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PhD Thesis

An Empirical and Comparative Analysis of Taiwanese Unemployment and Wages

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This doctoral thesis is dedicated to the memory of my beloved Grand Mother, Mrs. Chen Chiung Ying (1925~2012), who has spent most of her life holding our family as a whole, and bringing us all up to what we are. Her efforts, love, and laborious but meaningful life shall never be forgotten, never by her family.

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Faculty of Social and Human Sciences

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Abstract

Taiwan has long been recognized as an economic entity highly dependent on its international trade. The thesis discusses its labour predicament at both macro and micro levels, in terms of unemployment rate and labour wage determination, in a framework of international trade studies.

This thesis start with its attempt to examine if cyclical export gap is in fact beneficial to the local unemployment rate. Within an Autoregressive Distributed Lag(ADL) framework of Okun coefficients, cyclical export gap is added as an extra explanatory variable, to examine if Dutt et al.'s prediction that unemployment and trade openness are negatively related can be statistically supported with Taiwanese data. Furthermore, the Chow test demonstrates that there are "shocks" that would create structural changes, at 1990q1 when Taiwan reinitiates trade with China, and at 2002q1, when Taiwan joined WTO as a member country. Lastly, a Quandt Likelihood Ratio test is included so to locate the date when any additional structural break is most likely to happen.

This thesis also analyses the impact of different Taiwanese government policies affecting wages. For the past two decades, an expanding education policy has been implemented regardless of the alternating parties in administration. Also, the Taiwanese government maintained a tolerant policy regarding the expansion of the real-estate market bubble. Using three different estimators, this thesis finds evidence supporting that the wages of the youngest cohort suffer from lower education returns and the crowding-out effect of corporation indebtedness on real property reinforced by the housing bubble. The thesis could not find evidence supporting that the preferential bilateral free trade agreement between Taiwan and China, known as the Economic Cooperation Framework Agreement, is benign to Taiwanese labour wages.

The thesis also compares how the same wage determining factors would have similar or different impact on UK wages, so to see: How are the wage determinants (e.g., education attainment, industrial investment in real estate) affecting the UK labour force, in a similar or different ways as opposed to their Taiwanese counterparts? And how do such impacts change at different structural breaks?

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Declaration of Authorship

I, Yu Shen Liu, declare that the thesis entitled An Empirical and Comparative Analysis of Taiwanese Unemployment and Wages and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at the University of Southampton;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission

Signed: .....

Date: .....

Acknowledgements

To the Readers,

The following passage would be dedicated to several important people in my life, who have made their contribution to the thesis in various ways over the past years. Without their help, this thesis would never be completed as it is now.

Thank you, my dear late grand mother, Ms. Chen Chiung Ying (1923∼2012), who had always loved me, spent all your life holding our family together, and believed me to be able to reach where I am now. Also I would like to express my gratitude to my parents, Mr. Meng Ru Liu and Ms. Li Jiuan Chen, who have always believed in me, taken care of my grand mother while your prodigal son being away for so long. I should also thanks my sister, Ms. Tzu Chi Liu, and brother Mr. Shu Wei Liu, who have shared my responsibility to take care of our parents and grand parent. For that, I am always grateful. My family has assisted me to go through this insane journey of PhD study, both financially and mentally, they are the ones who made it possible.

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Nomenclature

ADL model	Autoregressive Distributed Lag model
BHPS	British Household Panel Survey
CFC	Consumption of Fixed Capital
CS	Cross Sectional
CSSTA	Cross-Strait Service Trade Agreement
ECFA	Economic Cooperation Framework Agreement
FE	Fixed Effect
FTA	Free Trade Agreement
GDP	Gross Domestic Product
H-O model	Heckscher–Ohlin model
HP filter	Hodrick-Prescott filter
HPI	House Price Index
HW smoothing	Holt-Winters smoothing
MCA	Multiple Correspondence Analysis
NAFTA	North American Free Trade Agreement
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
the PRC	the People's Republic of China
PSFD	Panel Study of Family Dynamics
QLR	Quandt Likelihood Ratio
QR	Quantile Regression
STAN database	Structural Analysis database
TEII	Technology and Empowerment Industry Index
UK	United Kingdom
UKHLS	United Kingdom Household Longitudinal Study
UKSIC92	United Kingdom Standard Industry Classification (of economic activities 1992)
US	United States
VAR	Vector Auto-Regression
WTO	World Trade Organization
2SLS	2 Stage Least Squares

Chapter 1

Introduction

As an overview for this doctoral thesis, this chapter includes a wide-ranging review of the empirical and theoretical literatures on parameters estimated in Taiwanese labour market such as unemployment and wages, how they are affected by various factors, it also considers how these results for Taiwan would be similar (or different) to that in the United Kingdom, which is a benchmark example of a developed, island country like Taiwan also depends on its international trade with neighboring states. Some stylized facts will be presented so as to allow readers to have a better understanding of these topics. This chapter also articulates the aims as well as motivation of the thesis, and identifies how this thesis should contribute empirical literatures of labour economics.

1.1. Overview of Post 1990s Taiwanese Economy, Its Policy, and Factors Affecting Labour Market

1.1.1. Taiwanese Economic Process, Issues, and related Policies

After the "economic miracle" during the 1980s when the GDP growth rate in average was 8.5% and unemployment rate, Taiwan has entered a whole new phase of economic development since the 1990s. Ever since the martial law was abolished in 1987, the interactions and communications between Taiwan and China started to be re-established, which later pushed up the Degree of Dependence on Foreign Trade (DDFT) that was already high[1].

In this period (1991∼2000), the average economic growth rate is 6.7% while the average unemployment rate in this period 2.17%. The increasing unemployment rate and decreasing growth rate could be a result of the loss of comparative advantage

[1]The DDFT ratio, also known as the trade-to-GDP-ratio, by definition is the sum of exports and imports divided by GDP. This indicator measures a country's "openness" or "integration" in the world economy. By the 1980s, the average DDFT is 83.46%, while that of the post 1990s is 90.4%

in the labour intensive, export processing sectors, i.e., sectors where materials may be imported into a designated area, handled, manufactured or reconfigured, before been re-exported without the intervention of the customs authorities(Encylopaedia-BriTannica 2015, Hsu 2013). To bring the economy out of the predicament, in the decade since 1990, Taiwanese government strived to promote industrial upgrade, by putting focus on the development of emerging industries, e.g., telecommunication, computer, consumer electronics, semiconductor, precision machinery, aviation engineering, advanced material, chemical product, and medical industry (Lian & Wang 2002). As a result, such industry restructuring process became effectively re-shaping Taiwanese industries into capital (or skill) intensive ones. Among all the emerging industries in the 1990s, computer industry especially has demonstrated its success, becoming one of the most prominent computer component suppliers in the world.

The closer and more frequent economic interaction and communication between Taiwan and China was de facto, one of the most effective external factors that fastens the aforementioned industrial restructuring process. Ever since its Economic Reform led by Reformists such as Den Xiaoping within the Communist Party, China starts to develop its labour intensive industries(Lardy 1998). The international trade between Taiwan and China (starting circa. 1991) further encouraged the aforementioned development of capital (or skilled) intensive industries. In 2002, following China's step, Taiwan also joined the World Trade Organization (WTO) as a member state, thereby developing even closer relation to, yet stronger dependence upon China. In the post-WTO decade, the average economic growth rate is 4.2%, while the unemployment rate is 4.5%. It is during this period that the slowdown of economy growth and the further worsening unemployment rate started to become a recurring theme in the mind of policy makers. This is also the period when Taiwan experienced its first ever alteration of ruling party, switching from Kuo Min Tang (KMT) to Democratic Progressive Party (DPP), since the end of World War II. It seems to be the belief of both parties, nevertheless, that the further access to the domestic market in China would be the remedy that stimulates economy, and reduce unemployment rate in Taiwan. In the year 2008, Taiwan experienced yet another alternation of its ruling party, i.e., KMT returned as the administrative government. In this period, Taiwan became even diplomatically closer to China, while the economic dependence on foreign trade with China increased. Furthermore, A free trade agreement between China and Taiwan, i.e., Economic Cooperation Framework Agreement (ECFA) was agreed between Taiwan and China in 2009. According to the ECFA, the local tariff in China charging against Taiwanese commodities would drop down to 10% in average. Such reduction was construed by many Taiwanese merchants and enterprises alike as an even bigger opportunity for their expansion and prosperity, while many Taiwanese workers regarded it as an imminent threat to their jobs. Starting in 2011, a even closer FTA, i.e., Cross-Strait Service Trade

Agreement (CSSTA) was under discussion by both countries, intend to open up even more industries by removing protective restraints and lowering tariff within than ECFA did. Before it could reach final agreement, CSSTA was heavily opposed by Taiwanese Citizens. One of the key arguments among others that these opponents stressed during protest is their concern over the potential increase of unemployment rate caused by the aforementioned industrial restructuring process that might be stimulated by CSSTA in the not so far future. Would the increasing foreign trades with China be influential to the local labour employment? If so, is such impact benign or malignant? We would like to figure it out in Chapter 2.

