time. Furthermore, Figure 4.2 shows that average working hours for primary school and junior high school graduates are higher than for other groups and also decreasing significantly over time. Therefore, the estimated returns to education may be biased when using monthly earnings as a dependant variable. Although hourly wage rates (monthly earnings divided by 4.33 multiplied by weekly working hours, as suggested in the literature) may not be a perfect earnings measure, they are adequate for the purposes of this study. So, in this thesis, wages are taken to be hourly wages deflated by consumer price indices on the basis of 1991 price levels.[15]

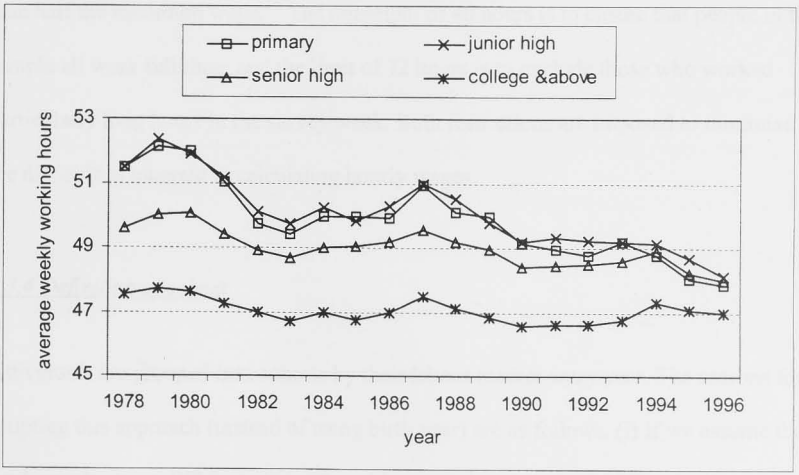
[15] The price indices are from the Commodity–Price Statistics Monthly in the Taiwan Area of the Republic of China published by Directorate-General of Budget, Accounting, and Statistics, R.O.C.

Figure 4.1: Indices of average real monthly wages and real hourly wages



Source: Author's calculations using data from MUS, 1978–96.

Figure 4.2: Average weekly working hours by education level



Source: Author's calculations based on data from MUS, 1978–96.

4.3.3 Sample selection criteria

The study focuses on paid male employees only. Self-employed workers, unpaid family workers and casual workers are excluded from the sample. Women are excluded

because married women are more likely to have discontinuous labour market experience; potential experience is an imprecise measure of actual experience for them. Actual labour market experience is often shorter than potential experience, but the differences are not as marked for younger cohorts due to increasing female labour force participation over time. Therefore, by using potential experience in the earnings equation, as I propose to do, the returns to experience for female will be underestimated and the degree of underestimation will differ by cohort. This may cause problems when comparing returns to experience across cohorts.

Age, working hours and wages are also employed to select representative samples. The sample includes individuals who are less than 65 years old, worked more than 40 but less than 72 hours in the survey week, and have monthly regular earnings of more than half the minimum wage.[16] The minimum of 40 hours is to ensure that people in the sample all work full time, and the limit of 72 hours is to exclude those who worked particularly long hours in the survey week. Both restrictions are imposed to minimise the difficulties inherent in calculating hourly wages.

4.3.4 Definition of cohort

Individuals are grouped into cohorts by their labour market entry year. The reasons for adopting this approach (instead of using birth year) are as follows. (i) If we assume that workers who have different years of working experience are imperfect substitutes, then it follows that economic conditions will have different effects on them. Grouping cohorts by individuals' labour market entry year means that workers in the same cohort

[16] In Taiwan, there are no strong restrictions on minimum wages, so it is possible for jobs to be paid at rates below the minimum wage, but it is not likely that a full-time worker would earn less than half the minimum wage, since this is well below basic subsistence requirements.

will have been subject to the same economic conditions in their working lives and it is more likely that they will have a similar experience earnings profile. (ii) Changes in labour supply affect wage setting. Under the definition of cohort adopted in this thesis, cohort size is a more direct indicator of labour supply than if cohort were defined by birth year.

Assuming that individuals enter the labour market immediately after completing their education, labour market entry year can be calculated as follows:

Labour market entry year = survey year – potential labour market experience

where potential labour market experience = age – years of schooling – 6.[17]

4.3.5 Summary statistics

Summary statistics of important variables by year and by selected cohort are presented in Tables 4.1 and 4.2. Cross-sectional average wages, presented in Table 4.1, nearly tripled between 1978 and 1996. Average years of schooling also increased over time. The stable average potential experience reflects two facts: (i) the age structure does not change much in Taiwan; (ii) the sampling method is reliable.

[17] In Taiwan, adult males are required to undertake two years' compulsory military service, with some exceptions. Unfortunately, the survey provides no information as to whether or when individuals undertook military service. In general, individuals with high school education or less enter military service at 20 years of age, and those with college education or more undertake military service after finishing their education. These factors increase the complexity of calculating potential experience and labour market entry year. Because many employers view military service as a kind of training in obedience and reward it positively, I have treated military service as working experience to simplify matters.

Table 4.1: Summary statistics by year

	hourly wage		years of schooling		potential experience		weekly working hours		
year	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	no of obs
1978	51.88	24.13	8.50	3.81	18.92	12.92	50.31	6.58	9,477
1979	56.37	27.54	8.66	3.82	18.75	13.15	50.92	6.43	10,399
1980	57.84	27.83	8.93	3.77	18.95	13.12	50.76	6.41	10,703
1981	61.78	28.24	8.94	3.77	18.86	13.24	49.99	6.02	11,399
1982	68.45	31.84	9.14	3.71	19.03	13.16	48.97	5.90	10,991
1983	72.72	35.95	9.49	3.72	19.13	13.15	48.62	5.59	10,745
1984	74.63	35.28	9.65	3.71	18.89	13.06	48.95	5.68	11,218
1985	78.32	37.07	9.62	3.67	18.83	12.88	48.88	5.63	11,325
1986	83.18	39.96	9.71	3.62	18.81	12.77	49.01	5.73	11,301
1987	87.01	43.14	9.92	3.58	18.76	12.68	49.57	6.14	12,172
1988	94.76	44.73	10.01	3.57	19.14	12.66	49.16	5.69	12,352
1989	106.71	47.81	10.22	3.58	18.92	12.48	48.79	5.42	12,359
1990	116.47	50.15	10.25	3.53	19.08	12.47	48.20	5.41	12,019
1991	125.25	51.40	10.29	3.48	19.11	12.41	48.30	4.99	11,631
1992	132.79	56.83	10.50	3.44	19.27	12.31	48.19	5.07	11,739
1993	140.86	67.59	10.55	3.44	19.16	12.18	48.32	5.27	12,853
1994	144.09	60.40	10.55	3.37	19.02	12.13	48.45	5.27	12,868
1995	147.40	67.41	10.79	3.32	19.10	11.97	47.92	4.96	12,782
1996	149.07	75.73	11.09	3.31	18.91	11.74	47.60	5.01	11,870

Source: Author's calculations based on data from MUS, 1978–96.

Table 4.2: Summary statistics by selected cohort

	hourly wage		years of schooling		potential experience		weekly working hours		
year	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	no of obs
1930	49.17	20.99	4.04	3.15	49.80	1.42	47.96	5.98	113
1935	58.27	27.83	4.95	3.48	45.98	2.44	49.69	6.90	546
1940	70.87	34.99	6.53	3.57	43.05	3.75	48.99	6.52	1,395
1945	84.42	41.82	7.45	3.94	39.69	4.68	48.52	6.21	2,303
1950	94.63	52.31	7.47	4.27	35.79	5.18	48.52	5.93	2,844
1955	103.07	54.98	7.94	3.71	31.37	5.34	48.79	5.99	2,918
1960	108.52	64.21	8.70	3.58	26.52	5.39	49.24	6.20	3,341
1965	101.79	57.72	8.68	3.39	21.41	5.50	49.44	6.00	4,850
1970	105.70	61.68	10.56	3.19	16.62	5.39	49.07	5.72	5,300
1975	99.02	59.67	11.13	2.71	11.98	5.24	49.04	5.49	7,736
1980	98.78	59.16	11.46	2.47	8.73	4.58	49.13	5.36	6,208
1985	106.56	53.15	11.93	2.36	6.46	3.23	48.80	5.19	4,311
1990	105.36	43.87	12.32	2.29	3.70	1.93	48.55	5.03	1,801
1995	81.59	33.87	11.57	1.75	0.41	0.49	47.74	4.53	331

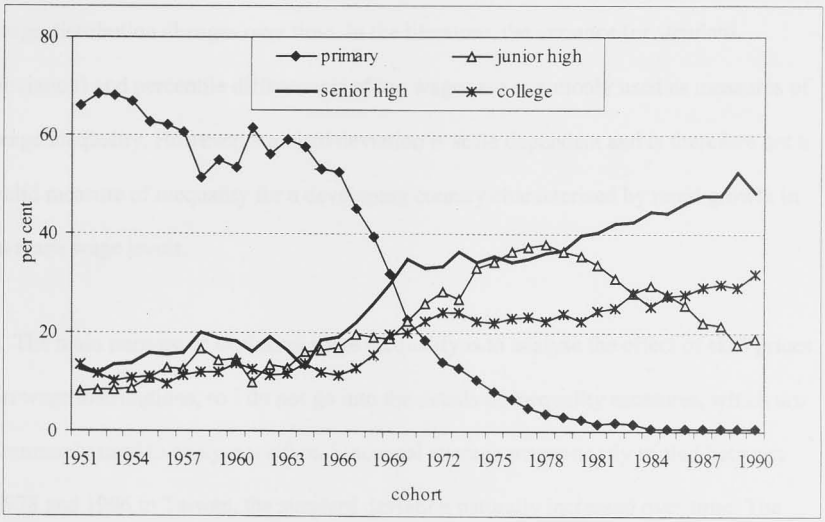
Source: Author's calculations based on data from MUS, 1978–96.

Average wages by cohort presented in Table 4.2 do not show a monotonic trend. The low average wages for the 1930s and 1940s cohorts may be a result of low years of schooling or high years of experience (they may be observed beyond the peak of their

experience–wage profiles). Because the 1930s cohort was surveyed later in life, their average years of experience are much higher than the 1990s cohorts. Average years of schooling increase even more dramatically than the increase in cross-sectional averages. The number of observations for the 1930s, 1940s and 1990s cohorts is small because these cohorts are only observed in some years, not over the entire 19 survey years.

To clarify the increase in education level among cohorts, Figure 4.3 shows the proportion of workers at each education level against all workers for each cohort.

Figure 4.3: Distribution of workers by education and cohort, 1951–90[18]



Source: Author's calculations based on data from MUS, 1978–96.

[18] The cohorts that entered labour markets before 1950 or after 1990 are not presented in this graph. The share of higher educated workers in the old cohorts is biased downward because they have reached retirement age, but the less educated workers have not. For the young cohorts, some of them are in military service, and they are not included in the sample. The distribution of workers by education may thus be distorted. For these reason, only the distributions for 1951–90 cohorts are reported.

Nearly 70 per cent of workers in the 1951 cohort have primary education only, while almost all workers in the 1990 cohort have at least junior high school education. From these figures we can see the dramatic change in workers' educational levels. This reinforces the importance of looking at wage structures from both cross-sectional and cohort perspectives. To focus on only one aspect may mean that important findings are missed.

4.4 Changes in wage inequality

This section presents changes in wage inequality among male workers over the past two decades in Taiwan. The purpose of this section is to provide a broad picture of wage distribution changes over time. In the literature, the variance (or standard deviation) and percentile differentials of log wages are commonly used as measures of wage inequality. However, standard deviation is scale dependent and is therefore not a valid measure of inequality for a developing country characterised by rapid growth in average wage levels.

The main purpose of exploring wage inequality is to analyse the effect of skill prices on wage distributions, so I do not go into the details of inequality measures, which are commonly used to analyse welfare. Since real average wages nearly tripled between 1978 and 1996 in Taiwan, the standard deviation naturally increased over time. The coefficient of variation can be used instead of standard deviation to avoid the scale dependency problem. However, percentile differentials of log wages are used to represent wage inequality in this chapter for comparability with the literature. Another reason for adopting this method is that the coefficient of variation provides only a summary measure of inequality, while by using the inter-percentile range of log wages,

an entire picture of the distribution of inequality can be built by varying the width of the percentile range.

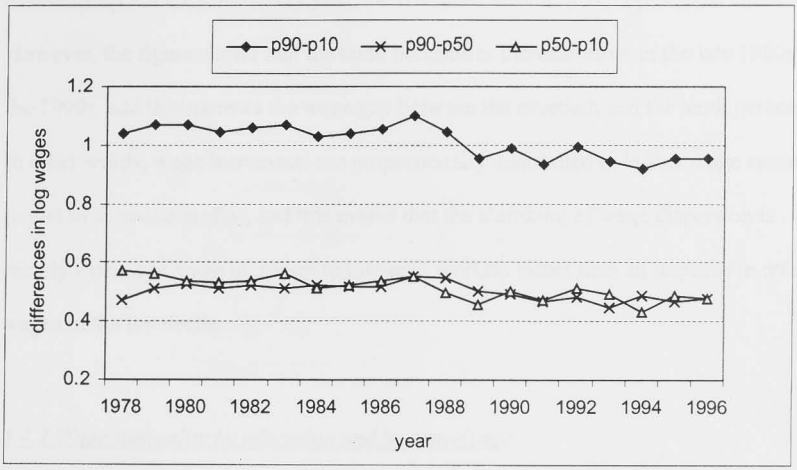
4.4.1 Overall wage inequality

Figure 4.4 shows differences in log wages by survey year. The ninetieth–tenth percentile log wage differentials are fairly stable from 1978 to 1988, fluctuating around 1.05. After 1989, the log wage differentials drop slightly to below 1 and remain stable to 1996. This means that high wage earners (represented by the ninetieth percentile) earned about 2.9 times more than low wage earners in the late 1970s and early 1980s, and 2.6 times more in the late 1980s and early 1990s. Using this measure, unlike developed countries with increasing wage dispersion over the past two decades, wage inequality seems to be fairly stable in Taiwan. This result does not support Kuznets's conjecture of increasing wage inequality during economic development (Kuznets 1955). Furthermore, the wage distributions are very close to symmetric. The lines of ninetieth–fiftieth and fiftieth–tenth percentile wage differentials almost lie on top of each other. The one exception is in 1978; this oddity remains a puzzle.

The inter-decile ranges of log wages presented in this chapter are slightly lower than those in Hsu and Chen (1998). This is because of different sample selection criteria. Hsu and Chen exclude workers less than 20 years old,[19] and these are the people who are most likely to be in low paying jobs. This is most likely the reason for the lower wage inequality they observe.

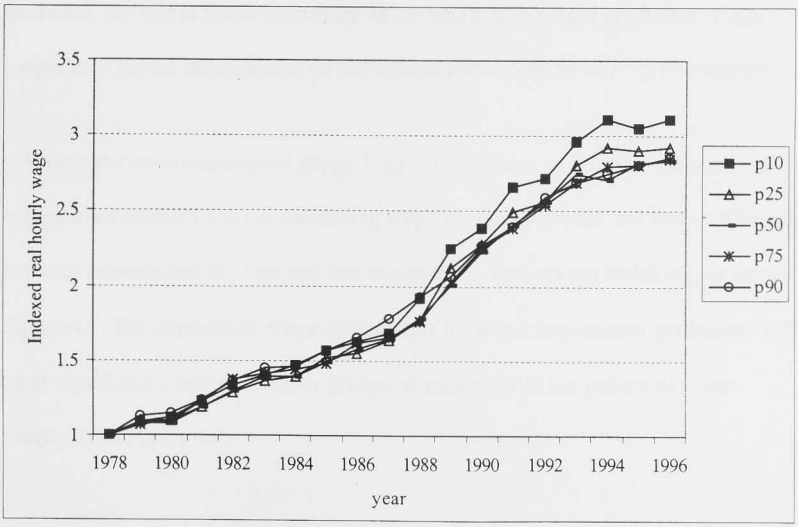
[19] Most people who are less than 20 years old and are working have high school education only, or less than high school education, and fewer years' working experience. Hence, they are more likely to belong to the low paid group.

Figure 4.4: Inter-percentile range of log real wages



Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.5: Indexed real hourly wages by percentile



Source: Author's calculations based on data from MUS, 1978–96.

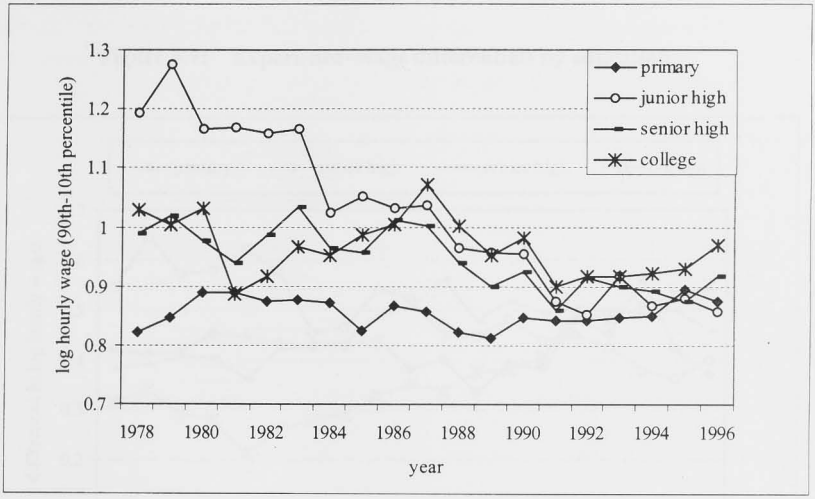
Figure 4.5 presents indices of real hourly wages for different percentiles. If wage distributions are the same every year, the five lines should lie on top of each other. However, the figure shows that the tenth percentiles increase more in the late 1980s and the 1990s, and this narrows the wage gap between the ninetieth and the tenth percentile. In other words, wage increments are proportionally distributed to higher wage earners (equal to or above media), and this means that the shrinking of wage dispersion is mainly a result of wage increases to low-paid workers rather than an increase in relative wages in the top decile.

4.4.2 Wage inequality by education and by experience

Within-group wage inequality by education is presented in Figure 4.6. For junior high school graduates, the ninetieth and tenth percentile wage ratio is much higher in 1978 than in 1996. We can also see decreasing wage inequality among senior high school graduates, but this is not as significant as for junior high school graduates. Wage inequalities for the other groups do not exhibit trends over time, only fluctuations.

Within the same educational group, high wage earners, in general, are more experienced workers. Hence, decreasing wage inequality means that wage differentials between experienced workers and less experienced workers are shrinking, as shown in Figure 4.7. The experience–wage differentials for junior high school graduates decline most significantly among the four groups, consistent with the pattern of wage inequality in Figure 4.6.

Figure 4.6: Inter-percentile (90th–10th) range of log wage by education



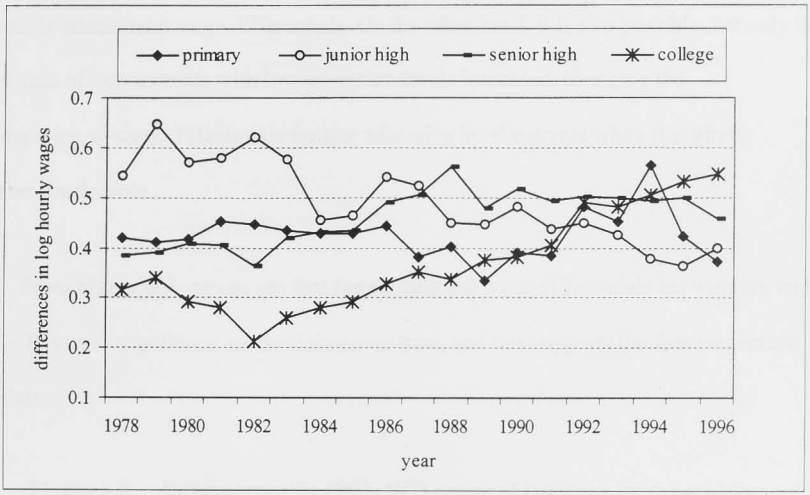
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.7 shows that the wage differentials between experienced and less experienced workers for the primary education group do not display a significant time trend. The slight decline in the late 1990s is possibly due to the increase in the wages of new labour market entrants caused by the unskilled labour shortage in that period, as mentioned in Chapter 2. After the legalisation of foreign labour, wage differentials increase again in the 1990s.

The experience–wage differentials for college graduates increase over time, possibly as a result of the increase in the supply of college graduates among young cohorts (which would drive down the wages of new college graduates). For senior high school graduates, the experience–wage differentials increased slightly in the 1980s but did not change much in the 1990s. This does not match the pattern of the inter-percentile range

of the log wage for high school graduates. What caused this contrast is still a puzzle to be solved by future research.