1.1.2. Another Analytical Perspective of Taiwanese Labour Market: Wage determining factors

In the period post 1990s, the labour market in Taiwan also experienced other reformations. Among other things, one of the most significant changes was the average education level improvement within Taiwanese labour market caused by education expansionary reformation. Different policies such as: Middle School Voluntary Access Experimental Program (1990∼ 2002) that allowed junior high school student to enter senior high school without taking entrance exam. The promulgation of Educational Fundamental Act became effective in 1999, according to which people should be the primary subject of education right, and such right should be delegated to local government. This is the law act that often been deemed as the "spine" of education reformation (Hsu 2001). The University Consolidation Policy in 1999, allows vocational education institutes to be merged and thus becoming universities. Other policies such as multiple-entrance program (in 2008), Twelve-years National Education, construction of high school community and exam free admission (all in 2011) were all parts of the educational reformation, that might have different functions yet similarly exposing higher education to a greater part of the Taiwanese local population, on direct or indirect terms (Chi 2012). These expansionary education policies are often construed by many as one of the driving factors lowering the entry requirement of higher education in Taiwan, thereby increasing the number of graduate level workers in the labour market. Furthermore, it is often considered as one of the reasons that Taiwanese industries could smoothly be transformed into capital (or skill) intensive industries. Be that as it may, what are the implications thereof upon Taiwanese labour? More specifically speaking, how would such changes affect the labour wage? Would other external factors, e.g., the aforementioned FTA participation be plausibly effective to wage determining factors such as education return?

Empirical economists among Taiwanese academe and those from the rest of the world alike have shown great interest in analyzing the factors that hinder Taiwanese real wage growth and tend to focus onto human capital, i.e., the implication of education, experience, and other characteristic factors, e.g., marital status, number of children, and so on. By and large, they agree on the negative impact of education expansion policies initiated in 1994 to be the sole factor that has driven down the quality of education received by Taiwanese labour force, causing the labour quality diluted at both uneducated and educated sectors, thereby undermining the real wage in Taiwan. Their argument sounds solid, from Figure 1.1 it is obvious that graduates from higher education demonstrates a three-fold increase since 1994 (from some 80,000 graduates in 1994 to some 291,000 in 2012)[2]. On a relative basis, from Figure 1.2,the number of people graduated from higher education and above also increases since 1994, and becomes of the highest share among the total educated population in Taiwan. Such expansion would shift the labour supply of educated workers outward, and hence is often described as a driver that makes the "education premium," i.e., the increase in wage once one succeeds in finishing one's education, to be smaller. From Figure 1.3, it is easy to notice that Taiwanese education premium, say, between university and below, is shrinking since mid 1990s, and the difference is almost negligibly small after 2011. However, due to limited data availability, Taiwanese economists tend to focus more on analyzing wage determination of older cohorts (say, those in their mid-30s or above), but rarely address wage stagnation of the younger cohorts.

[2]In April 10th, 1994, a demonstration named "410 educational reform march," was initiated by a mathematic professor in National Taiwan University, Prof. Huang Wu Shiong, along with the "Humanistic Education Foundation" and dozens of other civil organizations. The demonstration called for public attention to the then long-waited education reformation, and proposed 4 points of their concern, including: 1. decrease the number of students in each class, and that each school so to better the education quality shared and recieved by each student. 2. Increase the number of senior high schools (for the students above age 16) and universities. 3. Modernization of education system, including primary school localization, parent participation, school privatization. and 4. to establish education basic law.

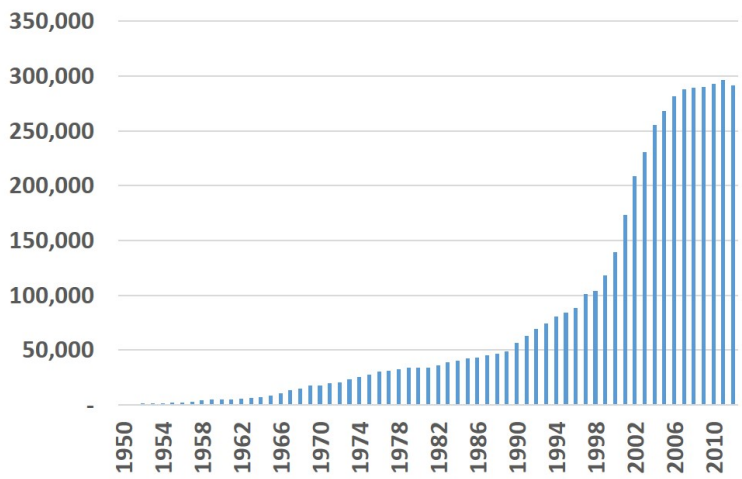


Figure 1.1: Number of Taiwanese Higher Education Graduates 1950-2012(Ministry-Of-Education 2014)

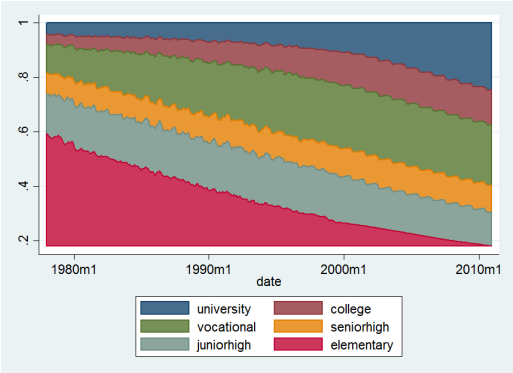


Figure 1.2: Education Structure of Labour Force in Taiwan 1978∼2010 (DGBA 2014)

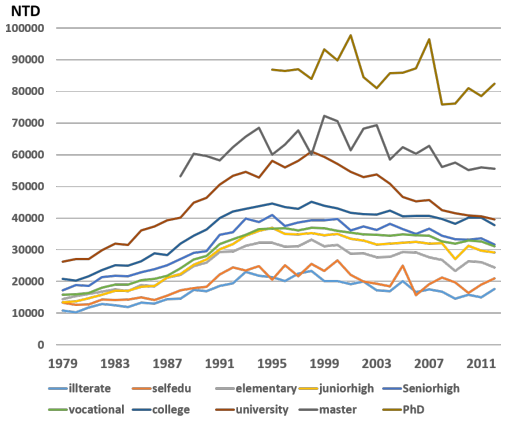


Figure 1.3: Real Monthly Wage by Skill Composition 1979-2013 (SRDA 2014)

In the following subsections, we would like to include and examine the empirical works established by researchers from Taiwan and the other parts of the world alike. These works had applied different empirical or theoretical models respectively, which would become important references here and there within the thesis. Following the long tradition of economic empirical studies, we would include economic papers published in peer reviewed, international economic journals as our priority choice of reference. Be that as it may, for Chapter 2 and 3 especially, i.e., the empirical studies of Okun structure and those of Mincerian wage determining structure analysing Taiwanese context, such papers are more often written by Taiwanese empirical economists and published by Taiwanese journals. Hence we also include a good portion of paper published in Taiwanese journals. Also, aside from journal in the field of empirical / theoretical economics, due to the nature of interdisciplinarity and broad adaptability of the Mincerian structure, we also include some literature outside economic studies, e.g., education, social statistics, and sociology as our ref-

erence. Furthermore, due to the scarcity of relevant Taiwanese empirical paper for Chapter 2 and 3 respectively, we also include PhD or Master thesis as our reference. Though not yet been recognized by international or Taiwanese journals, these thesis still make their unique contribution in their intended fields. In the following subsection we shall discuss some of these key references, by identifying their contribution, what yet to be achieved, and could be acieved by the scope of the thesis, so to clarify the possible contribution to the academe made by our own work.

1.2. Unemployment: Okun Coefficients, Exports and Structural Breaks

1.2.1. Okun Coefficients

The minimization of unemployment and the promotion of economic growth, beyond question, have been the two recurring themes in macro-policy implementation of all countries. In the field of applied economic analysis, the relation between the growth rate of Gross Domestic Product (GDP) and the unemployment rate has been widely examined in various contexts, and remains controversial. Ever since the Okun's empirical observation between the two variables has received attention worldwide, the well-known and constantly-elaborated "Okun's law" became one of the mainstream approaches as to examining the dynamics of the overall economy. In his research, Okun(1962) proposes two versions of his model, i.e., the "difference version" and the "gap version." For the difference version, the structure of the empirical model is composed with the first difference of GDP (y_t) and that of unemployment rate (u_t):

$$\Delta y_t = \beta_0 + \beta_1 \Delta u_t + \epsilon_t \tag{1.1}$$

where Δ is backward difference operator, ϵ_t is white noise, and β_1 is the Okun Coefficient. As for the gap model, it includes the gap between actual GDP and the long term equilibrium GDP, and the gap between actual unemployment rate and the long term equilibrium unemployment rate. The model is structured as follows:

$$y_t - y_t^* = \beta_1 (u_t - u_t^*) + \epsilon_t \tag{1.2}$$

The y_t is the current GDP level, and y_t^* is the long term equilibrium GDP, both measured in the natural-log scale. On the other hand, u_t is the current level of unemployment rate, while u_t^* is the natural unemployment rate. Hence the coefficient β_1 is the percentage change by which the GDP would deviate from current level with respect to 1% change in unemployment rate from its potential level. With the latter model, Okun concludes that: for every 1% increase in the unemployment rate, by and large, GDP will drop by an additional 2% lower than its potential GDP (Okun 1962). In chapter 2, both first difference model and gap model would be tested, but later part of the chapter would focus on the latter approach so to address the issue of stochastic trend. The latter structure follows part of the empirical model

established by Webber (1995) and Moosa (1997), focusing on the short term ratio between GDP gap ($y_t - y_t^*$) and unemployment gap ($u_t - u_t^*$)(Weber 1995, Moosa 1997). Without deriving an estimate on the long term Okun coefficient that applied by Webber or Moosa, the result in Chapter 2 still allows us to examine the Granger causality between GDP gap and unemployment gap in the short run, and compare the impact at different sub periods.

Okun Coefficients might function as benchmarks for macro policy fine-tuning in well-diversified manners. As a case in point, given a constant economic growth rate, the government could get a fix on estimation of expenditure on unemployment benefit, based on the estimated Okun coefficient. Another simple instance is the estimation of the short run Phillips curve, i.e., the nonlinear, negatively sloped correlation between unemployment rate and inflation rate. Such connection allows policy makers to forecast how prices would react to a current shock, and how monetary (or fiscal) policy should be implemented accordingly(Chen & Lin 2005). In a similar yet different vein, the structural changes of the said Okun coefficients, i.e., their stability (or instability) would allows policy makers (or more often, economists) to examine how factors changing in politics, labour markets, international or economic policies would have influence on the Okun coefficient, thereby determine the growth in production would more efficiently adjust the unemployment rate downward or not.

Okun Coefficients possesses different implications in different models. Weber (1995) applies the Autoregressive Distributed Lag (ADL) model to test the short term interactions between the post-war U.S. cyclical unemployment rate and cyclical GDP (Weber 1995). Constructing a Vector Auto-Regression (VAR) model, in which the Okun Coefficient is derived from the coefficients of residuals (disturbances). Blanchard and Quah (1989) point out the negative relationship between the two variables would sustain only when the short term shock comes from the demand side (disturbance), whereas the short term shocks from supply side (disturbance) would only affect the cyclical GDP but not unemployment, and even a positive correlation between the two variables is observed (Blanchard & Quah 1989). Provided that GDP and unemployment rate are cointegrated, as Attfield and Silverstone (1998) demonstrate, the Okun coefficient can be thus interpreted as the cointegrating coefficient between the variables, with the two-step cointegration model constructed by Engle and Granger (1987), while treating the stochastic trend or "permanent" component in GDP and unemployment both defined in terms of the Beveridge and Nelson decomposition(Attfield & Silverstone 1998, Engle & Granger 1987). Suffice it to say, these different empirical results do not estimate the same parameter, yet, each of them provides an estimate of the relationship between GDP and unemployment rate on different time scales. The original static model proposed by Okun in 1962

focuses on the interactions between GDP and employment in the current period, while Weber's ADL model shows the short term interactions between the two variable. The estimates in the VAR model by Blanchard and Quah (1989) measures the interactions between the one step ahead forecast errors, whereas the cointegrated coefficients proposed by Engle and Granger (1987), and latter estimated by Attfield and Silverstone (1998) should be deemed as the long run estimates of the interactions between the GDP and unemployment rate at equilibrium.

1.2.2. Expanding the Okun Structure

A key component of the thesis is to include new explanatory variables into the Okun dynamic structure, so to examine if the fluctuation in unemployment rate shall be affected by these factors equivalently as by GDP, if not more. To name but a few, Prachowny (1993) introduces supply side variables such as: capacity utilization rate, labour supply, and numbers of hours worked into the Okun structure, and determines that changes in weekly hours and movements in capacity utilization, in addition to adjustments in the unemployment gap, are significant influences on changes in the GDP gap(Prachowny 1993). Furthermore, in their attempt at reassessing Prachowny's result, Attfield and Silverstone (1998) derive a robust result using the aforesaid cointegration model, which is consistent with previous research on the same U.S. data set(Attfield & Silverstone 1998). Be that as it may, Prachowny (1993) and Attfield and Silverstone (1998) only follow the original structure proposed by Okun in 1962. That said, in their costructed Okun structure they include the output gap and unemployment gap in the same period, hence the Okun coefficient they derived respectively only account for the association between output gap and unemployment gap, rather than causality. Other types of variables are also of potential to be included in the basic interactions between GDP growth and the unemployment rate. Chang (2007), for instance, has included variables such as Foreign Direct Investment (FDI), the degree of openness of the domestic market, and exports to the rest of the world, into the relationship between GDP growth and unemployment in an expanded VAR model framework (Chang 2007). Chang concludes that FDI, one of the results of trade liberalization, in fact has a positive impact on the economic growth and no significant relationship with the unemployment rate, but exports have a negative relationship with the unemployment rate and a positive relationship with output gap in Taiwan. Other Economist such as Tien (2010), also attempts to add novel variables including the openness of economy (measured with the ratio between net export and GDP), the change of industry structure (measured with ratio between numbers of workers in manufacturing sector,

and in tertiary sector), and the ratio of immigrant workers(Tien 2010)[3] Both Chang (2007) and Tien (2010) had applied a similar structure, i.e., taking the current GDP gap (in log difference term) (or unemployment gap) as the regressand in the left hand side, while the unemployment gap (or the output gap) of previous periods are included as regressors at the right hand side. That is to say, the significant "Okun coefficient" (or the reciprocal of such coefficient) derived in their result might de facto account for the "Granger causality."[4] **As discussed in Section 1.1.1, Taiwanese labour employment might be, to some great extent, affected by its foreign trade. Even though Chang (2007) and Tien (2010) have expand their Okun Structure by adding exports, they did not measure it as the "export gap," i.e., the difference between actual value and trend estimated. The first part of this doctoral thesis will attempt to make its innovative contribution by extending the works of Chang (2007) and Tien(2010), and including cyclical export gap into the Okun structure, as to examine whether the cyclical fluctuation in exports would significantly account for the variation in unemployment rate in Taiwan.**

1.2.3. Decomposition of Stochastic Trend in Time Series Data

The first part of this thesis considers the "gap version" of Okun structure, amid which one of the puzzling tasks is to estimate the long term level of the variables in potential magnitude (e.g., y_t^* *and* u_t^*) so to derive the gap at each period. As Lee (2000) points out, in the original gap model proposed by Okun, Lee applied linear (deterministic)trends to measure the potential output level and the natural rate of unemployment, while since variables such as GDP and unemployment rate tends to be "integrated," i.e., requiring at least one time of difference to achieve as being covariance stationary series. Okun's approach would be hence misleading, which is why succeeding researchers "focus on estimation results that take the possible existence of stochastic trends into consideration" (Lee 2000, Nelson & Plosser 1982).

Gifted econometricians worldwide in the latter half of the last century has made different contributions in establishing econometric methods so to estimate the stochastic trend from integrated time series data. One of the most common approaches in Okun structure analysis is the nonlinear filter proposed by Hodrick and Prescott, i.e., the H-P filter. They constructed a minimizing loss function which is able to decompose the the smoothed trend component and the cyclical trend component from the stochastic series(Hodrick & Prescott 1997). The H-P filter has the

[3]For further detail of Tien's work, please refer to Section 1.2.5.

[4]Granger causality should not be mistaken as the "true causality" but only the correlation between regressand, say, y in current term with regressor x in previous terms. That said, chronologically x might "Granger-cause" (be correlated with) y, but the true causality between should never be that easily derived, but requiring economic logic and experience of the economists.

following structure:

$$\min \sum_{t=1}^{T} [(y_t - \hat{y}_t)^2 + \lambda((\hat{y}_{t+1} - \hat{y}_t) - (\hat{y}_t - \hat{y}_{t-1}))^2] \tag{1.3}$$

where y_t is the original data observed, $\hat{y}_t$ is the trend component at time t to be solved with this minimization function, and λ is the penalty parameter. The first term within the brackets is the cyclical component, and the second term is the stochastic trend being smoothed. As Cogley and Nason points out, one of the many advantage in using the H-P filter in particular is that the resulting detrended component is a stationary series(Cogley & Nason 1995). Many empirical economists have applied such technique and demonstrated the consequentiality and robustness of the H-P filter. Lee (2000) as a case in point, has evaluated the robustness of the Okun relationship based on postwar data for 16 OECD countries, and discovered mixed evidence of asymmetric behavior, but strong evidence of structural breaks occurring around the 1970s, after which time most countries began to experience a smaller output loss associated with higher unemployment (Lee 2000). Also, Adanu (2005) has applied the H-P filter in the Okun estimation for the provinces in Canada and concludes that the cost of unemployment in terms of the loss in real GDP is higher in the bigger and more industrialized provinces than for the Maritime provinces (Adanu 2005).