Figure 4.7: Experience–wage differentials by education



Source: Author's calculation using data from MUS, 1978–96.
Note: Average log wages of workers with 30 to 40 years of experience – average log wages of workers with 0 to 10 years of experience.

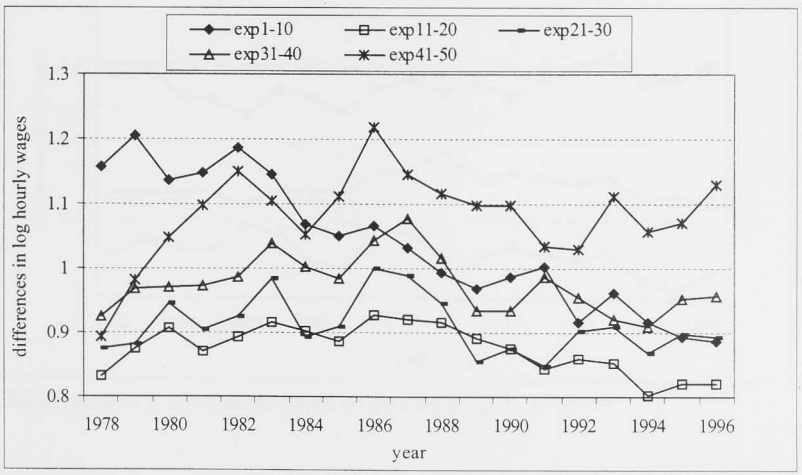
One thing to be kept in mind is that decreasing experience–wage differentials do not necessarily mean that returns to experience are decreasing over time. As discussed in the previous chapter, in a cross-section, people with different years of experience belong to different cohorts, and their wage differentials may be caused either by differences in experience or in cohort characteristics.

Figure 4.8 shows the trends in wage inequality by experience groups. Wage inequality among workers in the less experienced group (1–10 years' experience) fell from nearly 1.2 to 0.9. The group includes workers with different education levels and different years of experience. Possible reasons behind the decreasing trend are that: (i)

the education–wage differential for this group is decreasing; and/or (ii) the experience–wage differential is decreasing. In general, low wage earners are new entrants with less education. It is possible that wages for all new entrants with different education levels increased and led to decreasing experience–wage differentials but stable educational wage differentials. On the other hand, it is also possible that only the wages of new entrants with low education levels increased, changing the experience–wage differentials for low education level entrants while the others remained stable.

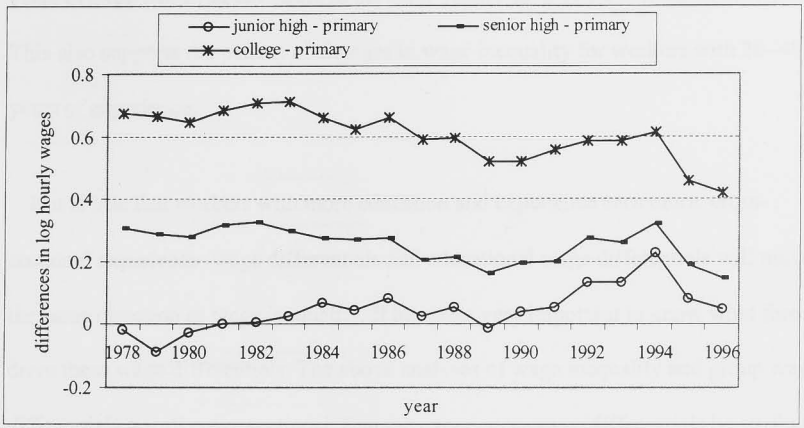
From Figure 4.9, we can see that the educational wage differentials for workers with 1–10 years' experience are declining over time, and this supports the first conjecture above.

Figure 4.8: Inter-percentile (90th–10th) range of log wage by experience



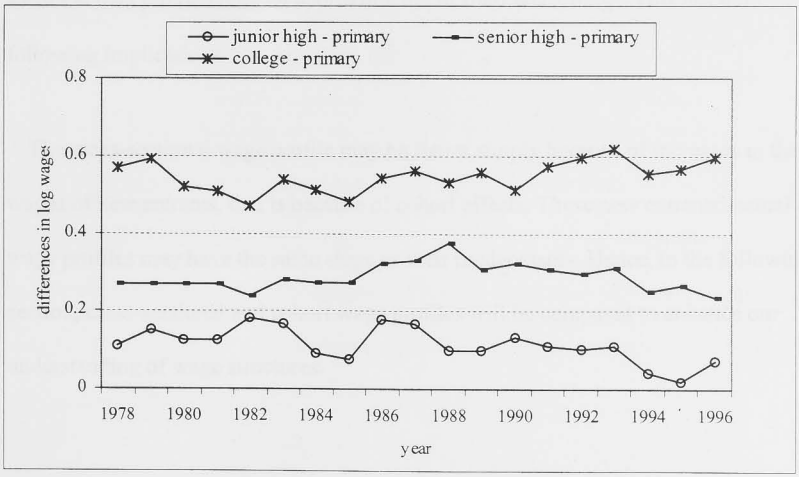
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.9: Educational wage differentials (1–10 years of experience)[20]



Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.10: Educational wage differentials (30–40 years of experience)



Source: Author's calculations based on data from MUS, 1978–96

[20] The Manpower Utilisation Survey only focuses on individuals who are 15 and over. Primary graduates with less than three years' experience are therefore not included in the sample. Average experience is therefore higher for the group with primary education than for those with junior high school education. This may be the reason why the average wage for high school graduates is lower than that for primary school graduates in the first few years.

Figure 4.10 shows that the educational wage differentials for workers with 30–40 years of experience remain stable in the early years and increase slightly in later years. This also supports the pattern of changes in wage inequality for workers with 30–40 years of experience.

If it is true that workers with more education and experience earn more, cross-sectional experience–wage differentials and educational wage differentials will move in the same direction as wage inequality. It becomes very important to know what forces drive these wage differentials. The above analyses of wage inequality and group wage differentials are all cross-sectional. Can the experience–wage differentials be attributed completely to returns to investment in human capital? As discussed in Chapter 3, the concept of returns to human capital is based on life-time working experience, but cross-sectional data provide only an approximation of lifetime earnings. This has the following implications.

The cross-sectional wage profile may be flatter simply because of increases in the wages of new entrants, that is because of cohort effects. These new entrants' actual wage profiles may have the same slope as their predecessors. Hence, in the following section, cross-sectional and cohort wage profiles will be compared to enhance our understanding of wage structures.

4.5 The evolution of wages

In this section, the evolution of wages for different cohorts is illustrated by graphing the average wages of cohorts at different points of time. As discussed in earlier chapters, rapid changes in demographic features may give rise to cohort effects on wages; an

analysis of changes in cross-sectional wage profiles over time is not sufficient for an understanding of the evolution of wages. Therefore, tracing cohorts' average wages over time can help us to understand better the life-time earnings of different cohorts as well as changes in wage structures.

4.5.1 Grouping individuals

Cohort, education and survey year are employed to group individual observations into cells. The averages of wages and other relevant variables for each cell are calculated in order to trace cohort wages over time. The constructed grouped observations can be regarded as a pseudo-panel dataset.

When a population is not greatly affected by immigration and a cohort is not so old that its members are dying in significant numbers, membership of the cohort is basically stable over time. If we suppose that individuals are randomly selected into the survey, the cohort sample means can represent the cohort population means, so we can follow each cohort over time from successive surveys in just the way that we follow the same individuals over time in a panel survey. In this way, panel data analysis techniques can be applied to the analysis of pseudo-panel data. What is different is that individuals' heterogeneity can be controlled using genuine panel data while the analysis of pseudo-panel data take cohorts' heterogeneity into account.

As mentioned, cohort wage structures can be investigated using this pseudo-panel data instead of using separate cross-sections to avoid the bias caused by cohort effects. In this section, the pseudo-panel dataset is used for graphic analysis of the evolution of wages.

One advantage of grouping observations is that some measurement errors will be eliminated by the procedure of taking averages. There is a trade-off between the number of cells and cell size. When we group five entry years together in a cohort, there are more individual observations in each cell, and individual measurement errors are more likely to be eliminated by taking group means. On the other hand, grouping five year cohorts together means that fewer cells are formed. Some variations between cohorts in the same cells will be offset when taking cell means. In other words, small cell sizes (fewer observations per cell) imply less precise estimates of the population group means but it increases the number of observations.[21]

Another reason of grouping five entry years together is to reduce the complexity of the graphs. For single entry year cohort, more than 50 cohorts are observed in the survey period. It is very difficult to decipher the trends when more than 50 cohorts' wage paths are included in the same graph. The regrouped cohorts are cohorts 1 to 10 and each redefined cohort is divided into four educational groups (primary education and less, junior high school, senior high school, college and above). In total, 651 cells are formed. Table 4.3 shows the definition for each group, data for the observed years, average cell size and the numbers of cells for each cohort.

[21] A detailed discussion of these issues can be found in Verbeek (1992).

Table 4.3: Structure of pseudo-panel data constructed from MUS

	cohort	period of observation	experience observed	number of cells	average cell size
cohort 1	1946–1950	1978–96	28–50	74	180
cohort 2	1951–1955	1978–96	23–45	76	188
cohort 3	1956–1960	1978–96	18–40	76	197
cohort 4	1961–1965	1978–96	13–35	76	284
cohort 5	1966–1970	1978–96	8–30	76	335
cohort 6	1971–1975	1978–96	3–25	76	456
cohort 7	1976–1980	1978–96	0–20	75	480
cohort 8	1981–1985	1981–96	0–15	61	414
cohort 9	1986–1990	1986–96	0–10	41	333
cohort 10	1991–1996	1991–96	0– 6	20	197

Source: Author's calculations based on data from MUS, 1978–96.

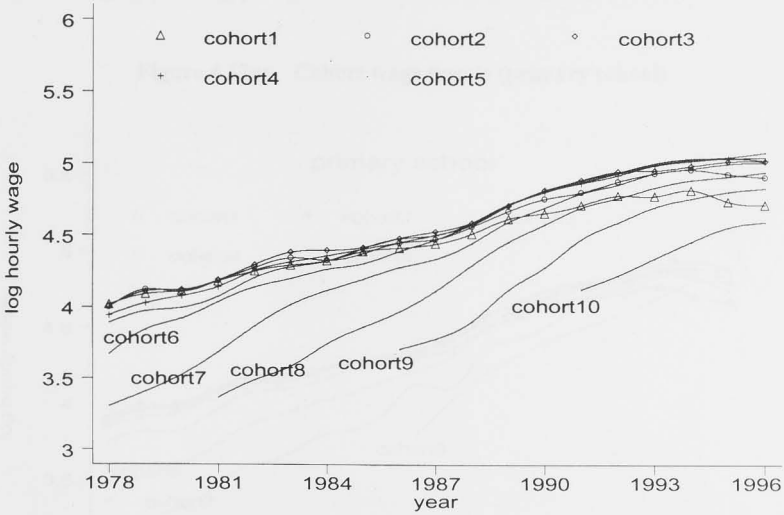
4.5.2 Graphical analysis of cohorts' wage trend and experience–wage profiles

Figure 4.11 presents wage trends over time by cohort. The graph can be read from two different perspectives. One is to compare the wage of the same cohort over time, and the other is to compare different cohorts at the same time point. The increase in the average wage of a cohort over time may be caused by an increase in workers' experience and economic growth.[22] For example, workers in cohort 1 had 28–32 years of experience in 1978 and 29–34 years of experience in 1979. In 1978, cohort 2 had 5 years' less experience than cohort 1, on average. Differences in experience and differences in cohort characteristics may therefore have been the factors underlying the wage gap between two cohorts at different points in time.

[22] There are other possible explanations of wage increases, such as better match. Here, the explanations mainly follow human capital theory.

From Figure 4.11, we can see that cohorts' average wages all trend up over time, except cohort 1 in the period after the early 1990s. One possible reason is that people in cohort 1 who had more than high school education retired during that period, leaving only lower educated workers in the sample and this lowered the average wages of that cohort. Another possibility is that cohort 1 has reached the stage where their wages are actually falling. A similar time profile over the 1990s can also be seen in Figure 4.12 for the primary education group, but it is not as pronounced as that in Figure 4.11. This implies that the wage trend for cohort 1 in Figure 4.11 is possibly driven by both of these reasons. If only the first reason is correct, then the picture of wage paths for the primary education group would have been the same as that in Figure 4.11.

Figure 4.11: Cohort Wage Trends[23]



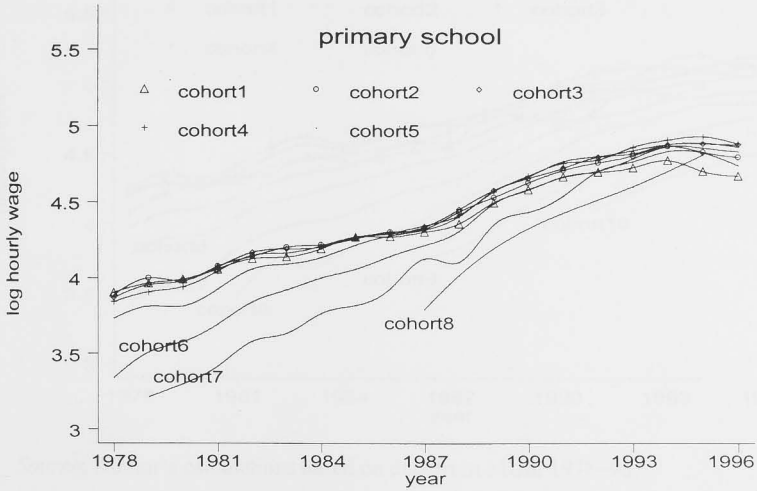
Source: Author's calculations based on data from MUS, 1978–96.

[23] The cohorts' average wages for this figure are calculated from samples with all education levels pooled together.

The wage trends and levels for cohorts 2–5 are very similar. This shows that experience does not have a significant effect on wages for workers in their middle and late working lives, or the experience effect is offset by differences in cohort characteristics, such as changes in average education levels or cohort sizes. The young cohorts, cohorts 6–10, all started on lower wages and caught up later on. This reflects the fact that wages increase faster in workers' early working lives.

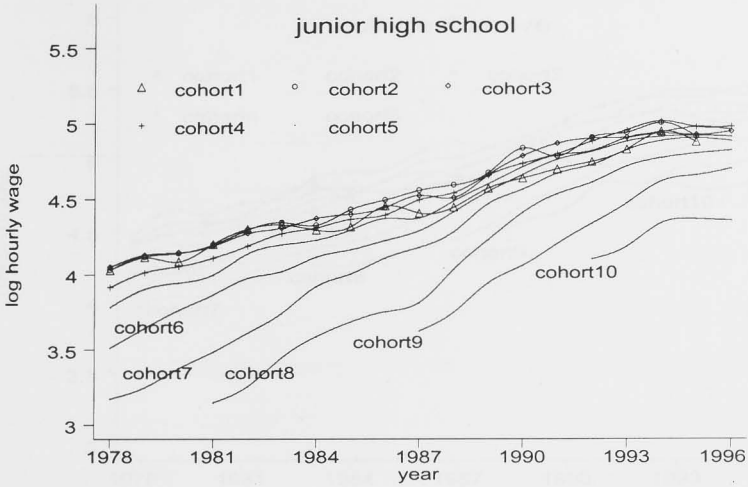
Cohort wage trends by education level are presented in Figures 4.12a–4.12d. For the first five cohorts (cohorts 1–5), the wage paths are closer for primary and junior secondary education levels. From Figure 4.12d we can see that college graduates in cohort 3 have higher average wages than those in cohorts 1 and 2, even though they have less experience. This implies that the effects of cohort characteristics dominate the effects of experience. It also reflects the higher relative starting wages and smaller cohort wage gap among young cohorts with a college education.

Figure 4.12a: Cohort wage trends (primary school)



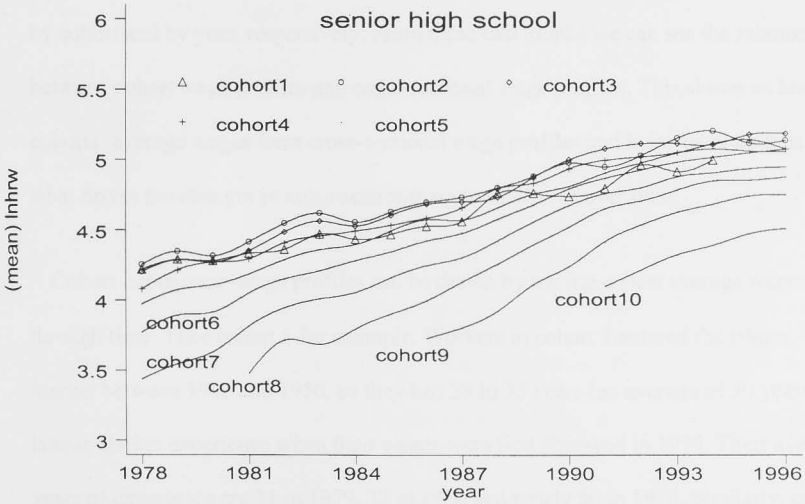
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.12b: Cohort wage trends (junior high school)



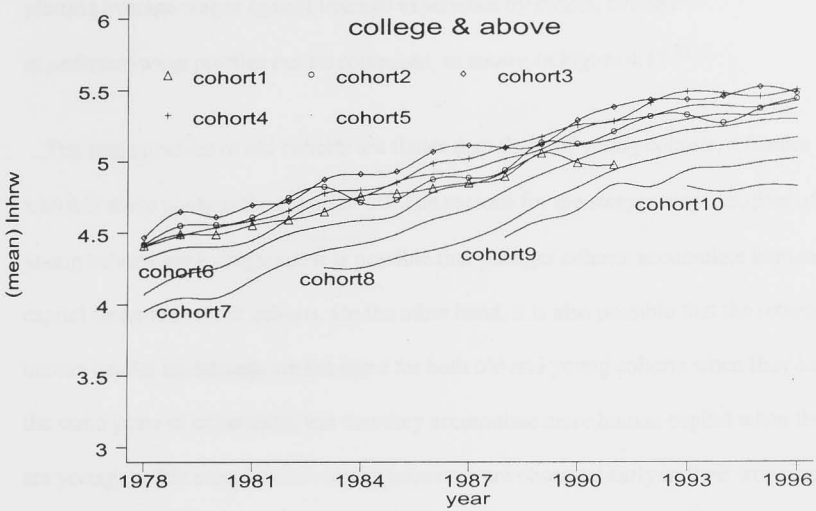
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.12c: Cohort wage trends (senior high school)



Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.12d: Cohort wage trends (college)



Source: Author's calculations based on data from MUS, 1978–96.

Figures 4.13 and 4.14 plot the averages of log real hourly wages against experience by cohort and by year, respectively. From these two graphs we can see the relationship between cohort wage profiles and cross-sectional wage profiles. This shows us how cohorts' average wages form cross-sectional wage profiles and helps us to understand what drives the changes in cross-sectional wage structures over time.

Cohort experience–wage profiles can be drawn by tracing cohort average wages through time. Take cohort 1 for example. Workers in cohort 1 entered the labour market between 1946 and 1950, so they had 28 to 33 years (an average of 30 years) of labour market experience when their wages were first observed in 1978. Their average years of experience are 31 in 1979, 32 in 1980 and nearly 50 in 1996. Similarly, cohort

9 was observed from 1985 to 1996 with average experience from 0 to 9 years.[24] By plotting average wages against average experience by cohort, cohorts' experience–wage profiles can be compared, as shown in Figure 4.13.[25]

The wage profiles of old cohorts are flatter than those of young cohorts, a feature which is more obvious for cohort 6–10. The reasons for the steeper wage profiles of young cohorts are ambiguous. It is possible that younger cohorts accumulate human capital faster than older cohorts. On the other hand, it is also possible that the returns to human capital investment are the same for both old and young cohorts when they have the same years of experience, but that they accumulate more human capital when they are young. In this case, because young cohorts were observed early in their working lives, it is natural that the wage profiles would be steeper. Unfortunately, the data series is not long enough to investigate wages over workers' entire lives for every cohort, so it is impossible to solve the problem. Hence, it is necessary to make some assumptions before setting the econometric model.