Similarly, for Taiwanese empirical studies, Hung and Liang (2007) adopt the Hodrick-Prescott filter as to decompose the variables down to trend component and cyclical component, thus discovering asymmetry of the Okun coefficients, that is, the coefficients tend to be larger in a recession period than in expansion (Hung & Liang 2007). Other economists such as Tien (2010) also utilizes the H-P filter in one of her empirical models so to examine for robustness (Tien 2010). **Learning from theisss aforementioned literature, this thesis would also apply the H-P filter as one of the two methods to estimate the trend in time series data. However, in Hung and Liang (2007) work, the issue of "seasonality" hidden in the time series data is not identified and addressed. In Tien's work (2010) she tackles seasonality by directly using the seasonally adjusted data, within which only the time series data of GDP is in real value, while the openness of trade is measured in nominal values. That being said, she fail to account for the seasonality in foreign trade. Such omission motivates the thesis to apply yet another decomposition technique, the Holt-Winters Smoothing technique, which is rarely applied in Taiwanese Okun empirical literature and thus might be construed as our contribution.**

1.2.4. Stability Analysis: Asymmetry and the Test for Known/Unknown Structural Breaks

As Prachowny (1993) opines, the Okun structure often suffers from being neglected by empirical and macro economists, in the sense that the negative relationship between unemployment and GDP is often taken for granted, or as implied by common sense, and thus receiving relatively less attention as opposed to that received by the Phillips Curve, even though it is "every bit as important as the Phillips curve in understanding the Aggregate Supply curve for any macro-economy". (Prachowny 1993). As a matter of fact, some empirical economists discover that this relation is not as stable as many assumed, as the value and even the signs of the Okun coefficient might be altered by certain exogenous factors, be it macro policies for fiscal or monetary matters, or external events that would have influence on domestic economy via the said variables. Thence the studies of the stability of the Okun structure becomes salient for policy making. To start with, Silvapulle et al. (2004) discover an asymmetric relationship between GDP and unemployment rate in the Okun dynamic structure for the U.S. post-war, further substantiating that the short-run effects of pro-cyclical output on cyclical unemployment are quantitatively different from counter-cyclical ones, and the data are consistent with the proposition that cyclical unemployment is more sensitive to counter-cyclical than to pro-cyclical output (Silvapulle et al. 2004). Harris and Silverstone, on the other hand, corroborate an asymmetric structure between changes in unemployment and real output for seven OECD countries, while finding that failing to take account of asymmetries would see a rejection of the hypothesis that there exists a long run relationship between unemployment and output (Harris & Silverstone 2001). Chiang (2006) has further provided empirical evidence of the negative correlation between GDP growth and unemployment in the cyclical sense, and asymmetric reaction of the Okun coefficients with different defined threshold values, based on quarterly data from 1961 to 1999 (Chiang 2006). Wan and Kaoh (2008) also proved such asymmetry with both a first-differenced model and filtered model, and tested with different threshold values (Wan & Kao 2008). The related part of this doctoral thesis would continue in testing such postulation of asymmetric pattern in the Okun structure, the method of which will be elaborated in Chapter 2.

Another possible reason that the Okun coefficient appears to be unstable along the time axis is the existence of structural change, or a "break" as certain econometricians describe it, occurring within the economy being studied, due to some macro parameters exposed to certain shock, be it identifiable or not. One of the most common methods applied by econometricians to identify such a break is the Chow test. For expositional simplicity, suppose a regression model of Ordinary Least Squares

(OLS):

$$y_t = \alpha + \beta x_t = \epsilon \tag{1.4}$$

where the data can be split into two groups, in this case, separated by a designated time:

$$\begin{aligned} y_t &= \alpha_1 + \beta_1 x_t = \epsilon \\ y_t &= \alpha_1 + \beta_2 x_t = \epsilon \end{aligned} \tag{1.5}$$

The Chow test is thus to test the null hypothesis H_0: $\beta_1 = \beta_2$, while the residual term (ϵ) is postulated to be independent and identically distributed (i.i.d), and follows a normal distribution, with 0 mean and some unknown variance(Chow 1960). In this simple regression model, let S_C represent the the sum of squared residuals from the whole data, S_1 and S_2 be that of the first and second group respectively, N_1 and N_2 the numbers of observations in each group and k is the total number of parameters, then the Chow statistics that follows F distribution with k and $N_1 + N_2 - 2k$ is:

$$\frac{(S_C - (S_(1) + S2))/k}{(S_1 + S_2)/(N_1 + N_2 - 2k)} \tag{1.6}$$

Among the literatures that studies the Okun structure, the Chow test is often applied to examine if the coefficient experiences any structural break at certain time point, when some historical event, be it political, economical, diplomatic or even military, occurs and shocks the economy. To name but a few, economists such as Weber (1995) applied the Chow test on post-war data in the U.S. to examine whether a structural break occurs in the third quarter of 1973 (Weber 1995). Likewise, Moosa (1997) executes the Chow test to investigate the stability of Okun's law for the G7 countries and finds some evidence supporting structural breaks at 1973 for countries such as Germany, France, and the UK (Moosa 1997). Freeman (2000) has applied the said test and could not find evidence to substantiate that the Okun coefficient experiences structural change at 1977 for the national and regional data in the U.S. data set between 1959 and 1997 (Freeman 2000). Sögner and Stiassny (2002) discover a significant structural break occurred between 1982 and 1983 using Markov-chain Monte Carlo (MCMC) method on data sets of 15 OECD countries (Sögner & Stiassny 2002). Similar empirical attempts are made by Harris and Silverstone (2001) on the seven OECD countries, and Prachowny(1993) on the U.S. macro data set (Harris & Silverstone 2001, Prachowny 1993). For Taiwanese Okun Literature, Chiang (2006) performs chow test on two of her decomposed datasets (HP and BN, would mentioned in the next subsection) and found no significant breaks at the time 1970, 1972 and 1987, thereby she argues the Okun coefficient in her estimation is stable over time. Tien (2010) also conduct break point analysis in her ADL model, so to see if the break occurs in 1990 and 2000 respectively, and confirms that the coefficients in her Okun structure model are experiencing changes

at year 1990 and 2000 respectively (Tien 2010). **Inspired by their attempt, in Chapter 2, we also perform Chow test on different break points, i.e., 1990q1 and 2002q1 respectively, and derive a different conclusion that a break might occur as our selected theoretical model predicts. Such difference seemingly argues against the stability of Okun coefficients estimated by Chiang (2006), it might be caused due to different period inclusion of data (especially important for HP filters), different decomposition methods, and different lag length. Such difference might be construed not only as an incremental supplementary analysis to the existing literature, but also as a unique contribution by providing statistically significant evidence from an different point of view.**

1.2.5. Empirical Literature on Taiwanese Okun Structure

To start summarizing the empirical literature that deciphers the Taiwanese Okun coefficients, Chen and Lin (2005) is probably among the earliest Taiwanese empirical papers studying the Okun structure in Taiwanese context. They use the first difference series of output and unemployment with both parametric (linear structure) and a non-parametric additive approach. From macro data of GDP and unemployment rate between 1966 and 2004, they derive the estimate of Okun coefficient(-2.34 percentage point change in real output gap for 1% change unemployment gap) with their linear estimator, yet also substantiating the nonlinear pattern between GDP growth and unemployment rate (Chen & Lin 2005). Though their non-parametric estimates seem to have established significant results, we find little succeeding researcher following such approach, since they did not derive estimates of Okun coefficent from such non-parametric approach, only showing evidence of such nonlinear relation between output gap and unemployment gap.

Applying the Okun structure constructed respectively by Prachowny (1993) and Attfield and Silverstone (1998), Chiang (2006) discover from the annual data (1961 $\sim$ 1999) collected from AREMOS data base (the GDP data within AREMOS database is collected from National Income Accounts- Annual (NIAA) while the unemployment rate from the Manpower Statistical Databank), that there are other variables from the supply side, such as labour supply and capital productivity that would significantly influence the Okun structure, but her finding does not fully corroborate with that concluded by the aforesaid result of Chen and Lin (2005), viz., asymmetric pattern is substantiated in her first difference model, but not the gap models, that are derived with Beveridge-Nelson decomposition method and H-P filter respectively (Chiang 2006). Even though Chiang's work was acknowledged by one of the most important peer-reviewed economic journal in Taiwan, that is, Academia Economic Paper, we would argue due to the non-causal nature of H-P filter, the trend decomposed from the original data might be affected by different data inclusion of

later periods. That said, albeit her work might draw conclusion from significant and robust results, it would be less referential for the post millennium period. That is also why, we believe our analysis would make suplpmentary contribution to such an inspiring work. Furthermore, as mentioned previously, Chang (2007) on the other hand, thinks "outside the box" by administering variables such as FDI, the degree of openness of the domestic market, and exports to the rest of the world, into the Taiwanese Okun structure in a VAR framework. From quarterly data over the period 1981:q1 to 2003:q3 in Taiwan, available in Nataional Statistics's Macro database, Chang corroborates the negative relationship between GDP growth and unemployment rate, and between FDI inflow with unemployment rate (Chang 2007). Be that as it may, though Chang's work is the first to include variables into Okun structure that account for the change outside Taiwanese economy (FDI inflow and outflow, openness of trade), the fact that he only utilizes the first difference model, and that he lacks of sub-period comparison, all leave spaces for this thesis to make contribution to the existing literature.

Adapting the H-P filter and Kalman Model respectively, Hung and Liang (2007) used quarterly data from the same data base (from 1964 to 2006), and they substantiated that the asymmetric pattern in Okun structure with a Markov regime switching model, to wit, the Okun coefficient is larger in the recession period than that in economic expansion period (Hung & Liang 2007). In a similar attempt, with the quarterly data (1979q1 to 2001q4) collected from AREMOS data base (quarterly GDP data is collected from National Income Account Quarterly (NIAQ) while the unemployment rate from the Manpower Statistical Databank) Chen and Chang (2007) apply a bivariate Markov switching model that estimates via Gibbs sampling, so to describe the business cycles and confirms the validity of asymmetry in the Okun coefficient(Chen & Chang 2007).
Nonetheless, both of their model focus only on the interaction between output gap and unemployment gap, therefore omitting other possible factors(e.g., export, import or FDI) that might be affecting the changes in unemployment gap in an open island economy such as Taiwan.

Furthermore, as a reassessment of Chiang's work (2006), Wan and Kaoh (2008) used the quarterly data (1978q1∼2007q1) collected from the database established by National statistics, once again substantiate the asymmetry in Taiwanese Okun structure with both first difference model and gap model, using Hanson's threshold test, and and robustly showing the Okun coefficient is larger in recession than in expansion (Wan & Kao 2008, Hansen 1999). Though they apply lagged values of unemployment gap and those of output gap as instrument variable for unemployment rate, Wan and Kaoh did not supplement the Okun structure with novel variable. The did not measure how Okun coefficient changes in different period of time, albeit

confirming the asymmetric pattern in different type of economy. Again, we would such omission would be where Chapter 2 of the thesis could make contribution to the existing literature.

Lastly, the most recent work is accomplished by Tien (2010). Using the same quarterly dataset(1981q1∼2009) applied by Wan and Kaoh (2008), Tien applies both the first difference model and the gap model are administered within a ADL framework, while the inclusion of other variables, viz., the openness of economy (measured with the ratio between net export and GDP), the change of industry structure (measured with ratio between numbers of workers in manufacturing sector, and in tertiary sector), and the ratio of immigrant workers, appears to reduce the importance of GDP growth in terms of explanatory power (current Okun coefficient without explanatory variables: -0.081 percentage point while that with extra explanatory variables is -0.075 percentage point). Tien further concludes with policy implications derived from her empirical findings, e.g., 1. expansion fiscal or monetary policy is suggested to be relatively more benign and thus to be implemented more in recession than expansion as her empirical results concludes that the unemployment gap (or the change in unemployment rate) would be wider during expansion period. 2. As the openness of economy increases, the impact of such upon unemployment rate become smaller (the coefficient of net export difference becomes smaller from -0.016 percentage point in period prior 1990s to -0.006 percentage point post 1990s, while the real net export experience increases as time being), ipso facto, the policy maker should try to cultivate and support medium sized corporations and domestic oriented industries, so to prevent the unemployment rate from worsening, since now the beneficial impact of economy openness on employment is smaller (Tien 2010). In general, Tien's conclusion is in accordance with those made by Taiwanese Okun Literature: the "contemporaneous" Okun coefficient(the short run, most recent interactions between) is negative, the impact of output gap on unemployment gap is larger in recession than in expansion, while the estimated values of her Okun coefficients (both short run and long run) are close to those estimated by other Taiwanese empirical economists, e.g., Chiang (2006). Ipso facto, we would include Tien's result as one of our key reference in Chapter 2. Still, we would still argue that her measurement of the openness of economy, using the ratio between net export and GDP (stock value), fails to capture the fluctuation of export change, which might be influential to Taiwanese economy. Such fluctuation is captured by our thesis, and is thus considered as one of our key contribution.

Thus from the literature discussed above, it can be seen that the Taiwanese empirical findings utilizing the Okun structure tend to locate their focus on the substantiation of the asymmetric pattern, while some strive to introduce new explanatory variables from the supply side.

In light of these established literature of Okun structure, first, this thesis strives

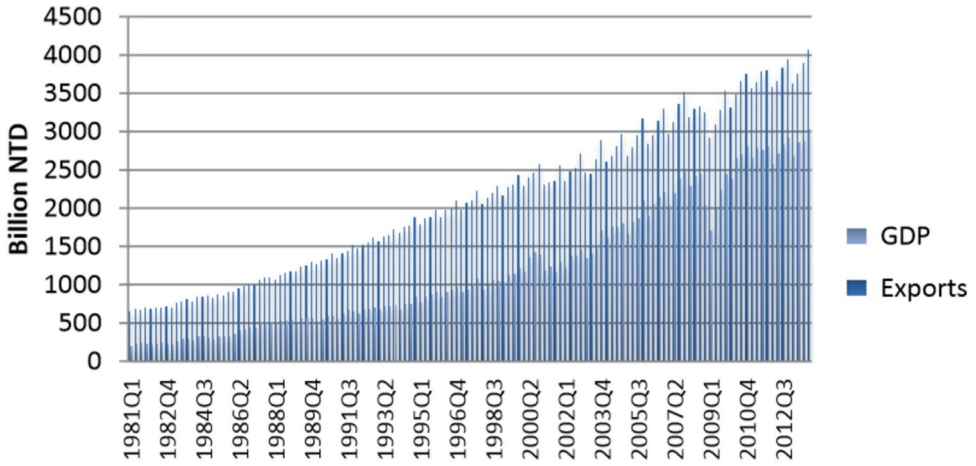


Figure 1.4: Quarterly data of Real GDP and Real Exports in Taiwan (National-Statistics 2013)

to include **a novel variable into the Okun structure, examining the relationship between unemployment gap and export gap.** Secondly, we would also want to compare our result of coefficient estimated in the Okun structure, as to see if it is similar with those estimated by other empirical literature, especially the one with a similar method and similar inclusion of data period, such as Tien's work (2010).

As a small open island economy, Taiwan is well known for the growing dependence on its exports. The fluctuation pattern thereof might be a missing piece to be added into the existing bilateral interactions between unemployment rate and economy growth. As presented in Figure 1.4, Taiwanese quarterly exports exhibit a rapid yet constant growth from roughly 29% of the total GDP in the 1980s, up to approximately 75% of the total GDP at the end of 2012 (National-Statistics 2013). Such increasing reliance upon international markets is greatly affected by Taiwanese trade policy.

One part of this thesis aims to include the trade growth into the aforementioned dynamic of Okun structure, as a possible omitted variable, which could be explained theoretically by the search and match model derived by Dutt et al. in an international framework (Dutt et al. 2009). Such an arrangement is inspired by Tien's work, but takes one step further, striving to utilize the said Okun structure in testing the break date when Taiwan experienced major historical change in terms of its international trade policy, joining a bilateral/multilateral Free Trade Agreement (FTA). Such an event might not be directly observed within the data on the unemployment rate, GDP growth, or export growth, nevertheless features in the interactions be-

tween these variables. With the Chow test, it is possible to examine whether these interactions experience a sudden "break" at the assumed dates, and hence to see if Taiwanese trading policies are in fact crucial as Taiwanese citizens and academics alike believe them to be. To test if the empirical method is robust, this method is applied to two data sets, which are both adapted from the PC-AXIS Macro data base of the National Statistics of Taiwan. The two data sets are differently filtered, either with the Hodrick–Prescott filter (H-P filter), a common method applied as to separate long term trend component and short-term cyclical component of variables, or with the Holt-Winters de-seasonal smoothing (HW de-seasonal) method, which tackles with the seasonality in GDP growth and cyclical export gap that might be inevitably included and thus might create a biased result.