From Figure 4.13 we can also see that the lines for younger cohorts are always above those for older cohorts. That is, younger cohorts earn more than older cohorts, even if they have the same years of experience. At this point, we can only conclude that younger cohorts are better off than older cohorts. Because the younger cohorts and older cohorts with the same years of experience are observed at different points of time, it is not clear what factors cause the higher wages for young cohorts. One possible explanation is that younger cohorts are observed later, so economic growth may have

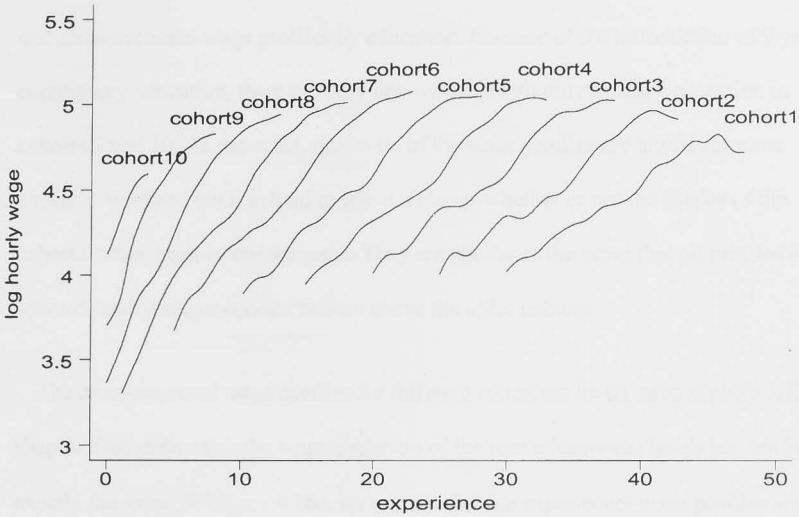
[24] In 1985, cohort 9 only included workers who entered the labour market in 1985 with 0 years of experience, but in 1986, it included workers who entered the labour market in 1985 and 1986, whose years of experience were 0 and 1. This means that average years of experience increased by less than 1 every year before 1990. After 1991, the cohort's average experience increased by approximately 1 every year.

[25] In a manner similar to Figure 4.11, the cohort's average wages in Figures 4.13 and 4.14 are calculated by samples with four educational groups pooled together.

increased their average wages. An alternative possibility is that their cohort characteristics are different, such as smaller cohort size or improved educational quality for young cohorts. It is more likely that both of the above explanations apply, and that the higher wage level of young cohorts is a product of the joint effects of economic growth and differences in cohort characteristics. The decomposition of the effects of economic growth and cohorts characteristics will be analysed using econometric methods in the next chapter.

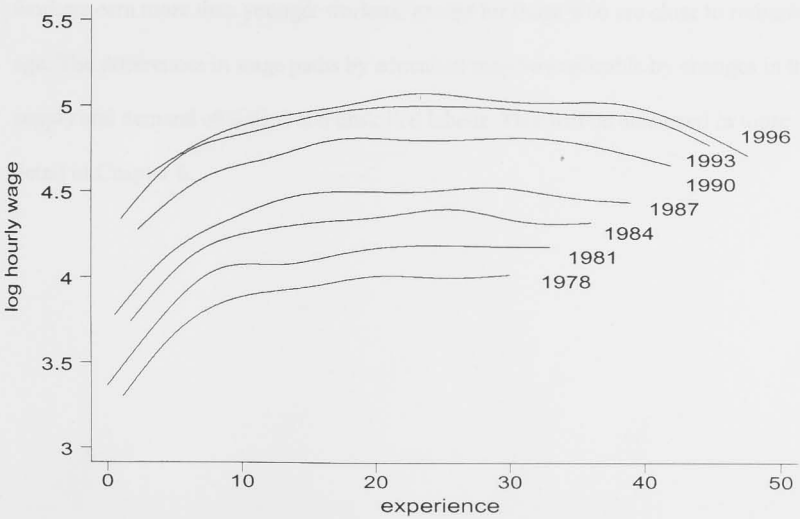
Cross-sectional experience–wage profiles are presented in Figure 4.14. Each line is drawn from the average wages of different cohorts observed in the same year. Only every third year's cross-sectional wage profiles are displayed in the graph for the sake of clarity. Since the lowest points in the wage profiles from cohorts 1–8 in Figure 4.13 are all from data surveyed in 1978, the 1978 cross-sectional wage profile is the line connecting these lowest points of different cohorts' wage profiles. In the same way, the 1996 cross-sectional experience–wage profile is the line connecting the end point of each cohort's wage profile. The wage profiles for later years are all higher than the wage profiles for earlier years. This reflects increasing average wages in the Taiwanese labour market. The gap between the 1987 and 1990 profiles is bigger than the gap between any other two profiles and this is consistent with the phenomenon of a booming economy in this period. The slowdown of economic growth after 1992 is reflected in the small distance between the 1993 and 1996 wage profiles.

Figure 4.13: Cohorts' experience–wage profiles



Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.14: Cross-sectional experience–wage profiles

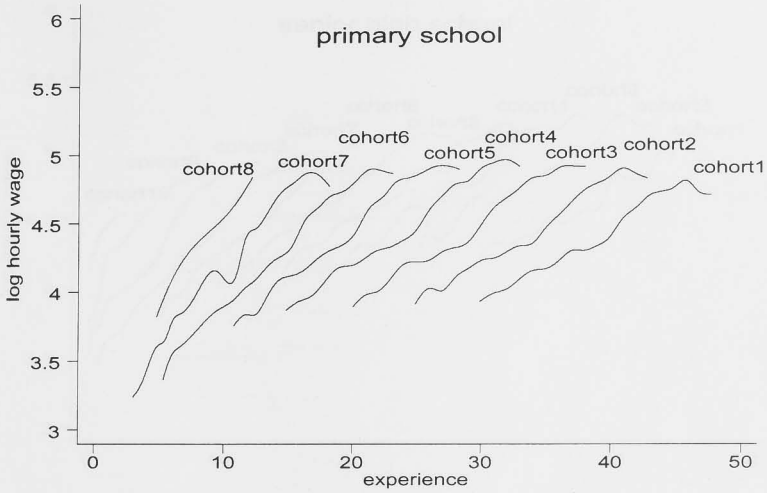


Source: Author's calculations based on data from MUS, 1978–96.

For further insights, Figures 4.15(a–d) and 4.16(a–d) illustrate cohorts' wage profiles and cross-sectional wage profiles by education. Because of the introduction of 9 years' compulsory education, there are very few workers with only primary education in cohorts 9 and 10. As expected, the levels of the wage profiles are higher for more educated workers, but it is hard to tell at a glance whether or not the shapes of the cohorts' wage profiles are the same. They are similar in the sense that all profiles slope upwards and younger cohorts line up above the older cohorts.

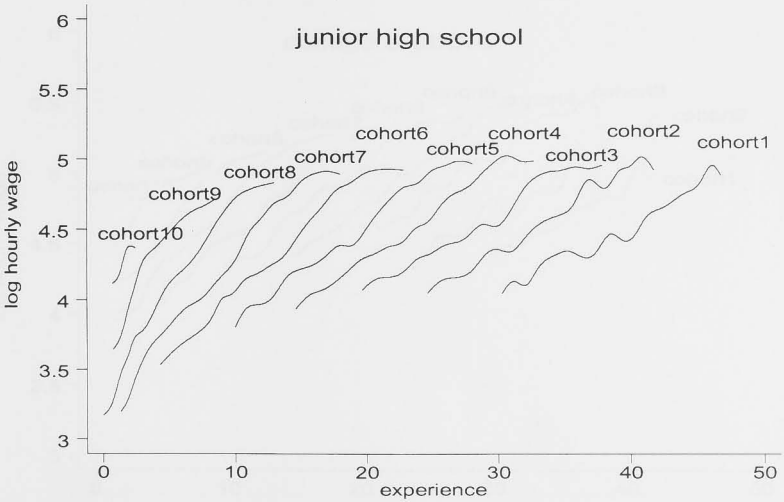
The cross-sectional wage profiles for different education levels have slightly different shapes. This means that the wage evolution of the four educational levels has not been exactly the same. In Figure 4.16a, we can see that the experience–wage profiles are steeper when experience is less than 10 years and that they remain flat for the rest of the wage profiles. This means that in the same year, the wages of older workers are similar to those of middle-aged workers. In the case of more educated workers, older workers earn more than younger workers, except for those who are close to retirement age. The differences in wage paths by education may be explicable by changes in the supply and demand of skilled and unskilled labour. This will be discussed in more detail in Chapter 6.

Figure 4.15a: Cohort experience–wage profiles (primary school)



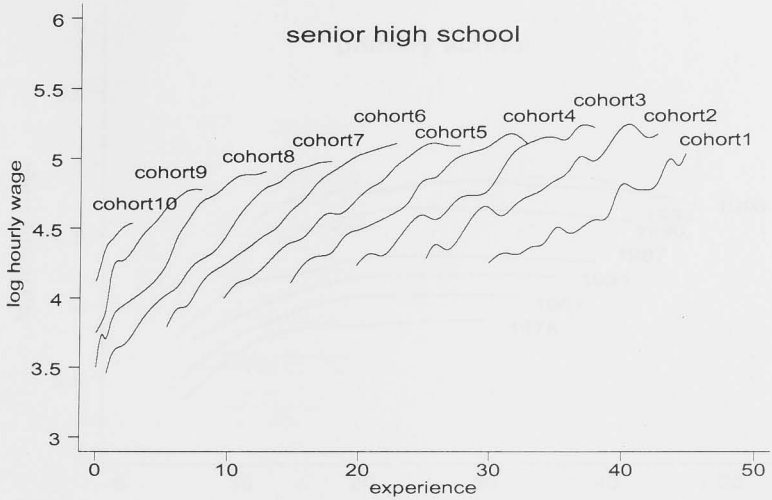
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.15b: Cohort experience–wage profiles (junior high school)



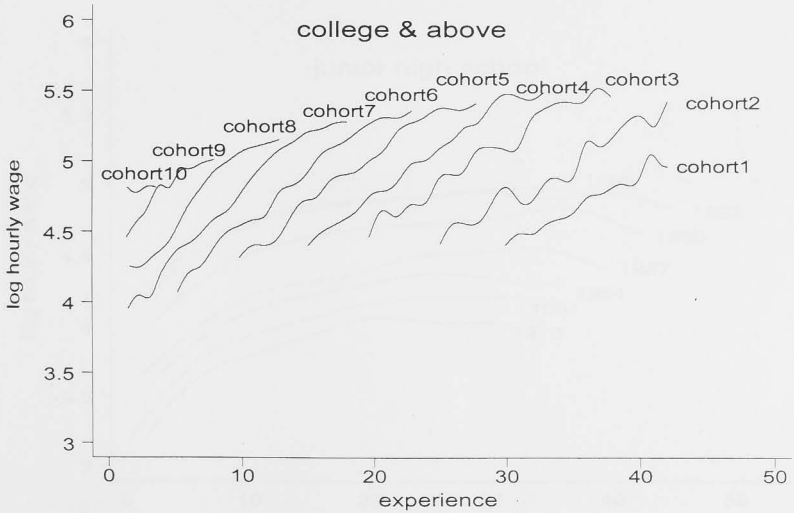
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.15c: Cohort experience–wage profiles (senior high school)



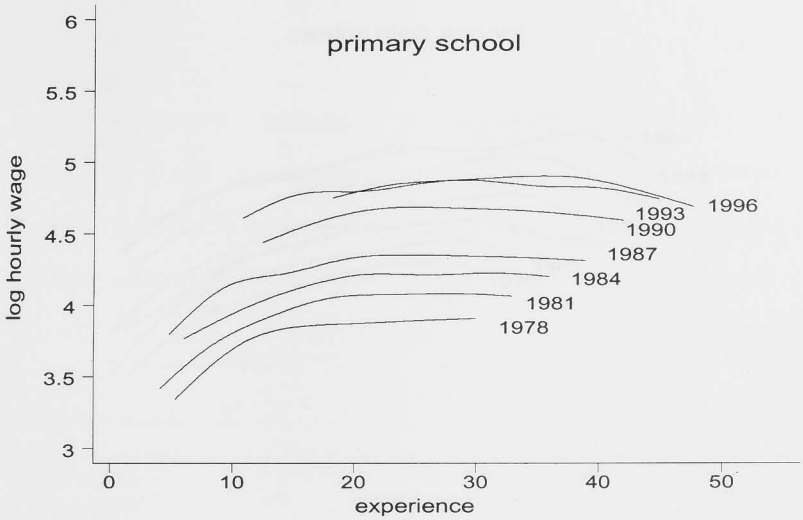
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.15d: Cohort experience–wage profiles (college)



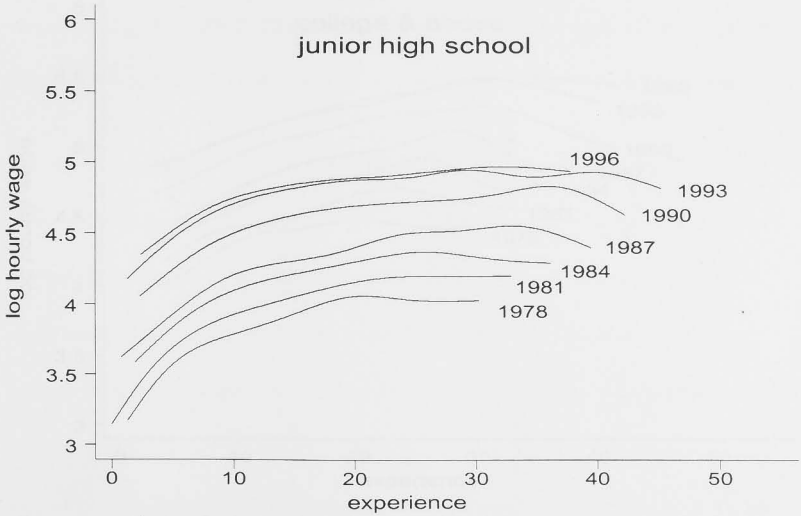
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.16a: Cross-sectional experience–wage profiles (primary school)



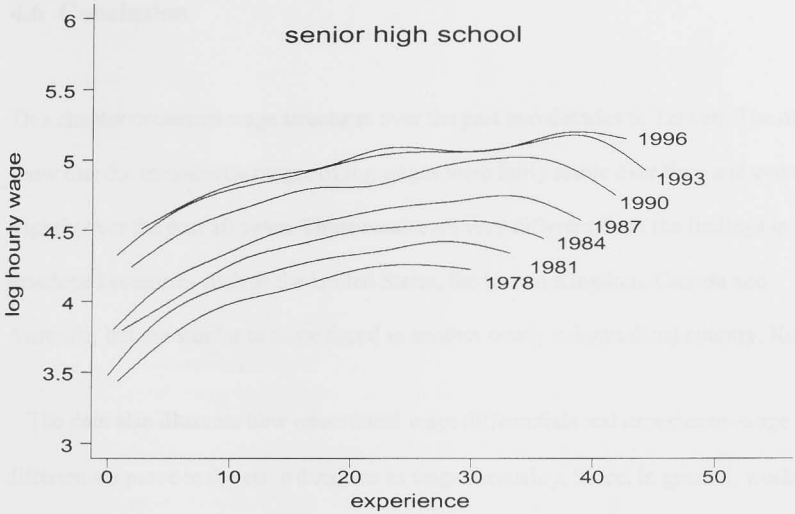
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.16b: Cross-sectional experience–wage profiles (junior high school)



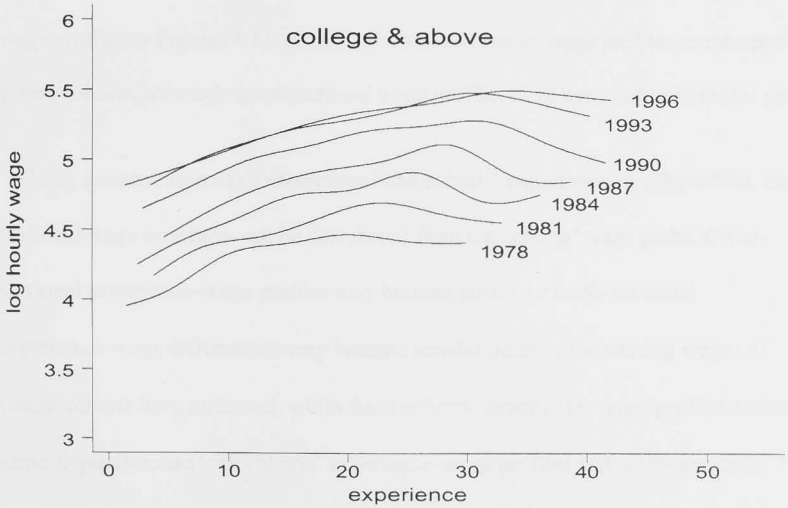
Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.16c: Cross-sectional experience–wage profiles (senior high school)



Source: Author's calculations based on data from MUS, 1978–96.

Figure 4.16d: Cross-sectional experience–wage profiles (college)



Source: Author's calculations based on data from MUS, 1978–96.

4.6 Conclusion

This chapter presented wage structures over the past two decades in Taiwan. The data show that the inter-decile ranges of log wages were fairly stable over time and even fell slightly over the past 10 years. These results are very different from the findings in developed countries such as the United States, the United Kingdom, Canada and Australia, but are similar to those found in another newly industrialised country, Korea.

The data also illustrate how educational wage differentials and experience–wage differentials move in the same direction as wage inequality. Since, in general, workers with more education and experience earn more, there is no doubt that wage inequality is always driven by experience and education–wage differentials. The experience–wage differentials presented in this chapter and in the literature are cross-sectional, so they do not necessarily represent just the returns to experience. The cross-sectional experience wage profiles in Figures 4.13 and 4.14 show that cohorts' wage profiles are steeper for young cohorts, although cross-sectional wage profiles have been flatter in recent years.

Using a comparison of cross-sectional and cohorts' experience–wage profiles, cross-sectional wage structures can be deciphered from the cohorts' wage paths. Cross-sectional experience–wage profiles may become flatter, or cross-sectional experience–wage differentials may become smaller because the starting wages of young cohorts have increased, while these cohorts' experience–wage profiles retain the same slope. Because both cohorts' experience–wage profiles and cross-sectional experience wage profiles are affected by at least two factors, it is not possible to determine the trends of changing experience–wage differentials from a simple graphic

analysis. Econometric analysis is necessary for an accurate analysis of returns to experience.

Nevertheless, the graphic analysis in this chapter has its uses. It helps us to observe a phenomenon often ignored in the literature — the bias caused by cross-sectional analysis. The problem may not be very serious for developed countries, but it is of great importance in developing or newly industrialised countries characterised by rapid economic growth and changes in the educational composition of the workforce. From the very different shapes of cohort and cross-sectional wage profiles, it is obvious that cross-sectional wage profiles are a poor proxy for lifetime wage profiles in Taiwan. True returns to experience will be investigated in the next chapter.

5 The effects of experience, cohort, and year on wages

5.1 Introduction

Analysis of the returns to human capital investment occupies an increasingly important role in the study of wage structures. Mincerian wage equations and mean wage differences between experience–educational groups are widely applied to estimate the returns to human capital. Most studies are based on cross-sectional analysis and attribute growing wage inequality to increasing education and experience wage differentials. (Murphy and Welch 1992; Juhn, Murphy and Pierce 1993; Constantine and Neumark 1996). In these studies, wage differentials are compared from years of cross-sectional data and the increasing experience–wage differentials are explained as increasing skill prices (returns to experience).

As noted in Chapter 3, cross-sectional experience–wage profiles can be biased by cohort effects when an economy is undergoing significant changes in cohort characteristics, as will be the case in rapidly changing economies. It is possible that the changes in experience–wage differentials are partly driven by cohort effects instead of changes in the returns to human capital investment. For this reason, the application of cohort analysis to the study of changing wage structures has become more prominent (Meghir and Whitehouse 1996; Beaudry and Green 1997; Deaton 1997; Hsu and Chen 1998).

Wage growth with experience within a single cohort can be calculated from repeated cross-sectional data. Nevertheless, within-cohort wage changes incorporate the effects

of economic growth, which are not attributable to returns to human capital investment. Therefore, in estimating the returns to human capital and in analysis of wage inequality, a crucial issue is the strategy one adopts to decompose experience, year and cohort effects.

In this chapter, cross-sectional and within-cohort wage profiles are compared, focusing on an analysis of the returns to experience, cohort effects and year effects. Four different methods are used to decompose these three effects. The structure of this chapter is as follows: Section 5.2 includes a brief literature review and discusses the identification problems associated with the modelling of separate cohort, potential experience and year effects. Section 5.3 describes the dataset. Section 5.4 illustrates the four different empirical models. Section 5.5 presents the empirical results and a comparison of the predicted experience earnings profiles from the four models. Section 5.6 puts forward some conclusions, along with a discussion of the advantages and disadvantages of the four models.

5.2 Literature review and methodological issues

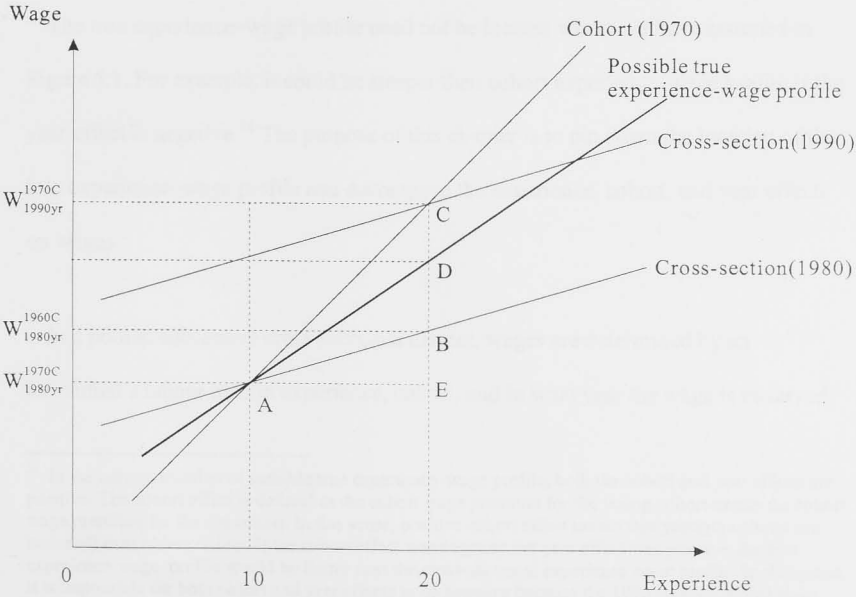
This section reviews the literature on cohort wage profiles and the decomposition of experience, cohort and year effects on wages using stacked cross-sectional data. A simple graph is employed to explain the methodological issues.

Figure 5.1 shows how cohort wage profiles are formed from successive cross-sections and the graphic decomposition of experience, cohort and year effects by taking the 1980 and 1990 cross-sections as examples. In the 1980 cross-section, the observations with 20 years of (potential) labour market experience belong to cohort

1960, denoted by point B. Those with 10 years of experience belong to cohort 1970 in the 1980 cross-section, denoted by point A, while individuals belonging to this cohort (cohort 1970) are observed to be those who have 20 years of experience in the 1990 cross-section, as denoted by point C. Therefore, the line AC is the wage profile for cohort 1970.

The experience–wage profile for the 1990 cross-section is drawn above the profile for the 1980 cross-section because the Taiwanese economy was growing between 1980 and 1990. Hence, the cohort wage profiles is steeper than the cross-sectional wage profiles. This analysis can be applied to other economies, but the relative position of the two cross-sections depends on the how labour market conditions change during the period of analysis.

Figure 5.1: The decomposition of experience, cohort and year effects



Source: Compiled by author.

As discussed in Chapter 3, the wage difference between A and B ($W_{1980yr}^{1970C} - W_{1980yr}^{1960C}$) is not purely a result of returns to experience. It contains both experience and cohort effects because A and B belong to different cohorts. Similarly, the wage difference between A and C ($W_{1990yr}^{1970C} - W_{1980yr}^{1970C}$) contains both experience and year effects because A and C are observed in different years.

Suppose that the true experience–wage profile for cohort 1970 is located between the observed cross-sectional and cohort wage profiles as denoted by AD, then the true experience effect can be denoted as DE, the vertical distance between A and D. CD represents the year effect, the observed experience–wage difference for the 1970 cohort minus the true experience effect, while BD is the cohort effect, the difference between the true experience effect and the observed cross-sectional experience-wage differential.

The true experience–wage profile need not be located where we have assumed in Figure 5.1. For example, it could be steeper than cohort experience–wage profile if the year effect is negative.[26] The purpose of this chapter is to pin down the location of the true experience–wage profile and decompose the experience, cohort, and year effects on wages.

In a pooled successive cross-sectional dataset, wages are determined by an individual's labour market experience, cohort, and in what year the wage is observed.

[26] In the current location of possible true experience–wage profile, both the cohort and year effects are positive. The cohort effect is defined as the cohort wage premium for the young cohort minus the cohort wage premium for the old cohort. In this sense, positive cohort effect means that younger cohorts are better off than older cohorts. If the cohort effect was negative but year effect was positive, the true experience-wage–profile would be flatter than the cross-sectional experience wage profile. In this graph, it is impossible for both cohort and year effects to be negative because the 1990 cross-sectional wage profile is above the 1980 cross-sectional wage profile.

In general, workers' actual labour market experience is not available in most data sets, and this information is not available in the MUS dataset. Potential experience, which is defined as age-year of schooling – 6 (or 5), is used as a proxy. Since potential experience, cohort, and year have a linear relationship (potential experience = survey year – cohort), there is an identification problem in estimating a wage equation including all the three variables. The problem arises from the fact that if we know any two of the three terms (experience, cohort and year), then we can calculate the third term (Heckman and Robb 1985).[27]

To solve the identification problem, Deaton (1997) uses a set of restricted year dummies to estimate the year effects. The year dummies are constructed so that (1) the sum of the year effects equals zero and (2) the year effects are orthogonal to a time trend. This implies that the year effects are assumed to be cyclical fluctuations only. Since the year effects from economic growth are not taken into account in Deaton's model, the estimated experience–wage profile corresponds to the line CD, cohort experience–wage profile, in Figure 5.1. The slope of wage profile is assumed to be the same across cohorts.

Using data from the Taiwan Personal Income Survey, Deaton found that younger cohorts are better off than older cohorts. As expected, the year effects account for cyclical fluctuations only. A very similar result is reported in this chapter using data from Taiwan's Manpower Utilisation Survey.

Meghir and Whitehouse (1996) estimate the cohort earnings profiles separately for different cohorts in their study of wage behaviour in the United Kingdom, using the

[27] See section 5.4 for detailed discussion.

unemployment rate to capture cyclical fluctuations. A similar method is employed in a study of Canadian cohort wage patterns by Beaudry and Green (1997). In these two studies, the idea is to estimate the AC line (cohort wage profile) and allow the slope to vary across cohort, so the estimates of the returns to experience still contain both growth effects and experience effects. Following the discussion in Chapter 3, the experience–wage profiles among different cohorts are comparable if changes in economic conditions have had similar influences on wages for older and younger cohorts.

Neither of the methods discussed above can be used to estimate the true returns to experience or to predict the life-time earnings profile. The life-time earnings profile can only be predicted using these methods when the economy is growing constantly after cyclical fluctuations are removed because growth effects are the same every year. However, while the assumption of roughly constant growth may be reasonable for a developed country, it is not reasonable in the case of a newly industrialised country with rapid and variable growth.

The basic idea of the four different models used in this chapter is as follows. The first model follows Deaton's method and the second model includes the unemployment rate in the wage equation to capture the cyclical effect, following the method employed by Meghir and Whitehouse (1996). The purpose of applying these two models is to allow comparison with the literature, and also to show the extent of the differences in returns to experience between these models and the estimates of true returns to experience.

The true returns to experience are estimated in the third and fourth models. The third model attempts to remove cyclical and growth effects from the cohort wage profile by including the indications of economic growth as explanatory variables in the wage

regression. In the fourth model, the cohort effects are removed in the regression on the basis of the cross-sectional wage profile. Corresponding to Figure 5.1, profile AD is estimated by removing CD from profile AC in the third model, and profile AB is shifted to AD by taking out BD in the fourth model.

5.3 Data

The details of the data employed in this chapter are the same as those presented in Chapter 4, except that workers who entered labour market before 1950 are excluded. In 1949, Taiwan experienced significant structural changes, as the government and large numbers of people moved from Mainland China to Taiwan. Labour supply increased significantly at that time. Most of these mainlanders were educated in Mainland China. Since Taiwan had previously been governed by Japan, the nature and quality of the education system and were different from Mainland China (Chang 1994).

Moreover, mainlanders tended to be either in the military service or in positions of high social economic status. Mainlanders who had finished their education by 1949 are therefore very unlikely to have similar wage profiles to their counterparts who were born in Taiwan. If these cohorts are included in the sample, the individuals with very different education and experience would be grouped together. This is likely to affect the accuracy of the results.

Table 5.1 shows the summary statistics for the sample employed in this chapter, comprising only those individuals who entered the labour market after 1950. If we compare this table with Table 4.1, the summary statistics for individuals who entered the labour market after 1945, the time trends of the means for most of the variables

follow the same pattern, with the exception of potential experience. In Table 4.1, the potential experience is stable over time in Table 4.1 while in Table 5.1 potential experience increases over time. This is because in the sample employed in this chapter, more old workers are excluded from the early survey years. In 1978, individuals with more than 28 years of experience are excluded, while, in 1996, only individuals with more than 46 years of experience are excluded and very few observations are dropped in 1996. Also, since, in general, the 1946–50 cohorts have less education than other cohorts, the average years of schooling is higher in Table 5.1 than in Table 4.1.

Table 5.1: Summary labour market statistics by year, 1978–96

	hourly wage		years of schooling		experience		
year	mean	std	mean	std	mean	std	no obs
1978	50.14	23.34	9.12	3.45	12.12	7.53	6787
1979	54.65	27.12	9.33	3.44	12.15	7.85	7619
1980	56.12	27.03	9.55	3.41	12.57	8.03	7943
1981	60.17	27.21	9.57	3.42	12.85	8.31	8697
1982	67.21	31.53	9.69	3.43	13.43	8.49	8582
1983	72.05	35.48	10.04	3.43	13.80	8.62	8530
1984	74.09	34.78	10.18	3.42	14.03	8.86	9133
1985	77.64	35.95	10.07	3.39	14.55	9.06	9486
1986	82.83	39.37	10.16	3.35	14.90	9.17	9639
1987	86.99	42.99	10.33	3.34	15.26	9.41	10593
1988	95.07	44.99	10.39	3.37	15.92	9.65	10878
1989	107.41	48.21	10.58	3.36	16.15	9.79	11114
1990	117.45	50.54	10.59	3.32	16.57	10.04	10931
1991	126.23	51.52	10.60	3.28	16.97	10.31	10738
1992	133.66	57.15	10.77	3.27	17.40	10.46	10959
1993	141.92	68.14	10.81	3.28	17.56	10.54	12137
1994	144.83	60.61	10.76	3.22	17.76	10.81	12309
1995	148.23	67.67	10.96	3.20	18.15	10.95	12368
1996	149.68	76.12	11.23	3.20	18.23	10.97	11601

Source: Author's calculations based on data from MUS, 1978–96.
Note: Only individuals who entered labour market after 1950 are included.

5.4 Empirical models

Here, four different econometric models are used to estimate wage equations. As discussed previously, the wage equation for the time series of the cross-sections can be written as:

$$\ln W_t^c = \alpha + f(\exp erience) + g(year) + h(cohort) + \psi(education,....) + \varepsilon \qquad (5.1)$$

where cohort is defined as labour market entry year. Controlling for education, wages can be explained by experience, cohort, and year effects. For the functional form, we can either use dummy variables or a polynomial form to estimate these three effects. Given the large sample size, it was decided to choose dummy variables for the three effects to improve flexibility. However, the decomposition of the three effects brings with it an identification problem because of the perfect collinearity of potential experience, cohort, and survey year (experience = year – cohort). Although we can use a polynomial form for the experience variable based on human capital theory, the equation is still not identified.

For example, assume that in 1990, workers who entered the labour market in 1980 earned 10 per cent more than workers who entered in 1975 earned in 1985. We can explain the wage difference by concluding that the workers in the 1980 cohort have gained more than their counterparts in the 1975 cohort. Alternatively, we can attribute the difference to the fact that economic conditions in 1990 are better than in 1985 or a combination of the above two explanations. This means that, in order to decompose the three effects, either year or cohort effects have to be parameterised. Another possible solution is to restrict year effects to be orthogonal to a time trend, the method employed in Deaton's analysis of Taiwan's consumption patterns (Deaton and Paxson 1994;

Deaton 1997). The four different models employed to decompose the three effects are discussed in the following.

5.4.1 Model A: restrict year effects to be orthogonal to a time trend

In this model, based on the method described in Deaton and Paxson (1994), besides education dummies, three sets of dummies are used, as shown in equation (5.2), to capture the experience, cohort and year effects.

$$\ln W = \alpha + \beta E + \gamma C + \delta Y + \theta ED + \varepsilon \qquad (5.2)$$

where E denotes experience dummies, C denotes cohort dummies, Y denotes year dummies, and ED denotes education dummies. As standard procedure in estimating equations with dummies, one column has to be dropped from each of the four matrices. It is still not possible to perform this estimation even after 4 columns are dropped. Since potential experience = year - cohort, it implies that the matrices of dummies satisfy

$$Es_e = Ys_y - Cs_c \qquad (5.3)$$

where s vectors are arithmetic sequences {0, 1, 2, 3, ...} of the length given by the number of columns of the matrix that pre-multiplies them. The parameter vectors β, γ, and δ can therefore be replaced by

$$\tilde{\beta} = \beta - ks_e, \qquad \tilde{\gamma} = \gamma - ks_c, \qquad \tilde{\delta} = \delta + ks_y \qquad (5.4)$$

For any constant k, based on equation (5.3), there is no change for the predicted value of log wage. That is, the time trend can be attributed to year effects, or a combination of

experience and cohort effects. In Deaton's procedure, year dummies are used to capture cyclical fluctuations, and the time trend is captured by both experience and cohort dummies. That is, business-cycle effects are assumed to average zero in the long run, and all the growth is attributed to the experience and cohort effects. If the economy is growing constantly, this is a reasonable assumption when predicting life-time earnings profiles. To satisfy the above assumption, a possible solution is to make the year effects to be orthogonal to a linear time trend as denoted in the following:

$$s_y'\delta = 0 \tag{5.5}$$

In practice, to estimate equation (5.2) subject to equation (5.5), we can regress log wages on the normal cohort and experience dummies and restricted year dummies defined as follows:

$$y_t^* = y_t - [(t-1)y_2 - (t-2)y_1], \quad \text{t=3, 4,....T} \tag{5.6}$$

where y_t is the normal year dummies. The year dummies generated from equation (5.6) satisfy both the restriction of equation (5.5) and the restriction that the year effects add to zero. The mathematical procedure is illustrated in the appendix. The coefficients on y^* give the year effects from the third to final year, and the year effects for the first and second year can be calculated from the restriction of equation (5.5) and the restriction that the sum of the year effects equal zero.

The experience–wage profile estimated from dummies suggests a quadratic functional form.[28] For the purpose of comparing the four models, a quadratic form in experience has been employed to estimate model A. The wage equation becomes:

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ + \theta ED + \gamma C + \delta Y \tag{5.7}$$

Where *EXP*, *EXPSQ* are experience and its quadratic term, respectively. The results are presented in the next section.

5.4.2 Model B: parameterise year effects with the unemployment rate

In Model B, the contemporaneous unemployment rate is used as the explanatory variable to capture year effects instead of year dummies. As in Model A, year effects are considered only as a measure of cyclical fluctuations. The wage equation is as follows:

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ + \theta ED + \delta_1 UNEMP + \gamma C + \varepsilon \tag{5.8}$$

where *UNEMP* is the contemporaneous unemployment rate.

Since Model A and B attribute year effects to cyclical fluctuations only, the estimated returns to experience still contain the effects of economic growth. These two models are not appropriate for analysis of returns to experience. They can only be applied to the analysis of life-time earnings profiles when the economy has relatively constant economic growth. Since growth effects are not removed, wage growth can be considered as pure returns to experience plus wage increase due to economic growth.

[28] The experience effects estimated from dummies are presented in Appendix 5B.

Whether the Taiwanese economy has been growing constantly after the effects of cyclical fluctuations are removed remains unclear. Very few studies have attempted a formal empirical test of this hypothesis.[29]

5.4.3 Model C: parameterise year effects with the unemployment rate and the capital–labour ratio

The aim of this model is to estimate the cohort wage equation and remove year effects from the equation. Not only are cyclical effects removed by the contemporaneous unemployment rate, but also the effects of economic growth, are captured by quadratic function of the capital–labour ratio. The model is as follows:

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ + \theta ED + \delta_1 UNEMP + \delta_2 KL + \delta_3 KLSQ + \gamma C + \varepsilon \qquad (5.9)$$

In a growing economy, workers' wages can increase even if there is no accumulation of human capital. Increased capital input may increase labour productivity. The capital–labour ratio captures the wage growth that is not attributable to human capital accumulation.[30]

5.4.4 Model D: parameterise cohort dummies

In the final model, an attempt is made to remove cohort effects from the cross-sectional wage equation. As discussed in Chapter 1, the cohort effect is derived from (i)

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[29] There is a debate in the literature about the appropriate way to test for constant growth (Leybourne, Mills and Newbold 1998). The problem is the low power of Dicky–Fuller tests if a series is generated by a process that is stationary around a broken trend.

[30] To make this model robust, an independent variable that can capture the effect of technological change should be included in the regression. Human capital adjusted total factor productivity (TFP) or R&D expenditure are two of the possible indicators for technological change. They are not included at

education quality; (ii) cohort size; (iii) economic conditions in the labour market entry year; and (iv) unobserved relative ability.

The wage equation is as follows:

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ + \theta ED + \gamma_1 UENTER + \gamma_2 AVGYOS$$
$$+ \phi AVGYOS * ED + \gamma Y + \varepsilon \qquad (5.10)$$

Where *AVGYOS* denotes cohort's average years of schooling and *UENTER* represents the unemployment rate in the labour market entry year.

The unemployment rate in the labour market entry year and average years of schooling by cohort are employed to capture entry year economic conditions and cross-cohort differences in unobserved ability.[31] In a cross-sectional estimation with education dummies, we are comparing the wages of workers with the same level of education but who entered the labour market at different points of time. Suppose the distribution of unobserved ability does not change much over time, and workers' unobserved ability is highly correlated with their education level. When the average education levels are significantly different across cohorts, the individuals' unobserved ability would be very different for different cohorts with the same level of education. This biases the returns to experience in a cross-sectional estimation.

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this stage because human capital adjusted TFP in Taiwan from 1978 to 1996 is not available and the R&D expenditure series only starts from 1986.

[31] In this model, the cohort effects caused by educational quality and cohort size are not removed due to the availability of explanatory variables. Part of educational quality may be captured by expenditure per student, but the effects of different course materials, education systems, and so on are very difficult to measure. For cohort size, there is no information on the number of new entrants to the labour market every year. It may be possible to calculate this by the number of graduates for every education level minus the number of new students who entered the next level of schooling. These data are not yet available and may be the subject of future testing. An alternative of constructing cohort size data is to sum up the weighted sample for each cohort. Because some individuals in young cohorts are in military service, the cohort sizes calculated from weighted data show an obvious bias. They are therefore not used in the regression.

For example, consider the comparison of wage differences between two workers with high school education, one who entered the labour market in 1955 and another who entered in 1990. The average educational level was much higher in 1990 than in 1955. The relative ability of the worker in cohort 1955 may therefore have a much higher unobserved ability. The calculated experience–wage difference between these two workers includes effects from the unobserved ability, which will bias the experience-wage profile upward. The cohort's average years of schooling and its interaction with education dummies are included to capture the effects of differences in unobserved ability across cohorts.

5.5 Empirical Results

Table 5.2 and Table 5.3 present the regression results for the four models. For the purpose of comparison, the results from Model A, B, and C are presented together with the estimated cohort wage equation without removing year effects and the results from Model D are presented together with the estimated cross-sectional wage equation without removing cohort effects.

In Table 5.1, the coefficients of education dummies are almost identical for all models. The unemployment rate, as expected, has a negative effect on wages. One percentage point increment of the unemployment rate leads to a reduction of wage by 4.6 per cent in Model B and 7.7 per cent in Model C. The positive coefficient of the capital–labour ratio and the negative coefficient of its square terms show that wages increase as the capital–labour ratio increases, but at a decreasing rate.

The returns to experience at the bottom of the table show how much wage change is induced by an increase of one year in experience at different stages of working life. There is not much difference in the estimated returns to experience from Models A, B and the basic cohort wage model, but the estimated returns to experience from Model C are much smaller because the effects of economic growth have been removed.

In Table 5.3, the results from Model D are compared with the estimated cross-sectional wage equation without removing cohort effects. The smaller coefficient on experience in Model D provides evidence for the argument that unobserved ability among different cohorts biases up the slope of experience–wage profile. Although the differences in the estimated returns to experience between model D and the basic cross-sectional model are very small, it does not mean that the cohort effects are not important. It maybe that cohort effects have not been adequately captured by the controls used in Model D. For example, there may be uncaptured cohort effects caused by differences in education quality and cohort size.

The coefficients of average years of schooling and the unemployment rate in the labour market entry year are not significantly different from zero, but they have the expected sign. The negative effect of the unemployment rate in the year of labour market entry implies that workers earned less if they entered the labour market in a period of recession.