1.3. Wage, and the Determining factors thereof in Taiwan

1.3.1. Motivation

Chapter 3 of the thesis incorporates a less discussed factor into the wage determination of younger generation, i.e., the housing bubble in Taiwan. As shown in Figure 1.5, the average Housing Price Index (HPI) over the years, which is measured with the ratio between average local house price and the gross annual income at the median, presents a long-term growth trend with cyclical fluctuation. Many scholars argue that the Taiwanese housing bubble in such long-term expansion, is a collusive result conspired by the government, corporations, and individual investors, which might cause negative impact on housing affordability of normal residents (Lu 2014, Wang 2013, Chao 2014). Nonetheless, many scholars, business leaders, as well as policy makers address in almost perfect harmony, stressing the positive spill-over effect from housing sector to the rest of the industries, and eventually onto overall Taiwanese economy, would mimic the beneficial housing boom in other countries, e.g., Japan in 1980s, or the United States in 2000s, when the average real wage increases respectively (Su 2010). Iacoviello and Neri have derived empirical evidence supporting a positive spill-over effect in terms of real wage, starting from the construction industry to the rest of the U.S. economy in mid 2000s (Iacoviello & Neri 2010). From Figure 1.6, in which Taiwanese real monthly wage is compared on industry basis, though monthly real wage in construction industry is not the highest, it might be concluded to share a similar pattern with the rest of Taiwanese economy, e.g., second (manufacturing) sector and tertiary (service) sector, while that in real estate shows less similarities. Still, such a change in trend might be driven by other macro variables or unexpected random events, e.g, the financial crisis in 2008 might be causing the wage to simultaneously plunge. The difference between wages in the finance industry and in other industries could be a result of an education premium, or having benefited from being intermediate in the arbitrage transactions in real estate market.

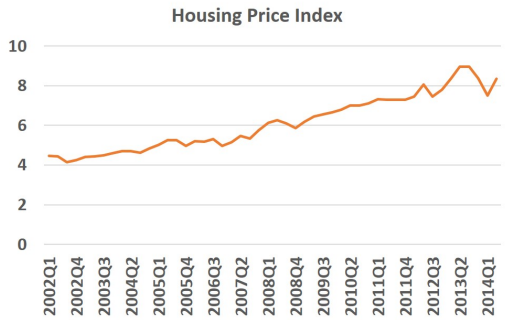


Figure 1.5: Quarterly Taiwanese Housing Price Index 1999-2013(Construction/Planning-Agency 2014)

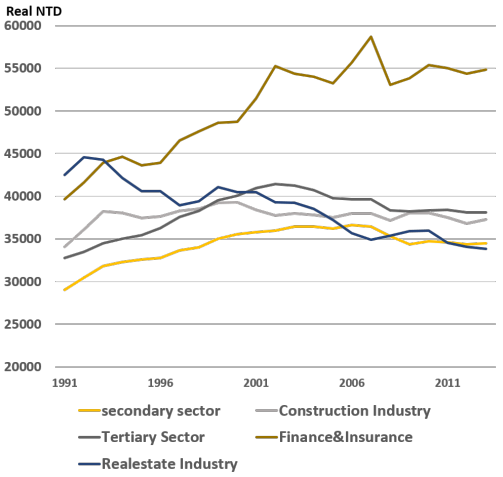


Figure 1.6: Monthly Real Wage by Industry 1991-2013 (DGBA 2014)

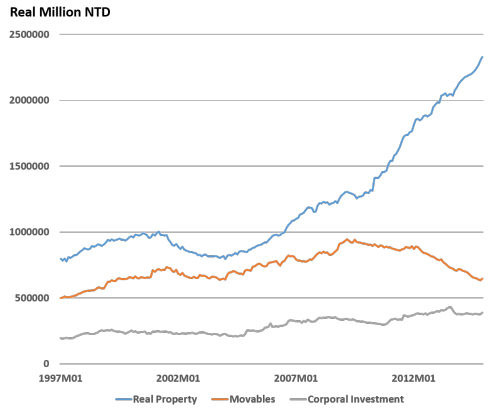


Figure 1.7: Monthly Indebtedness of Public and Private Sectors 1997-2013 (Central-Bank-Of-Taiwan 2014*a*)

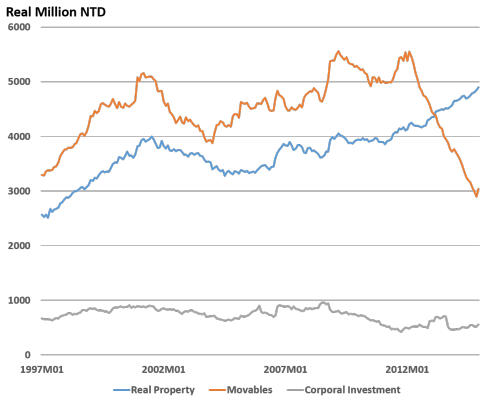


Figure 1.8: Monthly Indebtedness of Manufacturing Industry 1997-2013 (Central-Bank-Of-Taiwan 2014*a*)

Here this part of the thesis applies Mincer's (1974) wage equation as the primary structure, including estimates of average industrial arbitrage investment in the housing sector, in the hope to see another probable impact other than positive spill-over, i.e., a crowding out effect. Would the housing bubble become an incentive for the corporations to add property investment into their financial portfolio? If so, given the higher return in the housing market, such preference might crowd out the amount of investment that should have been spent on their operation, indirectly but largely undermining the marginal productivity of labour, and inevitably their real wage.

From Figure 1.7, which includes the sum of indebtedness of all industries (both private and public sectors), it is obvious that the amount borrowed (and invested

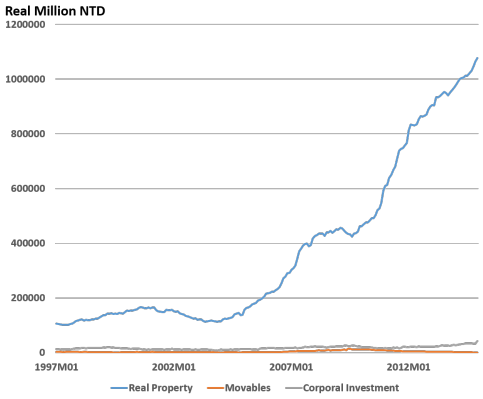


Figure 1.9: Monthly Indebtedness of Real Estate Industry 1997-2013 (Central-Bank-Of-Taiwan 2014*a*)

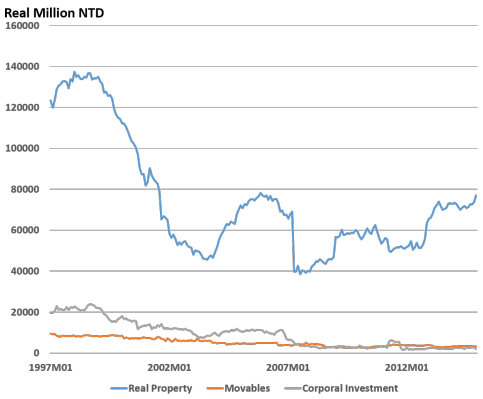


Figure 1.10: Monthly Indebtedness of Construction Industry 1997-2013 (Central-Bank-Of-Taiwan 2014*a*)

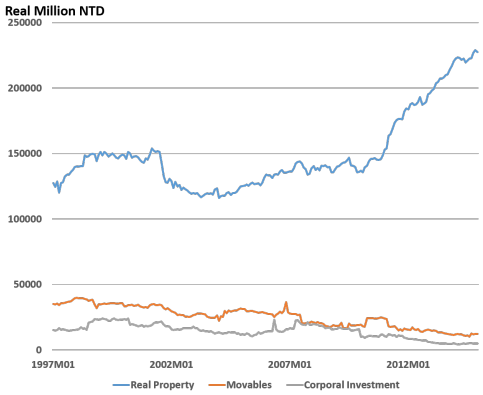


Figure 1.11: Monthly Indebtedness of Wholesale and Retail Industry 1997-2013 (Central-Bank-Of-Taiwan 2014*a*)

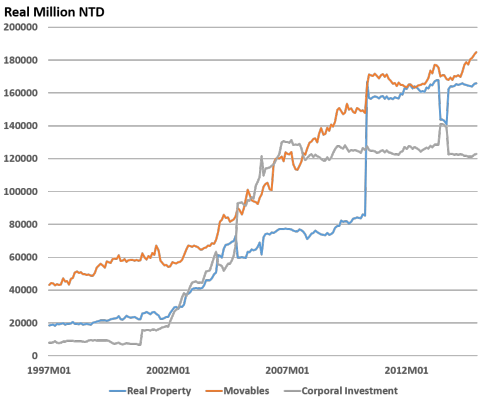


Figure 1.12: Monthly Indebtedness of Transportation and Storage Industry 1997-2013 (Central-Bank-Of-Taiwan 2014*a*)

later) for real estate property increased largely since circa 2010, as opposed to investment onto movables (e.g., materials, equipments and so on) or corporate investment (those onto other corporations). This might be partial evidence supporting the argument that Taiwanese industries tend to spend more on the real estate market, in the hope to earn arbitrage profits. The following figures (from Figure 1.8 to 1.12 further break down the aggregated indebtedness from Figure 1.7 into different industries. These are the top 5 industries in Taiwan that composes 84% of the industrial indebtedness[5]. From Figures 1.8, 1.9, 1.11, and 1.12, a similar increasing pattern of investment in real property can be observed in manufacturing industry, real estate industry wholesale and retail industry, while that in the construction industry demonstrates a long term decreases (but bounces back circa 2012) might be regarded as another evidence for the housing bubble fueled by arbitrage transac-

[5]However, the industrial indebtedness does not include those made by government agents, or individuals. Also another interesting fact should be emphasized, i.e., the majority of indebtedness for real estate property is contributed by domestic individuals, equivalent to almost 77% of the overall indebtedness.

tions: while the whole economy spends an increasing amount of financial resource on real estate property, the fact that the indebtedness for real estate made by construction industry decreases shows that the amount of property been built is less than that been sold and bought in the real property market. In Taiwan, buying existing real property is considered one of the most common ways to earn arbitrage profit from the housing bubble.