Because the average years of schooling are very low for the older cohorts, workers with high school education in the old cohorts have relatively high ability compared with their counterparts in the young cohorts. For high school graduates, those who belong to the old cohorts may therefore have higher relative wages than those who

Table 5.2: Estimated wage equations with cohort dummies

	basic model	Model A	Model B	Model C
intercept	1.6463	1.6278	1.6325	1.2025
	(184.61)	(155.07)	(183.38)	(47.33)
experience	0.1095	0.1101	0.1100	0.0827
	(291.03)	(288.54)	(292.95)	(62.50)
experience square	-0.0009	-0.0009	-0.0009	-0.0009
	(-95.49)	(-105.11)	(-95.97)	(-96.25)
Education dummies:				
junior high school	0.1037	0.1042	0.1040	0.1040
(JHIGH)	(41.72)	(42.68)	(41.99)	(42.03)
senior high school	0.2753	0.2759	0.2762	0.2759
(SHIGH)	(114.47)	(117.76)	(115.17)	(115.15)
college & above	0.588	0.5898	0.5893	0.5894
(COLLEGE)	(219.78)	(233.68)	(220.76)	(221.10)
year effects:				
unemployment rate			-4.592	-7.7217
(RUM)			(-34.41)	(-43.48)
capital-labour ratio				0.0033
(KL)				(29.07)
capital-labour ratio square				-0.000002
(KLSQ)				(-23.27)
returns to experience				
experience=5	0.1003	0.1009	0.1008	0.0735
experience=10	0.0911	0.0916	0.0915	0.0643
experience=15	0.0820	0.0824	0.0823	0.0550
experience=20	0.0728	0.0732	0.0731	0.0458
experience=25	0.0636	0.0639	0.0639	0.0366
experience=30	0.0544	0.0547	0.0547	0.0273
experience=35	0.0452	0.0454	0.0455	0.0181
experience=40	0.0360	0.0362	0.0363	0.0089
number of observations	190044	1090044	190044	190044
adjusted R-square	0.652	0.658	0.654	0.656

Notes: 1. The basic model include experience, experience square, education dummies and cohort dummies as regressors.
2. The coefficients of year dummies in Model A and cohort dummies in all of the four models are not presented in this table. They are presented later in figures.
3. T-statistics are in parentheses.

Table 5.3: Estimated wage equation with year dummies

	Basic Model	Model D
intercept	3.1821	3.1611
	(648.77)	(105.08)
experience	0.0552	0.0546
	(193.60)	(135.39)
experience square	-0.0010	-0.0009
	(-127.55)	(-117.60)
Education dummies:		
junior high school	0.1029	0.14
(JHIGH)	(43.29)	(8.35)
senior high school	0.2749	0.3737
(SHIGH)	(118.40)	(23.09)
college & above	0.5887	0.6093
(COLLEGE)	(225.53)	(33.63)
Cohort effects:		
unemployment rate at labour		-0.0194
market entry year (UENTER)		(-0.14)
average year of schooling		0.0032
(AVGYOS)		(1.20)
AVGYOS*JHIGH		-0.0045
		(-2.55)
AVGYOS*SHIGH		-0.0103
		(-6.03)
AVGYOS*COLLEGE		-0.0029
		(-1.57)
returns to experience		
experience=5	0.0457	0.0452
experience=10	0.0361	0.0357
experience=15	0.0265	0.0262
experience=20	0.0170	0.0167
experience=25	0.0074	0.0073
experience=30	-0.0021	-0.0022
experience=35	-0.0117	-0.0117
experience=40	-0.0212	-0.0211
number of observations	190044	190044
adjusted R-square	0.658	0.658

Notes: 1. Both models include year dummies as regressors.
2. T-statistics are in parentheses.

belong to the young cohorts, even if they have the same years of experience. In other words, since unobserved ability has positive effects on wages, high school graduates will have higher wages when their cohort's average years of schooling are low. This is why the cohort's average years of schooling have significant negative effects on the wages of workers with high school education.

For primary educated workers, there is not much difference in unobserved ability. These workers belong to low relative ability group no matter whether they are in the older or younger cohorts, so the cohorts' average years of schooling have smaller effects on wages. Moreover, one factor that offsets the effects of increasing average years of schooling is the sharp decline in the supply of unskilled labour. Similarly, college graduates do not have significant cohort effects, possibly also due to the increasing demand for skilled labour. This raises an important issue for further study.

In order to further compare the results of the four different models, the experience–wage profiles, cohort effects, and year effects are illustrated in Figures 5.2–5.5. The results for Models A and B are almost identical, positive cohort effects and fluctuating year effects, except that the variance of year effects is slightly bigger in Model A.

The cohort effects for most of the models display an upward trend, except in Model D. The negative cohort effects for high school graduates in Model D are as expected because of the lower unobserved ability for young cohorts. However, this does not mean the total cohort effects are negative because the effects of cohort size and education quality have not been captured. Assuming cohort effects are positive, as estimated by dummies in Model C, the components of the cohort effects which are not captured in Model D must, in Model D be attributed to both year and experience

effects. This leads to a flatter experience–wage profile because the experience effect is partly offset by these positive cohort effects.[32]

The year effects in model A and B do not show any time trend because only cyclical effects are taken into account. In model C, growth effects are removed from experience effects and attributed to year effects, so that the year effects demonstrate a positive time trend. The year effects from model D show an even stronger time trend because part of the positive cohort effects is attributed to the year effects.

Figure 5.6 presents the predicted experience–wage profiles from the four different models together for the purpose of comparison. The experience profiles predicted for Models A and B are steeper because they incorporate both the returns to experience and economic growth. Removing the effect of economic growth (Model C) brings down the slope of the wage profile, as shown by the line with small circles. The wage profile from Model D is very similar to standard cross-sectional wage profile, but it is not clear whether the cross-sectional wage profile is a good approximation of a life-time wage profile because, again, many potential components of the cohort effects have not been adequately controlled for.

[32] Positive cohort effect means that younger cohorts earn more than their counterparts in older cohorts.

Figure 5.2: Estimated experience, cohort, and year effects using Model A — restrict year effects to be deviation to a time trend

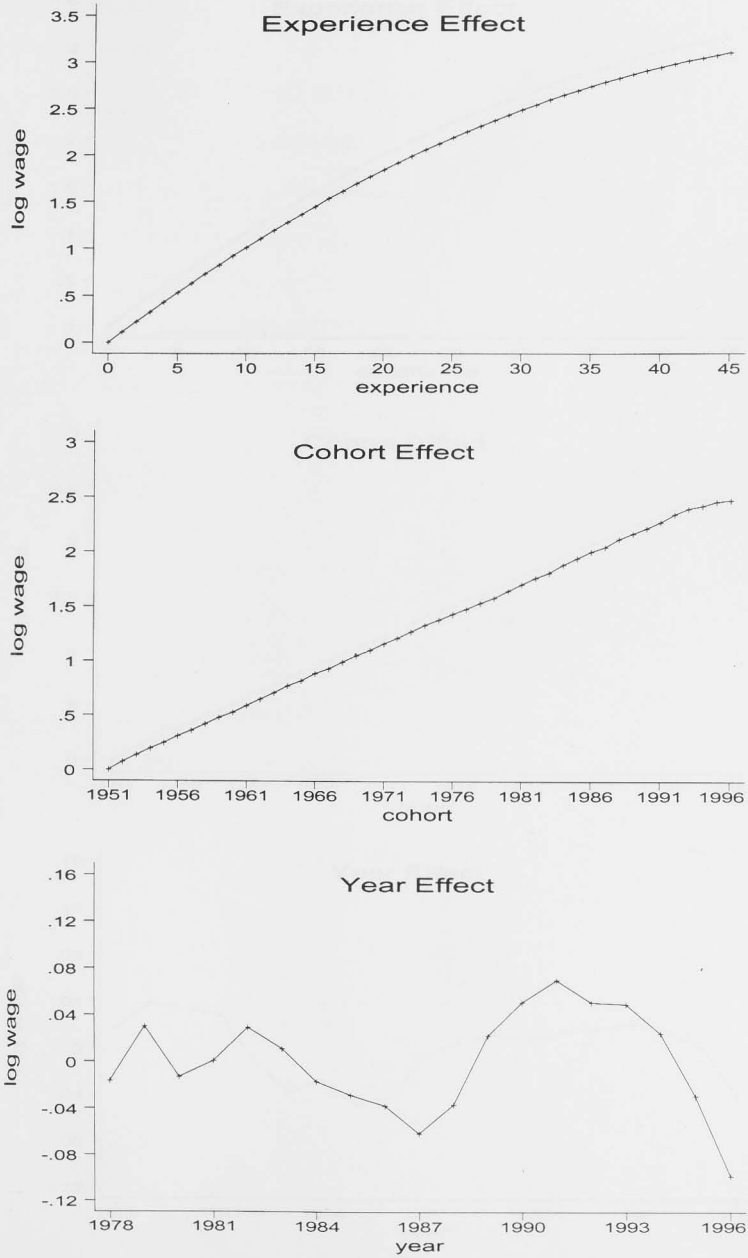


Figure 5.3: Estimated experience, cohort, and year effects using Model B — parameterise year effects with unemployment rate

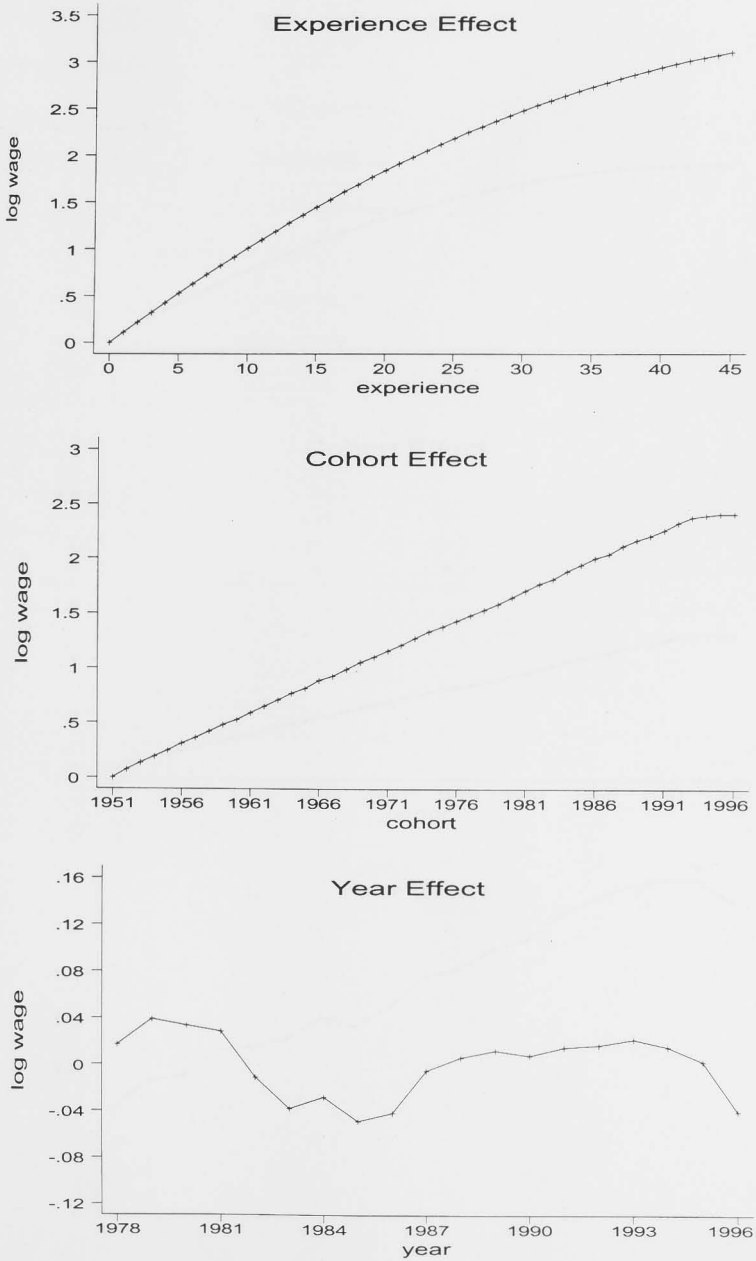


Figure 5.4: Estimated experience, cohort, and year effects using Model C — parameterise year effects with K/L and unemployment rate

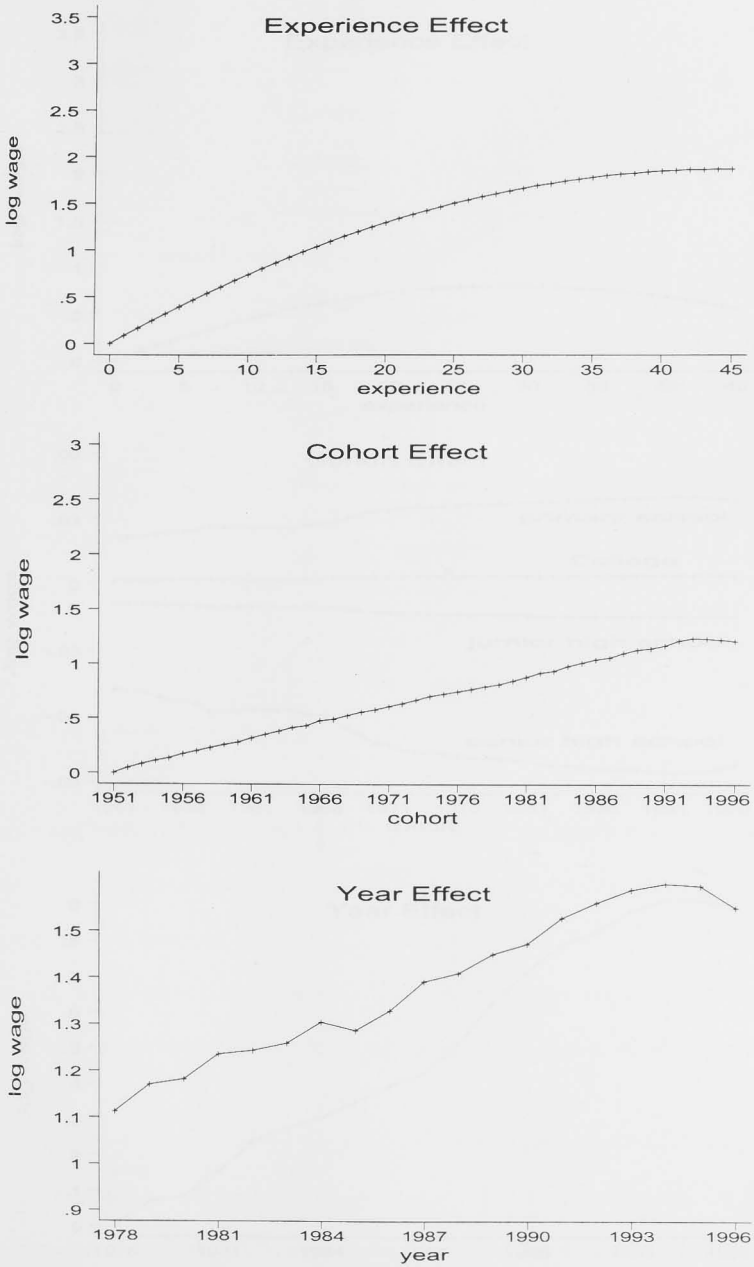


Figure 5.5: Estimated experience, cohort, and year effects using Model D — parameterise cohort effects

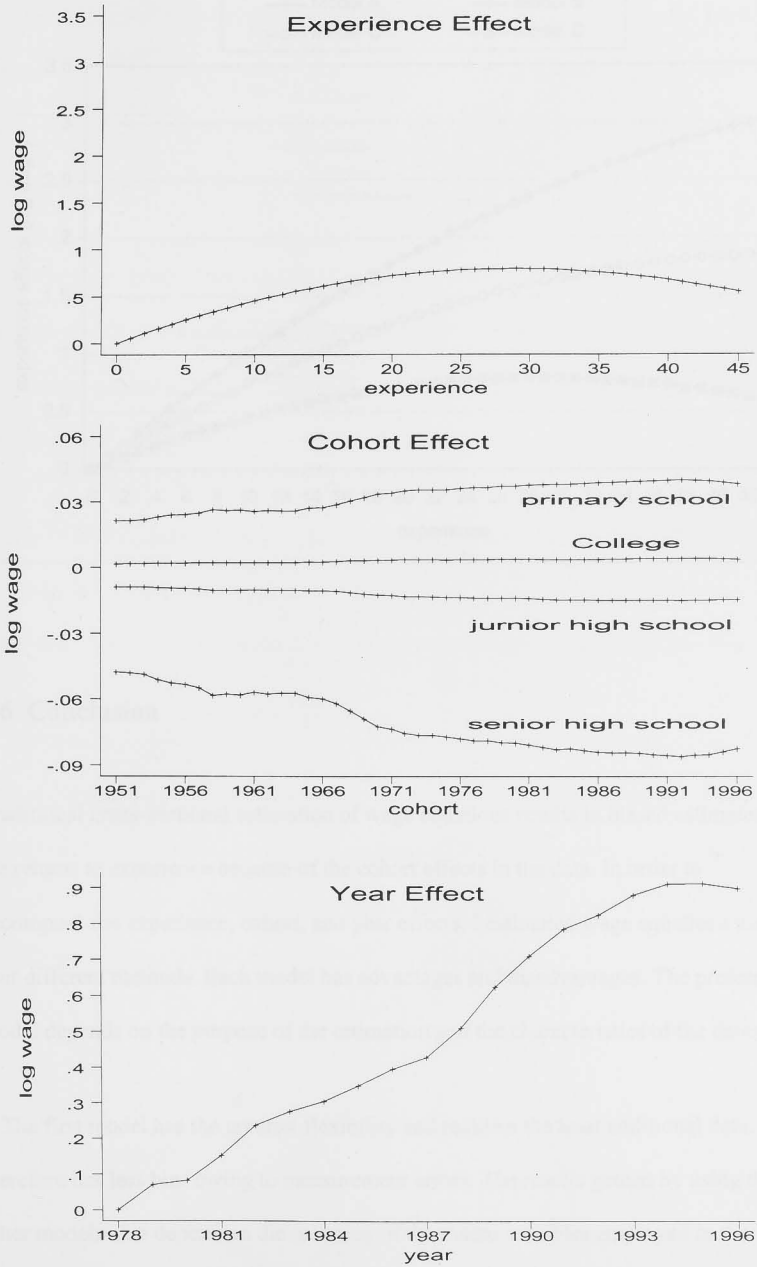
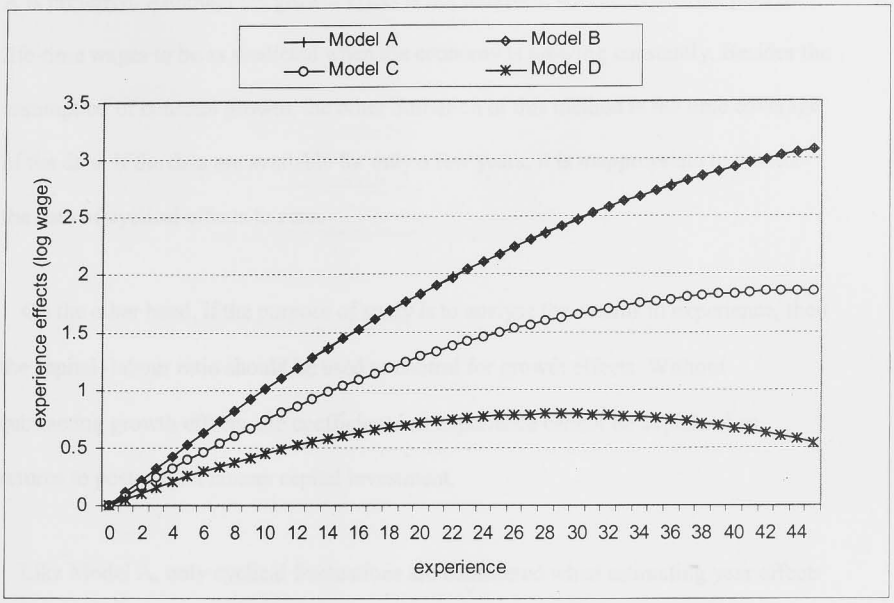


Figure 5.6: Predicted experience–wage profiles



5.6 Conclusion

Traditional cross-sectional estimation of wage equations results in biased estimates of the returns to experience because of the cohort effects in the data. In order to decompose the experience, cohort, and year effects, I estimated wage equations using four different methods. Each model has advantages and disadvantages. The preferred model depends on the purpose of the estimation and the characteristics of the dataset.

The first model has the greatest flexibility and requires the least additional data. It therefore has less bias owing to measurement errors. The results gained by using the other models also depend on the accuracy of the macro variables employed in the

estimation. When the purpose of a study is to estimate the life-time wage profile, Model A is preferred. Although the growth effect is not removed, we can expect the path of life-time wages to be as predicted when the economy is growing constantly. Besides the assumption of constant growth, the other limitation of this method is the time coverage of the data. If the data are available for only a few years, it is inappropriate to restrict the sum of cyclical effects to zero.

On the other hand, if the purpose of study is to analyse the returns to experience, then the capital–labour ratio should be used to control for growth effects. Without subtracting growth effects, the coefficients on experience cannot be explained as returns to post-school human capital investment.

Like Model A, only cyclical fluctuations are considered when estimating year effects in Model B, and the estimated returns to experience still contain growth effects. Therefore this model is only applicable to the study of life-time earnings profiles.

The disadvantage of Model D is the difficulty in adequately capturing cohort effects with the types of data which are typically available. Most of the factors that may contribute to cohort effects, such as educational quality and unobserved ability, are very difficult to measure. However, this method is still worthy of further study because it is an option if only a single cross-section of data is available.

Appendix 5A

Let y_t denotes year dummy for year t

$$w = \delta_1 y_1 + \delta_2 y_2 + \cdots + \delta_t y_t \qquad \text{(a1)}$$

$\delta_1 + \delta_2 + \cdots + \delta_t = 0$ that is, the sum of year effects equal zero
(a2)

$\delta_1 + 2\delta_2 + 3\delta_3 + \cdots + t\delta_t = 0$ that is, year effects are orthogonal to a time trend (a3)

Substitute δ_1 by $\delta_2 \cdots \delta_t$ generated from (a2) into (a1)

$$w = \delta_2(y_2 - y_1) + \delta_3(y_3 - y_1) + \cdots + \delta_t(y_t - y_1) \qquad \text{(a4)}$$

from (a2) and (a3),

$$\delta_2 = -2\delta_3 - 3\delta_4 - \cdots - (t-1)\delta_t \qquad \text{(a5)}$$

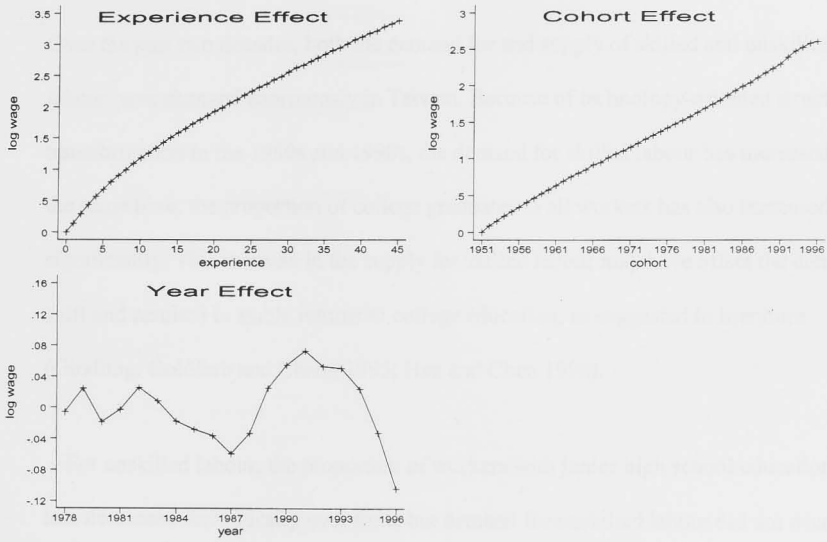
Substitute (a5) to (a4)

$$w = \delta_3(y_3 - 2y_2 + y_1) + \delta_4(y_4 - 3y_2 + 2y_1) + \cdots + \delta_t[y_t - (t-1)y_2 + (t-2)y_1]$$

That is $y_t^* = y_t - (t-1)y_2 + (t-2)y_1$

Appendix 5B

Figure A1: Experience, cohort, and year effect using model A (with experience dummies)



6 Changes in the returns to education

6.1 Introduction

Over the past two decades, both the demand for and supply of skilled and unskilled labour have changed enormously in Taiwan. Because of technology-oriented structural transformation in the 1980s and 1990s, the demand for skilled labour has increased. At the same time, the proportion of college graduates to all workers has also increased significantly. This increase in the supply for skilled labour may have offset the demand shift and resulted in stable returns to college education, as suggested in literature (Gindling, Goldfarb and Chang 1995; Hsu and Chen 1998).

For unskilled labour, the proportion of workers with junior high school education or less decreased dramatically over time, but demand for unskilled labour did not decrease as much as supply. Although demand for labour in manufacturing industries has declined, total demand for unskilled labour has not declined greatly as a result of the expansion in the service industries and the implementation of public construction projects. This interaction between demand and supply led to unskilled labour 'shortages' in the 1980s which were reflected in increasing relative wages of less educated workers and in the declining returns to senior high school graduation.

Existing empirical studies of the returns to education generally focus on cross-sectional analysis. The returns to education are therefore assumed to be the same across cohorts. However, the analysis in Chapter 5 reveals significant differences in cohort effects among the four different educational levels (Figure 5.7). Including the

interactions between cohort — average years of schooling and education dummies in the regression, Model D implicitly allows the returns to education to be different across cohorts.[33] The results show that the cohort-average years of schooling have different effects for different education levels. Although the returns to education are allowed to vary across cohorts in the previous chapter, they are restricted to be the same over time. This restriction is relaxed in this chapter by investigating the returns to education over time separately for different cohorts.

In reality, rapid changes in economic conditions may have different impact on the returns to education for different cohorts because these cohorts are in different stages of their working lives and labour supplied by different cohorts may not be perfectly substitutable. Since the available data period does not cover the whole working lives of every cohort, in general, older cohorts are surveyed at older ages. These older cohorts may be well established in labour market so that the shifts of labour demand and supply may have little impact on their wages. New labour market new entrants, on the other hand may be strongly affected. Hence, a better approach to understanding the impacts of labour demand and supply on the returns to education is to choose a more flexible functional form and to allow the returns to education vary in two dimensions, across cohorts and time. This is the approach adopted in this chapter.

The arrangement of this chapter is as follows: the next section briefly reviews studies that explore changing returns to education over time in Taiwan, Korea and developed countries. Data and methods of estimating the returns to education are discussed in

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[33] The model D in Chapter 5 is as follows:

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ + \theta ED + \gamma_1 UENTER + \gamma_2 AVGYOS + \phi AVGYOS * ED + \delta Y + \varepsilon$$

$$\partial \ln W / \partial ED = \theta + \phi AVGYOS$$

Since $AVGYOS$ varies across cohorts, the returns to education are different across cohorts.

section 6.3. The empirical returns to three different educational levels (junior high school, senior high school and college) by cohort and time are presented in section 6.4. A brief conclusion follows in section 6.5.

6.2 Literature review

The returns to education have been widely discussed in the literature that examines the economic value of schooling as well as the those examining wage differentials by gender, ethnicity, region, or country. As discussed in Chapter 3, there are three definitions of the returns to education — returns to education directly estimated from Mincerian wage equations (or education–wage differentials)[34], the private rate of return to education, and the social rate of return to education. This section focuses on reviewing the literature that investigates changes in education–wage differentials over time.

Using Taiwan's Manpower Utilisation Survey, Gindling, Goldfarb and Chang (1995) explore the coefficients of junior high school, senior high school, junior college and university dummies in wage equations for men. They find that the coefficients on dummies for senior high school, junior college and university are fairly stable from 1978 to 1988 and decreased slightly from 1987 to 1991. The coefficients of junior high school dummies are stable from 1978 to 1991. Similar results are reported in Hsu and Chen (1998) and the observed period is extended to 1996. These coefficients measure a wage premia relative to the omitted group, which is less than junior high school

[34] Some studies calculate the ratios of average wages by educational level for experienced workers and new entrants separately to represent returns to education. The idea is the same as calculating the returns to education from the regression results of wage equations.

education. If returns to an education level are defined as the difference between the coefficient for this group and the coefficient for the next lower group, then this pattern of coefficients implies that the returns to senior high school education are stable in the early years but decrease after 1987, while the returns to junior high school, junior college and university education remain stable over the whole period.

Although there has been remarkable educational expansion in Taiwan over the past two decades, the returns to education have not fallen. This is very different from the conclusion that there are falling returns to education in developing countries (as summarised in the reviews of the literature by Psacharopoulos 1989 and Schultz 1993). The stable returns to college education in Taiwan are attributable to the interaction between the expansion of education and industrial shift towards skill-intensive industries.

South Korea also experienced rapid industrialisation and educational expansion in the 1970s and 1980s, the returns to education, however, are not as stable as in Taiwan. The returns to every educational level are decreasing, but the reduction is relatively insignificant at the college education level (Ryoo, Nam and Carnoy 1993). This illustrates the dominance of the effects of educational expansion over the effects of skill demand due to rapid industrialisation in Korea.

During the 1980s, Spain also experienced significant educational expansion, but its economic growth was moderate compared with Taiwan and Korea. Vila and Mora (1998) compare the returns to education between 1981 and 1991 in Spain. The results show that the returns to education for men in 1991, compared with 1981, are lower for those with lower secondary education only, higher for those with upper secondary education and short-cycle higher education, and show little change for those with long-

cycle higher education. They conclude that the stable returns to higher education are due to the fact that the labour market was able to absorb the increased supply of more educated workers, but there is no detailed discussion on the changing returns for other educational levels. Because only two years are investigated, it is not clear whether the changes in returns to education between these two years are time trends or simply differences between two points in time.

In developed countries, the distribution of the employed population by educational level is relatively stable compared with developing countries. The effect of demand shifts (the increasing demand for skilled workers due to skill-based technological change) dominates the effect of the increasing supply of more educated workers and leads to increasing returns to higher education (Katz and Murphy 1992; Bound and Johnson 1992). Murphy and Welch (1992) mention that the movement of employment structure from manufacturing towards services in the United States may also have contributed to rising returns to education.

The above studies all focus on changes in cross-sectional returns to education over time. As discussed earlier, the cross-sectional returns to education are combinations of the returns for different cohorts, in which the differences in returns among cohorts are ignored. The stable returns to education for older cohorts make the changes in cross-sectional returns to education smaller than the changes for young cohorts. It may be that the changes among young cohorts are more relevant in addressing policy questions since education policies are more closely related to young cohorts. This shortcoming of cross-sectional analysis will be remedied by an approach that examines the returns to education over time by cohorts, which has not been used in the existing literature.

6.3 Data

The data employed in this chapter are the same as in Chapter 5. The analysis focuses on the hourly wage rate of male full-time salary earners who entered the labour market after 1950. For an explanation of the earnings measure and sample selection criteria, see Chapter 4, and for summary statistics by year, see Chapter 5.[35]

In this chapter, bundles of five cohorts are grouped together, as in Chapter 4, to increase the cell size for each cohort and reduce the complexity of the graphs. Summary statistics by cohort are presented in Table 6.1. The sharp decrease in the coefficient of variation in years of schooling reflects the fact that the increase in the mean mainly comes from a decrease in the left tail of the distribution. This is a result of the successful implementation of the nine-year compulsory education policy in Taiwan from 1968. This can be clearly seen in the distribution of education among the employed population presented in Table 6.2.

Table 6.2 shows that more than 66 per cent of workers in cohort 2 (1951–55) have primary education only. The number of new entrants with only primary education drops sharply during the late 1960s and 1970s (again, due to the implementation of the nine-year compulsory education policy in 1968). Most workers in cohorts 7–10 (1976–96) have at least junior high school education. Senior high school graduates become the largest component of the workforce for young cohorts (cohorts 8, 9 and 10). Average years of schooling for young cohorts is around 12, equivalent to the educational level of senior high school.

[35] In Chapter 4, the sample for calculating wage inequality includes individuals who entered the labour market before 1950, so they are included when calculating the summary statistics.

Table 6.1: Summary labour market statistics by cohort[36]

cohort	hourly wage		years of schooling		experience		no. of
(labour mkt entry year)	mean	sd	mean	sd	mean	sd	obs.
cohort2 (1951-55)	99.88	54.60	7.52	4.00	33.05	5.43	14293
cohort3 (1956-60)	107.26	63.25	8.40	3.55	28.43	5.62	15031
cohort4 (1961-65)	104.24	58.39	8.48	3.44	23.34	5.64	21566
cohort5 (1966-70)	103.95	61.06	9.60	3.42	18.48	5.57	25493
cohort6 (1971-75)	101.85	64.19	11.03	2.92	13.55	5.47	34709
cohort7 (1976-80)	97.41	63.56	11.34	2.59	9.83	5.06	36055
cohort8 (1981-85)	103.81	56.18	11.77	2.41	7.49	3.82	25282
cohort9 (1986-90)	107.49	50.90	12.18	2.32	5.04	2.65	13659
cohort10 (1991-96)	95.93	39.97	12.01	2.28	2.00	1.65	3956

Source: Author's calculations based on data from MUS, 1978–96.

Table 6.2: Distributions of workers' educational level by cohort

cohort	primary	junior high	senior high	college	Total
cohort2 (1951-55)	66.38	8.86	13.46	11.30	100.00
cohort3 (1956-60)	56.41	14.20	17.61	11.78	100.00
cohort4 (1961-65)	57.33	13.86	16.56	12.26	100.00
cohort5 (1966-70)	38.21	19.44	26.41	15.95	100.00
cohort6 (1971-75)	12.39	29.94	34.63	23.04	100.00
cohort7 (1976-80)	4.11	36.72	36.14	23.03	100.00
cohort8 (1981-85)	1.33	30.28	42.46	25.94	100.00
cohort9 (1986-90)	0.61	21.79	48.26	29.34	100.00
cohort10 (1991-96)	0.23	25.15	48.18	26.44	100.00
Total	26.79	23.68	30.13	19.41	100.00

Source: Author's calculations based on data from MUS, 1978–96.

The distributions of workers' educational level by year are presented in Table 6.3. The proportion of the employed population with primary education declines over time, and the proportion with senior high school and college education increases, but the change is not as great as the change of course across cohorts. The proportion of junior high school graduates to all workers does not change over time, in contrast to the pattern of cohorts' educational distributions. As mentioned earlier, workers in different

[36] To make the cohort number consistent with those in Chapter 4, workers who entered the labour market between 1951 and 1955 are defined as cohort 2. Cohort 1 is skipped.

cohorts are not perfect substitutes, so the different patterns of change in the distributions of workers' education over time and across cohorts reinforce the importance of investigating changes in returns to education over time separately for different cohorts.

Table 6.3: Distributions of workers' educational level by year

	primary	junior high	senior high	college	Total
1978	40.87	23.19	23.07	12.86	100.00
1979	37.75	24.37	23.49	14.39	100.00
1980	34.47	25.36	24.79	15.38	100.00
1981	33.89	25.64	25.54	14.94	100.00
1982	32.37	25.03	26.56	16.05	100.00
1983	28.24	24.40	28.86	18.50	100.00
1984	26.27	24.46	30.15	19.12	100.00
1985	27.16	25.12	29.37	18.35	100.00
1986	25.29	25.77	30.48	18.46	100.00
1987	23.52	25.49	31.22	19.77	100.00
1988	23.57	24.41	31.90	20.12	100.00
1989	21.63	24.06	32.84	21.47	100.00
1990	21.32	24.02	33.46	21.19	100.00
1991	20.95	24.53	33.53	20.99	100.00
1992	19.36	23.49	34.34	22.81	100.00
1993	18.59	24.19	34.60	22.63	100.00
1994	17.83	26.24	33.85	22.07	100.00
1995	16.49	24.09	35.45	23.97	100.00
1996	14.59	22.33	36.14	26.94	100.00
Total	24.35	24.52	31.13	20.00	100.00

Source: Author's calculations based on data from MUS, 1978–96.

6.4 Estimating the returns to education

As mentioned in the previous section, the analysis in this chapter focuses on returns to education estimated from wage equations. The equation is as follows:

$$\ln W = \alpha + \beta ED + \gamma C + \delta Y + \theta C * Y + \phi ED * C + \eta ED * Y + \xi ED * C * Y + \varepsilon \qquad (6.1)$$

where *ED* is a set of education dummies, including junior high school, senior high school and college education. The base group is individuals with primary education or less. *Y* is a set of year dummies eliminating the year 1978. *C* is a set of cohort dummies excluding cohort 2 (1951–55).

Cohort dummies, year dummies and the interaction between cohort and year dummies are used to capture experience, cohort and year effects. The interaction terms between year and cohort dummies are necessary because the two vectors, cohort dummies and year dummies, are not orthogonal. That is, for the same cohort, experience increases as year increases, and so does wage. The wage effect from experience can be captured by these cohort and year interaction terms.

The previous chapter reveals that there exist significant experience, cohort, and year effects on wages, but the three variables cannot all be included in the regression due to the identification problem. Since the main task in this chapter is to estimate returns to education, separation of the three effects is not important. Hence, none of the models used in the previous chapter is adopted here since the more variables employed to parameterise year or cohort effects, the greater the possibility of measurement errors.

Including interactions between education dummies and year dummies, education dummies and cohort dummies, and education, cohort and year dummies in the regression allows differences in the returns to education across to cohort to vary over time. From this fully flexible specification, the different time patterns of the returns to education for each cohort can then be graphed to show how different cohorts are differently affected by changing labour market conditions.

In practice, exactly equivalent results can be achieved by calculating the difference in the mean log wages between cells, grouped by cohort, year, and educational level. In this chapter, the results are generated by this method in order to avoid the computational difficulty of running a regression with excessively large numbers of dependent variables.

To compare changes in returns to education estimated from traditional cross-sectional wage equations and the returns estimated from equation 6.1, the following equations are estimated separately by year:

$$\ln W = \alpha + \beta_1 EXP + \beta_2 EXPSQ + \beta_3 ED2 + \beta_4 ED3 + \beta_5 ED4 + \varepsilon \qquad (6.2)$$

where *EXP* and *EXPSQ* are experience and its square term. *ED*2, *ED*3, and *ED*4 are dummies for junior high school, senior high school and college, respectively. β_3 denotes the returns to junior high school education. The cross-sectional returns to senior high school and college education are ($\beta_4 - \beta_3$) and ($\beta_5 - \beta_4$), respectively.

6.5 Empirical analysis of the returns to education

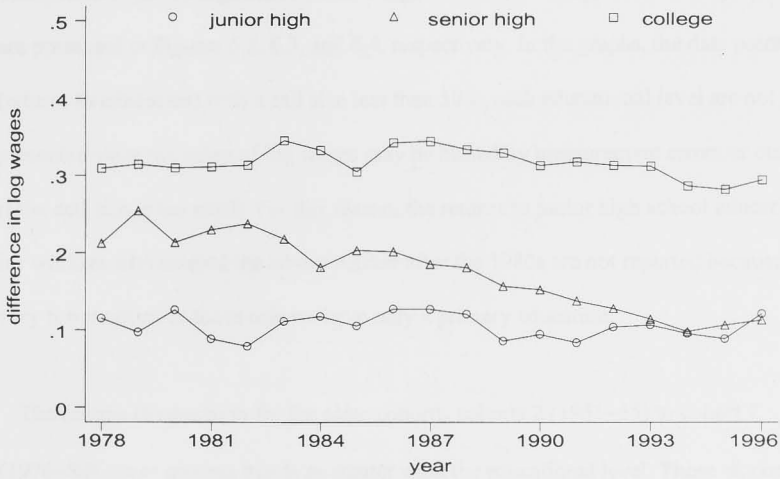
6.5.1 Cross-sectional returns to education

The returns to education estimated from separate yearly cross-sectional wage equations are shown in Figure 6.1. The returns to junior high school represent the percentage increase in the wages junior high school graduates can earn compared with their counterparts who have primary education only. Similarly, the returns to senior high

school and college graduates are the ratio of their own wages compared with their counterparts with one less level of education.

The discussion in this chapter focuses on the comparison of time trends for different educational levels rather then the magnitude of the returns among education levels. Because the costs of education are not taken into account in this study, it is meaningless to compare the level of returns to education among the three education levels.

Figure 6.1: Cross-sectional returns to education



Source: Author's calculations based on data from MUS, 1978–96

The returns to junior high school and college education remained stable over time, but the returns to senior high school education fell. Wages for college graduates relative to wages for primary school graduates also declined. Clearly, the coefficients on the college dummy were decreasing over time when primary school graduates were used as a base group. Thus, changes in educational returns may be due to the increase in the relative wages of unskilled labour rather than the increased pay-off for skilled labour.

The supply of unskilled labour (primary school graduates and junior high school graduates) dropped significantly over time, but demand did not drop as much, causing a severe (unskilled) labour shortages in the 1980s and 1990s. The excess demand has forced the wages for both junior high school[37] and primary school graduates to increase over time, and led to stable returns to junior high school graduates and decreasing returns to senior high school graduates.

6.5.2 Changes in the returns to education over time by cohort

The returns to junior high school, senior high school and college education by cohort are presented in Figures 6.2, 6.3, and 6.4, respectively. In the graphs, the data points (returns to education) with a cell size less than 50 in each educational level are not presented since the mean of log wages may be biased by measurement errors or outliers if the cell size is too small. For this reason, the returns to junior high school education for workers who entered the labour market after the 1980s are not reported because very few workers in those cohorts have only a primary education.