Furthermore, many politicians as well as many scholars declare that, the elixir to solve the long-term slackening of wage growth for the younger generation is the free trade agreement established between Taiwan and China in 2009, i.e., the Economic Cooperation Framework Agreement (ECFA), along with the upcoming Cross-Strait Service Trade Agreement (CSSTA) that causes the recent protest movement in Taiwan (i.e., Sunflower Student Movement) (Huang 2014). Based on common sense, FTAs such as ECFA and CSSTA would imply further access to the markets in Mainland China, one of the largest economies in the world. The Heckscher-Ohlin model provides a promising theoretical explanation: by producing and selling the good which requires the type of factor (skilled labour, for instance) with which Taiwan is assuming to be abundantly endowed, the factor price (wage of skilled labour) could be enhanced after the trade. Such a claim overlooks the possibilities of industries upgrading happening in Mainland China, which might partially replace the seemingly skill-intensive industries in Taiwan, i.e., increasing skilled labour supply via out-sourcing or FDI, which might cause the education return to be driven down. To test if this is true, we apply Mincer's minimum wage model as a basic theory to check, if the change in labour supply (demand) at a particular point of time would causes differences in education returns before/afterward.

Chapter 3 of this thesis consider three issues: **1. if higher education expansion indeed undermines wages for the younger generation, and 2. if corporation arbitrage investment in housing market is harmful to wages, and 3. if the government's proposed remedy, i.e., further opening trade with China will be a beneficial plan.**

1.3.2. Mincerian Equation

1.3.2.1. International Mincerian Literature

The primary structure applied in this part of the doctoral thesis is the wage decomposition structure derived by Jacob Mincer. In 1974, Mincer established his world-renowned equation, i.e., the Mincerian wage equation, incorporating variables such as education, experience, the square term of experience and other characteristic variables (Mincer 1974). Psacharopoulos (1985) applies the Mincerian framework

to estimate the profitability of investment in education at a global scale. From time series data including over 60 countries, Taiwanese education returns are roughly 15.8% and 18.4% in the years 1970 and 1972, which locate Taiwan in the lower half of the global distribution of nations(Psacharopoulos 1985).

1.3.2.2. Taiwanese Mincerian Literature

Since the late 1980s, Taiwanese empirical economists start to apply Mincerian equations in estimating factors that account for the marginal impact on wages. Given the period of time being studied, i.e., the early 70s up to late 90s, their results tend to corroborate the positive impact of education to wage, ranging from 3% to 14%, as differently estimated by different economists with different methods, approaches, and variables (Peng 1989, Ji 1998, Liao 2003).

1.3.2.3. Mincerian Structure: Ordinary Least Square (OLS)

Among the Mincerian literatures, the Ordinary Least Squares (OLS) estimator is one of the most common approaches for Taiwanese researchers to apply with, such as Luo (1993) Wu (2002), Liao(2003), Chiu (2004), Chen (2002) and several others. They discover empirical results such as: the Taiwanese education return depends on labour demand, and that during 1978 to 1998, the relative demand increases so that the return still increases, albeit the presence of education expansion policy, as the increase of relative demand outpaced that of relative supply in Taiwanese labour market(Wu 2002, Luo 1993). Nonetheless, education return starts to gradually decrease after 1987, which is construed as a structural break point, while it was observed that the relative labour supply caused by expansionary policy increased faster than the increase of relative labour demand caused by industrial re-structuring effect(Chiu 2004). To account for wage disparity, education is deemed as one of the most important factors in the wage determination equation (Luo 1993, Wu 2002, Liao 2003, Chiu 2004, Chen 2002). Although this thesis also follows the majority of academe in starting with the OLS structure, other estimation approach such as Quantile Regression Estimator is also applied and placed with higher focus and confidence, while the OLS estimator serves as an intermediate indicator, examining the validity of the instrument variables.

Each of the aforementioned literature has made its own contribution respectively. For instance, Peng (1989), Wu (2002) Chen (2002) has examined and compared the education return by industries, sectors, or disciplines, while drawing similar conclusion that one of the driving factor causing Taiwanese education return to decrease is

the increase supply of skilled labours, while such decrease is smoothed by educated labour demand caused by industrial restructuring. Also, Luo (1993) discovered the estimated "social return to education" for graduates of public universities is lower than that of private ones, yet the "private return to education" of public university graduates appears to be higher than that of private ones. One common characteristics of these literatures shared is their application of one of the most popular estimators, i.e., OLS estimator. Such common choice might allow the researchers to see the marginal education return "in average," while hinder them to break down the estimated education return at each income level as our Quantile Regression estimator could. Also, given the covered period of their data, we would argue that their result might seem less referential from now, which miss out other incident such as ECFA, hence leaving space for this thesis to fit in with our contribution.

1.3.2.4. Mincerian Structure: Quantile Regression Estimator

The second estimator applied in our attempt of Mincerian wage analysis is the Quantile Regression (QR). Since 1990s, many empirical economists have applied Quantile Regression to estimate wage functions. Heterogeneity caused by unobserved abilities could be thus addressed, and education return at different level of wage is thereby presented. Hartog et al., for instance, compare how Portuguese education returns change from 1980s to early 1990s, and shows strong evidence that education has played a prominent role in widening wage inequality (Hartog et al. 2001). The very first attempt of QR estimator on Taiwanese wage determination is Chen and Kuan's QR analysis in 2006, showing evidence of gender gap in wages, which is widened at lower quantiles of wage. Their work was also considered one of the earliest Taiwanese empirical papers that utilize Quantile Regression Estimator, and discovered the gender difference in labour participation rate to be bona fide(Chen & Kuan 2006). As a follow-up, Chuang and Lai (2011) has another QR estimates on Taiwanese data from 1978 to 2004, showing in different cohorts, Taiwanese education return has different implication with ability, i.e., for the elder cohort, education has strengthened effect with ability, whereas for younger generation, education is observed to have supplementary effect with ability (Chuang & Lai 2011). The two paper are important reference for this thesis, yet we still have identified some spots that these two paper did not focus and thus leaving space for this thesis to make contribution with. For one, in Chen and Kuan's work, their focus was on the characteristics variables such as gender, marital status, full /part time workers, region, job position, while lack of discussion of cohort differences, and did not identify the difference of wage determining factors over time. As for Chung and Lai (2011), we would also argue that their wage determining structure could be supplemented by a novel variable, e.g., real estate investment, while their data only covers upto 2004, which also omits the changes afterward.

To briefly sum up, this chapter of the thesis would utilize both estimators. However, due to over-identification issues caused by instrument variables, and the nature of an estimator that allows examination over different income levels, the QR estimator would be trusted with higher confidence, while the Cross-Sectional estimator would serve as an intermediate indicator for choosing IVs. For more detail, please refer to Chapter 3.

1.3.3. Expansionary Higher Education Policy: Over-education?

1.3.3.1. International Literature

In the context of Taiwanese labour market, among other things, one of the bigger issues that often caught education economists attention is the increasingly damaging impact of over-education of Taiwanese labour. Economists such as Fu (2008) argues that one of the driving factors of over-education in Taiwanese labour market is the expansionary education policy (Fu 2015). Be that as it may, different economists studying in fields of education economics derive different conclusions from such expansion education policies. Some empirical economists such as Duncan and Hoffman conclude from their the 1976 interview of 5000 U.S. household, that as one of the consequences from expansionary education policy, over-education might actually be beneficial to wages, as the "surplus education years" (the amount of education attainment years that is "over-qualified" for their jobs) is de facto positively correlated with wage (Duncan & Hoffman 1981). Similar results are found by McMillen, Seaman, and Singell, who established a "Wage Growth Regression" using data from British House Panel Survey (BHPS), from which they conclude that over-educated workers (whom often regraded as a result of increasingly excessive educational resources induced by expansionary educational policy) in particular, relative to workers who are continuously exactly educated might experience greater wage growth later in a career in exchange for a lower education return in the beginning of their career. That is to say, Overeducation might be benign in the later stage of one's career(McMillen et al. 2007). Others, however, found that education return is not necessarily observed to have positive correlation with expansion in education. Marchand and Thélot conclude that within the French "Trente Glorieuses," i.e., the "Glorious Thirty Years" between 1945 and 1975, the average education expansion is relatively slow, while France's economy grew rapidly over this thirty-year period, combining high productivity with high average wages and high consumption, whereas the generations actually suffer from a economic recession is those who were born after 1970, yet whose education attaintment years are by and large higher than their previous cohorts(Marchand & Thélot 1997). With a combination of search model and signalling game, Liu (2012) shows a theoreti-

cal explanation that, at separate equilibrium, expansionary education policy, which often is equivalent to lowering entry requirement to higher education, the labour quality would be thereby "diluted", with the wage inevitably decreased (Liu 2012). The decreasing marginal return of education attainment along with the education expansion or as Chauvel (2010) put it, "déclassement scolaire" (over-education and diploma inflation), is also an empirically observable and interesting topic in modern France after the "Les Trente Glorieuses" (the glorious thirty years). The negative impact thereof is not simultaneously observable among the generation who experience the education expansion at the "first wave", as he adds, but it is cumulated upon the younger generation who suffered from lowered education return, viz., the diploma inflation (Chauvel 2010).