The returns to education for the older cohorts, cohorts 2 (1951–55) to cohort 7 (1976–80), show no time trends no matter what the educational level. These workers' wages were observed after they had at least ten years' work experience. Since they are well established in the labour market, the structural changes in Taiwan between 1978 and 1996 may not affect their returns to education. Because of rapid changes in technology, the human capital accumulated in the labour market soon outstrips the

[37] Junior high school graduates are considered to be unskilled labour in the young cohorts but not in the older cohorts. More detailed discussion on this point can be found in the discussion of cohorts' returns education.

importance of that accumulated in school. Therefore the returns to education will not be affected by skill-based technological change. Nevertheless, the human capital accumulated in school is still a foundation for the learning of new skills, therefore education–wage differentials still exist.

The returns to junior high school education do not exhibit clear patterns over time, with each cohort fluctuating between 0 and 2. This means that there were neither cohort effects nor significant time trends on returns to education. Only cohort 6 (1971–75) shows a slightly decreasing trend, but this is not significant. The years of compulsory education changed from six to nine years in 1968. Almost all workers younger than cohort 7 (1976–80) have at least junior high school education. Junior high school graduates are equivalent to workers with primary education only in the older cohort, and they can only find employment as blue-collar workers. Junior high school graduates are considered to be substitutes for primary school graduates. Accordingly, the rate of increase in the wages of junior high school graduates was greater than that of more educated workers when the supply of blue-collar workers decreased in the 1980s and 1990s. This may be why the returns to junior high school remained stable over time.

In marked contrast to the returns to junior high school education, returns to senior high school education show a significant decreasing trend for cohorts 7 (1976–80), 8 (1981–85) and 9 (1986–90). The trend is less significant for cohort 6 (1971–75). Several possible factors caused the decrease in returns to senior high school education over time: (i) the increase in the supply of senior high school graduates over time. The supply of senior high school graduates in a cohort is fixed over time, but the supply increases with the arrival of new entrants every year — although the high school

graduates for young and old cohorts are not perfect substitutes, there is a degree of substitutability, and the substitutability is higher for less experienced workers, such as workers in cohorts 7 (1976–80), 8 (1981–85) and 9 (1986–90); (ii) the increase in the relative wages of blue-collar workers, whom we suppose to be junior high school graduates, leads to a decrease in returns to senior high school education over time; (iii) skill-biased technological change does not favour senior high school graduates.

In the first panel of Figure 6.4, the line for cohort 2 is well below the line for cohort 3. This shows that there are cohort effects on returns to education, possibly caused by differences in education quality. As mentioned earlier, the returns to college education for older cohorts (cohorts 2–7) remain fairly stable over time. For the younger cohorts (cohorts 7–10), returns to education decreased in the first few years after they entered the labour market and remained stable thereafter. Obviously, the returns to college education are correlated to labour market experience, that is, the returns to education decrease as experience increases.

The pattern of returns to college education mentioned above can be explained either by human capital theory or by a screening effect. It is possible that education is considered to be a signal of an individual's ability. This screening effect becomes a minor factor as the time spent in the labour market increases and employers get to know the workers better (Spence 1973).

Following human capital theory, education is a process of accumulation of human capital. In general, individuals accumulate more professional skills in college than in high school. The professional skills accumulated in college depreciate quickly when the

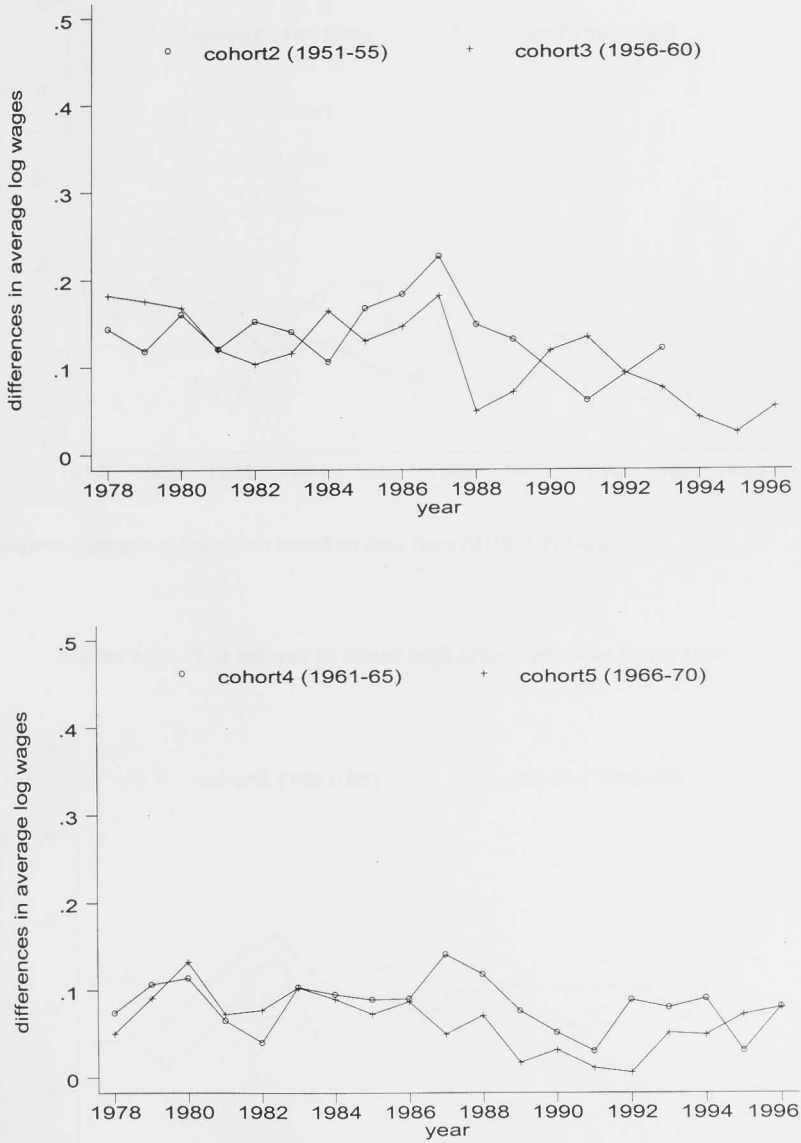
economy experiences rapid technological change, so the returns to college education late in workers' working lives come mainly from differences in general knowledge.

This empirical result, that there are falling returns to education in the first few years of workers' working lives and that they remain stable later on, is slightly different from the results in Farber and Gibbons (1996). In their model, the educational effects on level of wages[38] are considered to be independent of labour market experience, and this argument is also supported by their empirical results. Although the effects on the level of wages are the focus of the model, it is a simple matter to transfer their results to the effects of education on log wages. When the differences in wage levels between two educational groups remain the same while experience increases, the wage ratio (wages for more educated worker divided by wages for less educated workers) between these two groups must be increasing since both the denominator and numerator increase by the same amount. Thus, the experience independent wage gap in terms of wage level suggested by Farber and Gibbons is equivalent to that experience has a negative effect on returns to education in terms of wage ratios.

Except for the first few years after workers enter the labour market, the returns to college education remain fairly stable for cohorts 7–10. This suggests that the negative experience effects on returns to education only last for a few years. Although the supply of college graduates increases over time, the returns to college do not change. This implies that the increase in the demand for skilled labour due to skill-based technological change offsets the increase in the supply of more highly educated workers.

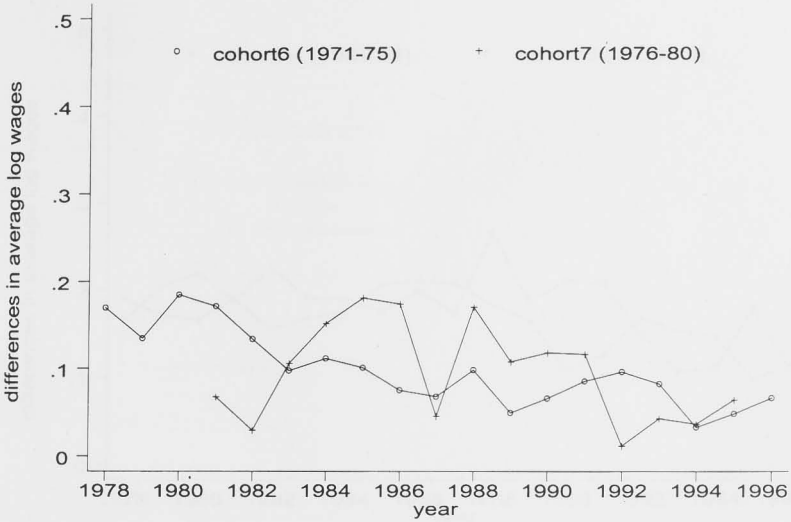
[38] They use wages as the dependent variable instead of log wages.

Figure 6.2: The returns to junior high school education over time



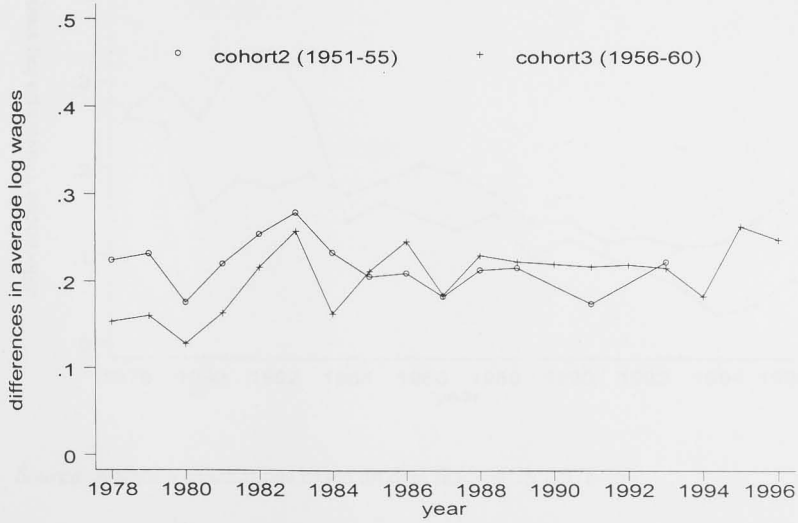
Source: Author's calculations based on data from MUS, 1978–96.

Figure 6.2: The returns to junior high school education over time (continued)



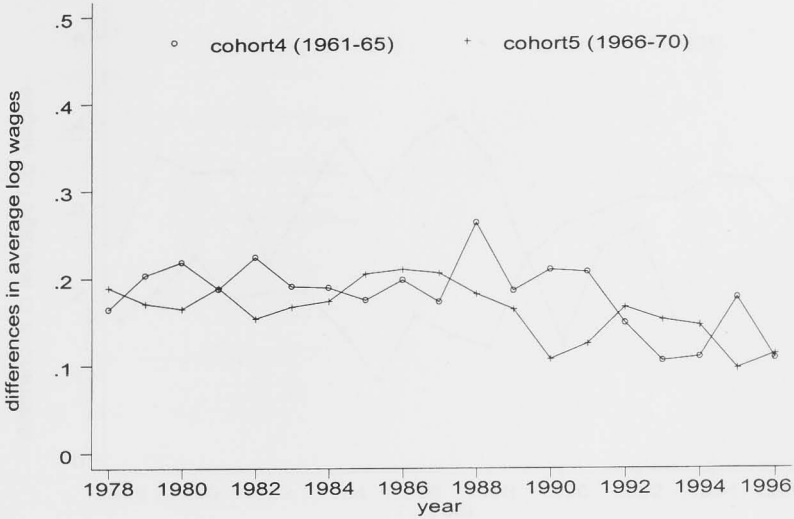
Source: Author's calculations based on data from MUS, 1978–96.

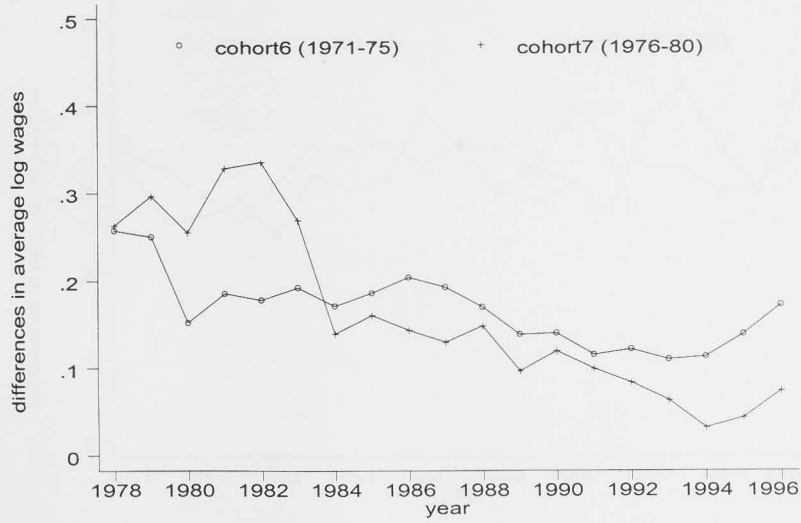
Figure 6.3: The returns to senior high school education over time



Source: Author's calculations based on data from MUS, 1978–96.

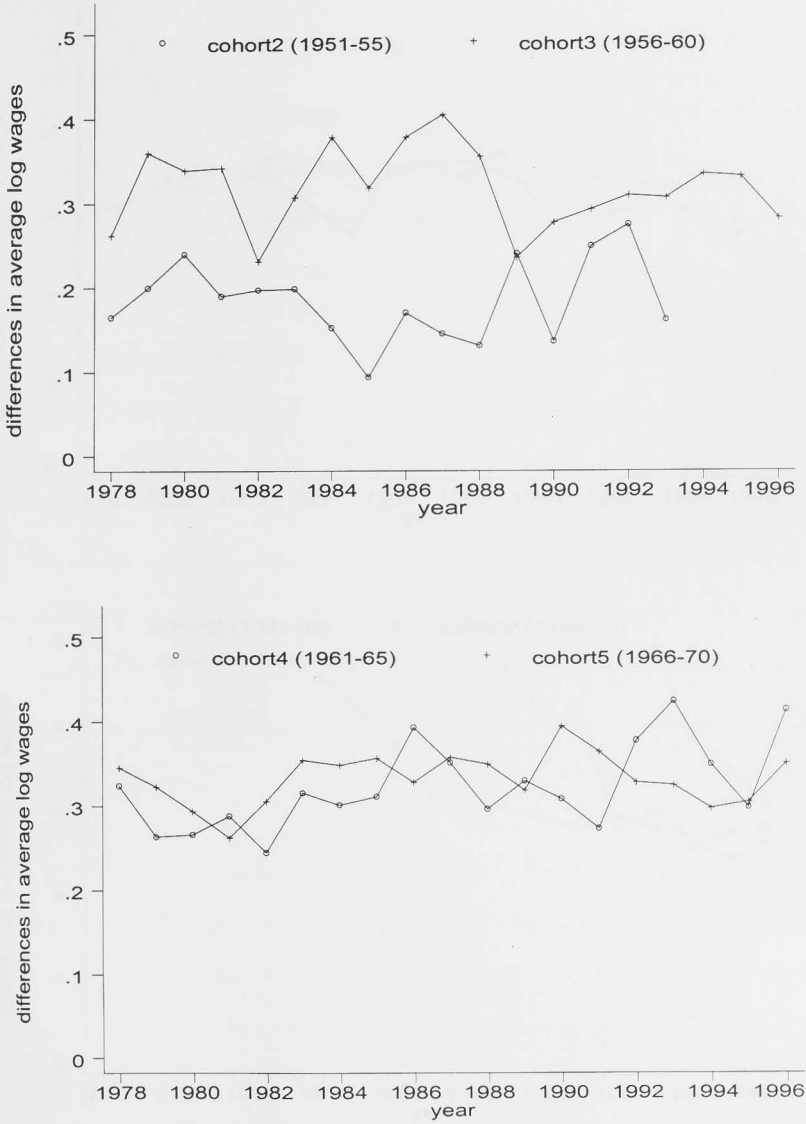
Figure 6.3: The returns to senior high school education over time (continued)





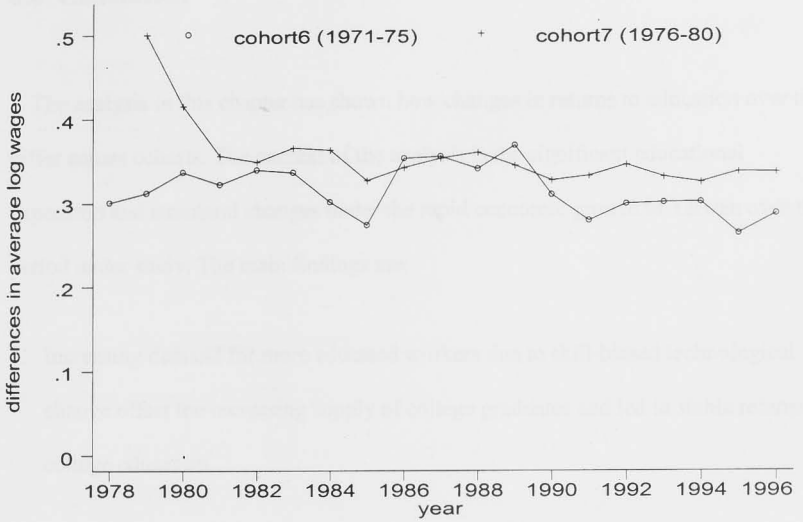
Source: Author's calculations based on data from MUS, 1978–96

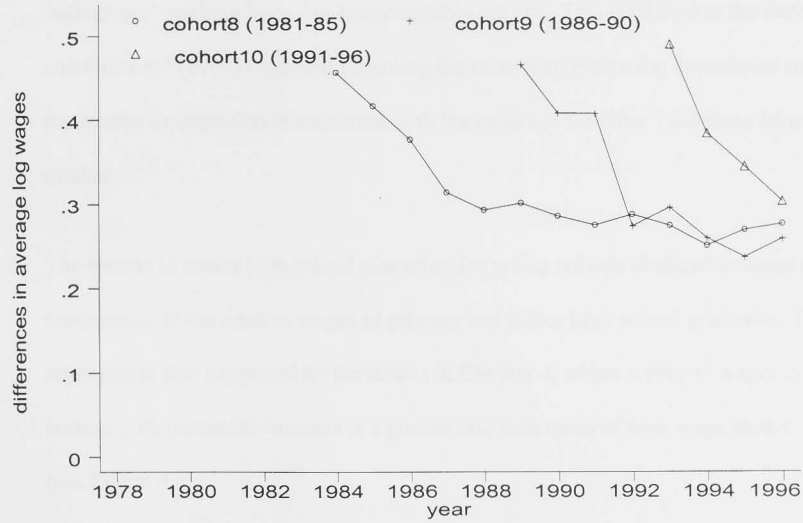
Figure 6.4: The returns to college education over time



Source: Author's calculations based on data from MUS, 1978–96

Figure 6.4: The returns to college education over time (continued)





Source: Author's calculations based on data from MUS, 1978–96

6.6 Conclusion

The analysis in this chapter has shown how changes in returns to education over time differ across cohorts. The context of the analysis is the significant educational expansion and structural changes under the rapid economic growth in Taiwan over the period under study. The main findings are:

1. Increasing demand for more educated workers due to skill-biased technological change offset the increasing supply of college graduates and led to stable returns to college education.

2. The returns to college education decrease significantly in the first few years of individuals' working lives, but become stable later on. This implies that the Farber and Gibbons' (1996) argument regarding the relationship between experience and the returns to education is consistent with the evidence from the Taiwanese labour market.

3. The returns to senior high school education for young cohorts declined because of the increase in the relative wages of primary and junior high school graduates. This argument is also supported by the results in Chapter 4, where workers' wages in the bottom 10th percentile increase at a greater rate than those of high wage earners (see Figure 4.5).

4. The returns to education for cohorts who entered the labour market before 1970 are not affected by changing labour market conditions. Thus, changes in returns to education in cross-sectional wage equations (which average the returns experienced

by the many cohorts in the data) will be more moderate than the changes experienced by younger cohorts. Thus, cross sectional and within-cohort analyses offer very different information to policy makers, and may have very different implications for educational policy.

Although the model employed here has great flexibility by using all dummy variables to capture the cohort and year effects in the returns to education, it can only expose the changing pattern of returns and not the factors that drove these changes. Only descriptive analyses of the effects of technological change, structural change, educational expansion and changing educational quality on the returns to education are provided in this chapter. Future studies could extend this work by the using variables that indicate demand and supply shifts to parameterise cohort and time effects on the returns to education. A methodology for separating the effect of experience and year on the returns to education is also worth further development.

This chapter has documented the problems caused by traditional cross-sectional analysis as well as providing a better understanding of how the trends in returns to education differ across cohorts. This provides a good basis for modelling changing returns to education and lays the groundwork for further studies.

7 Conclusion

The aim of this thesis was to explore how the wage structures changes over the past two decades in Taiwan by means of cohort analysis in order to correct the bias caused by cohort effects in traditional cross-sectional analysis. Using stacked cross-sectional data from Manpower Utilisation Survey, 1978–96, different methods have been developed to estimated the true returns to experience and education.

The background information in Chapter 2 revealed that the Taiwanese labour market is highly competitive, describing the absense of low interventions into wage determination. This implies that the changes in wage structures over the past two decades in Taiwan have been driven by supply and demand shifts. These shifts are in turn the result of the significant structural shifts and the changes in labour force composition.

The theoretical analysis in Chapter 3 showed that neither cross-sectional nor within-cohort wage–experience differentials are pure returns to experience. The cross-sectional experience–wage differentials are biased by cohort effects, caused by differences in education quality, cohort size, unobserved ability and the economic conditions faced across different cohorts. The cohort experience–wage differentials contain year effects, which are generated by economic growth and cyclical fluctuations.

The pictures of experience–wage profiles plotted from average wages in Chapter 4 revealed that cross-sectional wage profiles are much flatter than cohort wage profiles. Moreover, the cohort wage profiles are steeper for young cohorts, although cross-sectional wage profiles have been flatter in recent years. This implies that the flatter

cross-sectional wage profiles are caused by the higher starting wages of new entrants. It does not necessarily mean that the skill prices have decreased over time. The higher starting wages of younger cohorts could have been caused by higher education quality or smaller cohort size.

In Chapter 5, different approaches have been introduced to estimate the true returns to experience. For pooled cross-sectional data, the cohort and year effects cannot be removed from returns to experience by simply including cohort and year dummies in the wage equation. A wage equation with year, cohort and potential experience effects is not identified due to the linear relationship among potential experience, cohort and survey year. Four empirical models (wage equations) for pooled cross-sectional data have been employed in this thesis, each representing a different solution to the identification problem.

The goal of the first three models is to remove year effects from cohort experience–wage profile while the fourth model attempts to remove cohort effects from cross-sectional experience wage profile. In the first two models, year effects are regarded as cyclical fluctuations only, while the third model takes both cyclical and growth effects into account.

In the first model, year effects are restricted to be deviations from a linear time trend with zero sum. In the second and third models the year dummies are replaced by a parametric specification of the year effects. In the second and third model, the unemployment rate is employed to capture cyclical fluctuations. The capital–labour ratio is additionally employed as an indicator of economic growth in the third model. In the fourth model cohort dummies are replaced by a parametric specification of the

cohort effects. The cohorts' average years of schooling and the unemployment rate at the year of labour market entry are included to capture the cohort effects.

The empirical results have shown that the experience–wage profiles estimated using these different approaches differ greatly. The experience–wage profiles from the first two models are almost identical and much steeper than profiles from the other two models. The profiles from the third model are flatter because the growth effects are removed. The fourth model has the flattest wage profile, but this may simply reflect the fact that the controls used here for cohort quality are inadequate.

Each model has advantages and disadvantages. Which model is preferred depends on the purpose of the estimation and the characteristics of the dataset. The first model has the greatest flexibility and requires the least additional data. It therefore has less bias owing to measurement errors. The results gained by using the other models also depend on the accuracy of the macro variables employed in the estimation.

Since the growth effects are not removed in the first two models, they cannot be used for the study of returns to experience. They can be applied for the study of life-time wage profiles when the economy is growing constantly. The path of life-time experience-wages would be as predicted if the same amount of growth effects is added every year. Besides the assumption of constant growth, the other limitation of the first model is the time coverage of the data. If the data are available for only a few years (that is, less than a full business cycle), it is inappropriate to restrict the sum of cyclical effects to zero.

On the other hand, if the purpose of study is to analyse the returns to experience, then the capital–labour ratio should be used to control for growth effects. Without

subtracting growth effects, the coefficients on experience cannot be explained as returns to post-school human capital investment.

The disadvantage of the fourth model is the complexity of capturing cohort effects. Most of the factors of cohort effects, such as education quality and unobserved ability, are very difficult to measure. However, this method is still worthy of further study because most datasets only have one or very few single cross-sections.

In general, since the first model required the least extra information on macro variables, it is preferred, but only when the purpose is to estimate life-time wage profiles and the economy is expected to growth constantly. When the purpose of study is to investigate returns to experience, the third model is preferred because year effects are relatively easier to capture and also supported by growth theory. Due to the difficulty in finding adequate controls for differences in cohort quality, the fourth model should only be considered as an option only when a single cross-section of data is available.

The pictures of the returns to education over time by cohort were presented in Chapter 6. The analysis demonstrated that rapid educational expansion and structural shifts under conditions of high economic growth jointly determined the returns to education in Taiwan.

The empirical results reveal that: (i) increasing demand for more educated workers due to skill-biased technological change offset the increasing supply of college graduates and led to stable returns to college education; (ii) experience had a negative effect on returns to college education in the first few years after workers entered the labour market; and (3) the returns to senior high school education for young cohorts

declined because of the increase in the relative wages of primary and junior high school graduates. This argument is also supported by the results in Chapter 4, where workers' wages in the bottom 10th percentile increase at a greater rate than those of high wage earners.

Another interesting finding was that the returns to education for cohorts who entered the labour market before 1970 have been very stable through time. Because cross-sectional wage–education profiles are a mixture of the returns for different cohorts, this stability of returns among the older cohorts can mask important changes among younger cohorts if only a cross-sectional approach is followed. A cohort-based analysis offers very different information to policy makers, and may have very different implications for educational policy.

The thesis discussed the problem of cross-sectional estimation of returns to education and experience, which is commonly ignored in the literature. The empirical evidence also showed that there are great differences between the results from the cross-sectional approach and the cohort-based approach.

The contribution of the thesis is to address the wide applicability of the approaches and the importance of accurate estimates of returns to human capital for policy making. The models developed in this study can not only be applied in studies of returns to human capital but also to studies of gender wage differentials, industry wage differentials or, indeed, any application of Mincerian wage equations.

Future research could be directed towards the development of better controls for cohort effects. Application of the cohort approach adopted in this study would shed new light on the investigation of gender differences in returns to education and

experience. In most countries, the social and economic status of females has changed significantly. With these changes, the role of women in the labour market has been transformed. How do these changes affect the differences in male and female wage structures? Although the common phenonenon of discontinuous female labout market experience increases the complexity of the analysis, it is worthy of further study.

Bibliography

Beaudry, P. and DiNardo, J. (1991) 'The effect of implicit contracts on the movement of wages over the business cycle: evidence from micro data', *Journal of Political Economy* 99(4): 665–88.

Beaudry, P. and Green, D. (1997) 'Cohort patterns in Canadian earnings: assessing the role of skill premia in inequality trends', NBER Working Paper No. 6132.

Becker, G. (1975) *Human Capital*, Columbia University, New York.

Berger, M. C. (1984) 'Cohort size and the earnings growth of young workers', *Industrial and Labor Relations Review* 37(4): 582–91.

Berger, M. C. (1985) 'The effect of cohort size on earnings growth: a reexamination of the evidence', *Journal of Political Economy* 93(3): 561–73.

Berman, E., Bound, J. and Machin, S. (1997) 'Implications of skill-biased technological change: international evidence', Center for Economic Performance Discussion Paper No. 367.

Birdsall, N., Ross, D. and Sabot, R. (1995), 'Inequality and growth reconsidered: Lessons from East Asia', *World Bank Economic Review* 9(3): 477–508.

Blackburn, M. L. and Neumark, D. (1993) 'Omitted-ability bias and the increase in the return to schooling', *Journal of Labor Economics* 11(3): 521–44.

Blau, F. D. and Kahn, L. M. (1996) 'International differences in male wage inequality: Institutions versus market forces', *Journal of Political Economy* 104(4): 791–836.

Borjas G. (1985) 'Assimilation, Changes in Cohort Quality, and the Earnings of Immigrants', Journal of Labor Economics 3(4): 463-89.

Borland, J. and Kennedy, S. (1998) 'Earnings Inequality in Australia in the 1980s and 1990s', Centre for Economic Policy Research Working Paper No. 389, Canberra.

Borland, J. and Suen, A. (1994) 'The experience–earnings profile in Australia', *Economic Record* 70(208): 44–55.

Bound, J. and Johnson, G. (1992) 'Changes in the structure of wages in the 1980s: An evaluation of alternative explanations', *American Economic Review* 82(3): 371–92.

Chang, C. (1994) 'The Taiwanese education system over the past ninety years', pp. 403–45 in Liang, K. (ed.) *Essays on the Economic Development in Taiwan*, Taipei (in Chinese).

Chang, C. and Wu, T. (1983) 'The competitiveness of the Taiwanese labour market: implications of the movement of wages in manufacturing sector', paper for the Conference on *Industrial Development in Taiwan*, The Institute for Economics, Sinica Academia, Taipei, Taiwan (in Chinese).

Chapman, B. J. and Tan, H. W. (1980) 'Specific training and inter-industry wage differentials in U.S. manufacturing', *Review of Economics and Statistics* 62(3): 371–78.

Council for Economic Planning and Development (1997) *Taiwan Statistical Data Book*, Taipei, Taiwan.

Constantine, J. and Neumark, D. (1996) 'Training and the growth of wage inequality', *Industrial Relations* 35(4): 491–510.

Deaton, A. (1997) *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*, Johns Hopkins University Press for the World Bank, Baltimore and London.

Deaton, A. S. and Paxson, C. H. (1994) 'Saving, Growth, and Aging in Taiwan', pp. 331–57 in Wise, D. (ed.) *Studies in the Economics of Aging*, National Bureau of Economic Research Project Report series, University of Chicago Press, Chicago and London.

Directorate-General of Budget, Accounting and Statistics, Executive Yuan, R.O.C. (1997) *Monthly Bulletin of Manpower Statistics*, Taipei, Taiwan.

Doiron, D. J. and Barrett, G. F. (1996) 'Inequality in male and female earnings: The role of hours and wages', *Review of Economics and Statistics* 78(3): 410–20.

Durlauf, S. N. (1996) 'A Theory of Persistent Income Inequality', *Journal of Economic Growth* 1(1): 75–93.

Eriksson, T. and Jantti, M. (1997) 'The distribution of earnings in Finland 1971–1990', *European Economic Review* 41(9): 1763–79.

Farber, H. S. and Gibbons, R. (1996) 'Learning and wage dynamics', *Quarterly Journal of Economics* 111(4): 1007–47.

Fortin, N. M. and Lemieux, T. (1997) 'Institutional changes and rising wage inequality: Is there a linkage?', *Journal of Economic Perspectives* 11(2): 75–96.

Gindling, T. H., Goldfarb, M. and Chang, C. C. (1995) 'Changing returns to education in Taiwan: 1978–91', *World Development* 23(2): 343–56.

Hashimoto, M. and Raisian, J. (1992) 'Employment tenure and earnings profiles in Japan and the United States: Reply', *American Economic Review* 82(1): 346–54.

Heckman, J. J. and Robb, R. (1985) 'Using longitudinal data to estimate age, period and cohort effects', in Fienberg, S. and Mason, W. (ed.) *Cohort Analysis in Social Research: Beyong the Identification Problem*, National Academy Press.

Hsu, C.-M. and Chen, C.-L. (1998) 'Demographic transition, human capital and dynamic wage structure—Evidence from the Taiwanese labour market', paper for Conference on *Economic Aspects of Demographic Transition: The Experience of Asian–Pacific Countries*, Taipei, Taiwan.

Huang, F.-M. (1998) 'The effect of demographic factors and labour demand on the structure of wages in Taiwan 1978–1997', paper for Conference on *Economic Aspects of Demographic Transition: The Experience of Asian–Pacific Countries*, Taipei, Taiwan.

Huang, J. (1995) 'The Impact of Minimum Wage on the Labour Market in Taiwan', *Lao-tsu Kuan-hsi Lun-tsung* 3: 29–55 (in Chinese).

Jiang, M. and San, G. (1987) *The Effect of the Minimum Wage in the Taiwanese Labour Market* (in Chinese).

Johnson, G. E. (1997) 'Changes in earnings inequality: The role of demand shifts', *Journal of Economic Perspectives* 11(2): 41–54.

Juhn, C., Murphy, K. M. and Pierce, B. (1993) 'Wage inequality and the rise in returns to skill', *Journal of Political Economy* 101(3): 410–42.

Jung, J. H. (1992) 'Personal income distribution in Korea, 1963–1986: A human capital approach', *Journal of Asian Economics* 3(1): 57–71.

Katz, L. F. and Murphy, K. M. (1992) 'Changes in relative wages, 1963–1987: Supply and demand factors', *Quarterly Journal of Economics* 107(1): 35–78.

Kim, D. I. and Topel, R. H. (1995) 'Labor Markets and Economic Growth: Lessons from Korea's Industrialization, 1970–1990', pp. 227–64 in Freeman, R. B. and Katz, L. F. (eds) *Differences and Changes in Wage Structures*, National Bureau of Economic Research Comparative Labor Markets Series, University of Chicago Press, Chicago and London.

Knight, J. B. and Sabot, R. H. (1983) 'Educational expansion and the Kuznets effect', *American Economic Review* 73(5): 1132–36.

Kuznets, K. (1955) 'Economic Growth and Income Inequility', *American Economic Review* 45(1): 1–28.

Lai, C. (1989) 'Market structure and inter-industry wage differences: The case of Taiwan, *Economics Letters* 31(2): 199–204.

Lee, M. L., Liu, B. C. and Wang, P. (1994) 'Education, human capital enhancement and economic development: Comparison between Korea and Taiwan', *Economics of Education Review* 13(4): 275–88.

Lillard, L. A. and Tan, H. W. (1996) 'Private sector training: who gets it and what are its effects?', pp. 199–260 in Ashenfelter, O. C. and LaLonde, R. J. (eds) *The Economics of Training Volume 2: Empirical Evidence*, Elgar Reference Collection, International Library of Critical Writings in Economics, Vol. 65, distributed by Ashgate, Cheltenham, U.K.

Lin, C. and Chu, Y. (1985) 'Further evidence of cohort size effects on earnings: the case of Taiwan', *Journal of Economic Development* 10(2): 101–21.

Liu, K. (1994) 'Demographic transition and educational investment in Taiwan', pp. 326–47 in Liang, K. (ed.) *Essays on Economic Development in Taiwan*, Taipei (in Chinese).

Liu, Y. (1994) 'Female labour force participation in Taiwan', pp. 372–402 in Liang, K. (ed.) *Essays on Economic Development in Taiwan*, Taipei (in Chinese).

Lucas, R. E. Jr. (1988) 'On the Mechanics of Economic Development', *Journal of Monetary Economics* 22(1): 3–42.

Meghir, C. and Whitehouse, E. (1996) 'The evolution of wages in the United Kingdom: Evidence from micro data', *Journal of Labor Economics* 14(1): 1–25.

Mincer, J. (1974) *Schooling, Experience, and Earnings*, National Bureau of Economic Research and Columbia University, New York.

—— (1984) 'Human Capital and Economic Growth', *Economics of Education Review* 3(3): 195–205.

—— (1989a) 'Human capital responses to technological change in the labor market', NBER Working Paper No. 3208.

—— (1989b) 'Job training: costs, returns, and wage profiles', NBER Working Paper No. 3207.

—— (1993) 'Human capital, technology, and the wage structure: what do time series show?', pp. 366–405 in Mincer, J. (ed.) *Collected essays of Jacob Mincer Volume 1: Studies in Human Capital*, Economists of the Twentieth Century Series, Aldershot, U.K.

—— (1994) 'The production of human capital and the lifecycle of earnings: Variations on a theme', NBER Working Paper No. 4838.

Mincer, J. (1996) 'Economic development, growth of human capital, and the dynamics of the wage structure', *Journal of Economic Growth* 1(1): 29–48.

—— and Polachek, S. W. (1978) 'Women's Earnings Reexamined', *Journal of Human Resources* 13(1): 118–34.

Mosk, C. and Nakata, Y. F. (1985) 'The age–wage profile and structural change in the Japanese labor market for males, 1964–1982', *Journal of Human Resources* 20(1): 100–116.

Murphy, K. M., and Welch, F. (1990) 'Empirical age–earnings profiles, *Journal of Labor Economics* 8(2): 202–29.

—— (1992) 'The structure of wages', *Quarterly Journal of Economics* 107(1): 285–326.

Neuman, S. and Weiss, A. (1995) 'On the effects of schooling vintage on experience–earnings profiles: Theory and evidence', *European Economic Review* 39(5): 943–55.

Neumark, D. and Taubman, P. (1995) 'Why do wage profiles slope upward? Tests of the general human capital model', *Journal of Labor Economics* 13(4): 736–61.

Ohkusa, Y. and Ohta, S. (1994) 'An empirical study of the wage–tenure profile in Japanese manufacturing', *Journal of the Japanese and International Economy* 8(2): 173–203.

Polachek, S. W. (1995) 'Earnings over the life cycle: What do human capital models explain?', *Scottish Journal of Political Economy* 42(3): 267–89.

Psacharopoulos, G. (1989) 'Time trends of the returns to education: Cross-national evidence', *Economics of Education Review* 8(3): 225–31.

Romer, P. M. (1989) 'Human capital and growth: Theory and evidence', NBER Working Paper No. 3173.

Rosen, S. (1976) 'A theory of life earnings', *Journal of Political Economy* 84(4): 1976, pp. S45–67.

Ryoo, J. K., Nam, Y. S. and Carnoy, M. (1993) 'Changing rates of return to education over time: A Korean case study', *Economics of Education Review* 12(1): 71–80.

Schmitt, J. (1995) 'The changing structure of male earnings in Britain, 1974–1988', pp. 177–204 in Freeman, R. B. and Katz, L.F. (eds) *Differences and changes in wage structures*, National Bureau of Economic Research Comparative Labor Markets Series, University of Chicago Press, Chicago and London.

Schultz, T. P. (1993) 'The role of education and human capital in economic development: An empirical assessment', pp. 145–64 in Siebert, H. Mohr (ed.) *Economic Growth in the World Economy: Symposium 1992,* Kiel Institut fur Weltwirtschaft Symposien-und Konferenzbande series, Tubingen.

Shen, J.-H. (1998) 'The impact of minimum wage on employment opportunity in Taiwan', *Taiwan Yin-hang Chi-k'an* 49(3): 221–42 (in Chinese).

Spence, A. M. (1973) 'Job market signaling', *Quarterly Journal of Economics* 87(3): 355–74.

Tallman, E. W. and Wang, P. (1994) 'Human capital and endogenous growth: Evidence from Taiwan', *Journal of Monetary Economics* 34(1): 101–24.

Tan, H. and Batra, G. (1997) 'Technology and firm size – wage differentials in Colombia, Mexico, and Taiwan (China)', *World Bank Economic Review* 11(1): 59–83.

Tan, H. W. (1981) 'Human capital and technical change', Australia–Japan Research Centre Working Paper No. 78.

——(1982) 'Wage determination in Japanese manufacturing: A review of recent literature', *Economic Record* 58(160): 46–60.

—— (1989) 'Technical change and human capital acquisition in Japanese and U.S. labor markets', Rand Paper No. P-7588, Rand Corporation.

Topel, R. H. (1997) 'Factor proportions and relative wages: The supply-side determinants of wage inequality', *Journal of Economic Perspectives* 11(2): 55–74.

Uzawa, H. (1965), 'Optimum technical change in an aggregate model of economic growth', *International Economic Review* 6: 18–31.

Verbeek, M. (1992), 'Pseudo panel data', pp. 303–15 in Matyas, L. and Sevestre, P. (eds) *The Econometrics of Panel Data—Handbook of Theory* and *Applications*, Kluwer Academic Publishers.

Vila, L. E. and Mora, J. G. (1998), 'Changing returns to education in Spain during the 1980s', *Economics of Education Review* 17(2): 173–78.

Welch, F. (1979) 'Effects of cohort size on earnings: The baby boom babies' financial bust', *Journal of Political Economy* 87(5): 1979, pp. S65–97.

Wu, C. (1994) 'Workplace relations in Taiwan', pp. 348–71 in Liang, K. (ed.) *Essays on the Economic Development in Taiwan*, Taipei (in Chinese).

Wu, H.-L. (1987) 'The Taiwanese labour market and economic development', paper for Conference on Contemporaneous Economic Issues, Taipei (in Chinese).

—— (1992) 'The Taiwanese labour market and economic development: Retrospect and prospect', *Taiwan Yinhang Chi Kan* 43(4): 267–198 (in Chinese).

——, Wang, W.-T. and Wang, S.-W. (1998) *Research on Labour Shortages in SMEs in Taiwan*, Chung-Hua Institute of Economic Research, Taipei.

Zveglich, J. E. Jr., Rodgers, Y. M. and Rodgers, W. M. III (1997) 'The persistence of gender earnings inequality in Taiwan, 1978–1992', *Industrial and Labor Relations Review* 50(4): 594–609.