1.3.3.2. Taiwanese Literature

Likewise, Taiwanese Academe seems to have difficulties reaching consensus over the impact of education expansion. As mentioned earlier, Peng (1989), Wu (2002) Chen (2002) has derived conclusion that increase supply of skilled labours purportedly caused by expansion education policy, might drive Taiwanese education return to decrease,which is observed to be smoothed by educated labour demand upsurged by industrial restructuring. In her analysis over the education return of higher education from 1978 to 2003 in Taiwan, Chiu observes a decreasing pattern of education return after 1987, when the number of higher education institutes grows, increasing supply of educated workers (Chiu 2004). Opponents such as Li disavow such observations, and claims that once taking endogeneity into account, using the education attainment years of both the parent and that of spouse to the interviewees as instrument variables, then during the period between 1975 to 2001, education expansion does not significantly cause negative impact to education return (Li 2009). In the attempt to gauge education return between different groups of workers classified according to her experience years, Lin (2003) concludes that expansionary education policy would cause stronger negative impact on the education return of fresh graduates, but the impact would be mitigated with more experiences (Lin 2003). Besides the those literature discussed in 1.3.2.3, we argue there might be some space left unachieved in these aforementioned literature, which we believe could be supplemented by this thesis. For one, in Chiu(2004) her application of OLS estimator hinders examination of the difference coefficients estimated at different income level, her data is covered only up 2003; she did not discuss the impact coming from industries, nor did she consider endogeneity bias. As for Li (2009), similarly using an OLS estimator, she failed to identify the difference impact coming from gender or industrial factors upon wage, nor did she identify difference of coefficients estimated

in different cohorts. Lastly, in Lin(2003)'s work, similarly using an OLS structure, she omitted the discussion of cohort differences, and the endogeniety bias in education return.

In light of the education expansion in Taiwan over time, in terms of both absolute number of higher education graduates increasing, and the increasing portion of first degree and higher amid the relative education structure in Taiwanese labour force, Chapter 3 attempts to unravel the implication thereof upon wage.

1.3.4. Housing Bubble

Another important factor that would be taken into account quantitatively within the Mincerian structure is the industrial investment in the housing market, purportedly induced by the prospects of arbitrage from a consistent expansion in the housing market, or "housing bubble". In relation to the economy, relevant literature from empirical or theoretical alike, shows mixed conclusions of the impact. Some economists postulate that there would be a positive effect expected from a growing housing bubble. Economists such as Bernanke and Gertler (1989), or Holmstrom and Tirole (1997) conclude from their models that, being credit-constrained due to moral hazard, firms could borrow and invest more with their asset price increasing directly/indirectly in an expanding housing bubble since higher value of their collateral (Bernanke & Gertler 1989, Holmstrom & Tirole 1997). Different theories such as rational asset bubbles, in which interest rate increases of an asset (i.e., housing property), would crowd out real investment on other asset (Tirole 1985). Farhi and Tirole (2012) further provide theoretical explanation that financial institutes might substitute away from lending to commercial firms and investing more in bubbly objects, e.g., real estate (Farhi & Tirole 2012).

Regardless of the debate over the implication of housing bubble upon an economy as a whole, its implication upon wage is less addressed, but still in disagreement. For instance, with a Dynamic Stochastic General Equilibrium model (DSGE model), Iacoviello, and Neri (2010) concludes that, at equilibrium, real wages in the two sectors (manufacturing sector producing consumption goods, and construction sector producing housing property) should grow at the same rate as consumption along the balanced growth path. In other word, a perceivable boom in housing sector would have a "spill-over" effect onto the other sector (Iacoviello & Neri 2010). Empirical evidence in the Current Population Survey of the United States, found by Charles et al. (2013) shows the housing boom to be a positive shock to both the employment and wage to workers not just in construction industry, but generally having

large impact among non-college men and women (Charles et al. 2013). Chen and Wen (2014) draws a calibrated conclusion from their overlapping generations model, that in the presence of a housing bubble, workers' wages would decrease along with decreasing capital stock, as a result of crowding-effect of investment in the housing market (to earn arbitrage profit, or to hold as assets in corporation portfolio), and the lifetime utility of household would decrease in the post-transition period accordingly (Chen & Wen 2014).

Be that as it may, we could find little Taiwanese empirical Mincerian literature including the discussion on the impact of housing market on wage via any feasible channels. That is to say, In Chapter 3 of this thesis, we would consider our attempt as an innovative contribution by adding a proxy variable into the Mincerian structure so to examine if the industrial investment on real property, purportedly in the attempt to arbitrage from the housing bubble, could be benign or of malignant impact on wages.

1.3.5. Free Trade Agreement

1.3.5.1. International Literature

The empirical model in Chapter 3 of this thesis has adapted the idea applied in Chapter 2, to wit, the purported structural break point at the time when the context of international trade experiences alteration, which might have influence on the macro employment as well as the labour market. Wood (1995) applies a Hechsher-Ohlin framework, and provides a theoretical explanation that skilled labours in skill-abundant countries exporting a skill-intensive good, would earn a skill premium wage (Wood 1995).

Some empirical economists nonetheless find refuting evidence to the aforementioned reasoning. Esquivel and Rodríguez-López (2003) show from their observation on manufacturing industry in Mexico for the periods 1988-1994 and 1994-2000, that the education premium has decreased due to NAFTA (North American Free Trade Agreement). They find that this is in accordance with the prediction of the Stolper-Samuelson theorem,which states that a relative international price change while trade liberalization occurs would lead to a a rise in the return to the less skill-intensive factor which is used most intensively in the production of the good, i.e., a reduction of wage gap in Mexico in the first period. Nonetheless, the technological progress has offset such impact, viz., enlarging education premium, and become much more significantly observable in the latter period (Esquivel & Rodríguez-López 2003). Also, in Chile during 1960 to 1996, Beyer et al. (1999), using cointegration techniques to estimate the long run relationship between the skill premium in Chile and product prices, openness and factor endowments, discover that openness, measured as the volume of trade over GDP, widens the wage gap between skilled and

unskilled labour (Beyer et al. 1999).

1.3.5.2. Taiwanese Literature

The aforementioned conclusion made by Wood (1995) has been widely quoted and applied in the works of empirical researchers interested in the Taiwanese context. Chen et al. (2008), to start with, concludes that accompanied with industrial upgrade, expansionary education policy, and outsourcing of local skill intensive industries, a closer bilateral trade between Taiwan and China would cause relative demand for high-type workers (skilled or educated) to increase and that for low-type workers (un-skilled, or uneducated) decreases, which explains the increasing skill premium wage across different types in Taiwan after 1980 (Chen et al. 2008). Using a Mincerian equation, Lan (2010) demonstrates with his 2SLS (2 Stage Least Squares) estimators that the degree of dependence on the export to China would enlarge the education premium in wages (Lan 2010). Be that as it may, we would argue Lan's work failed to identify the differences made by gender, also as Lan admit in his conclusion, his work only focus on the international impact from the demand side, thereby omitting discussion on the macro impact from supply side in the labour market, e.g., education expansion policy.

Some economists such as Chen and Hsu's (2001), would hold a much more conservative point of view against the impact of FTA upon wage determining factor. From their empirical analysis, they argue that the education (skill) premium is enlarged when Taiwan initiated bilateral trade with developed countries, and shrunk when having bilateral trade with developing countries(Chen & Hsu 2001). However, Chen and Hsu's data only include young male with no more than 10 years of career. Such quasi experimental focus in a way captured the demographic group that might most likely be exposed to the impact from international factors change, yet we would argue the generalizability of their result, since it overlook demographic groups such as female, and male with career longer than 10 years, also, their OLS estimator could not examine the coefficients estimated at different income level. We believe this is where our thesis could make contribution.

The theoretical framework applied in Chapter 3 is a modified version of Mincer's cross sector minimum wage model (Mincer 1976), which is boiled down by Chiu (2004) so to home in on how the education return (premium) being affected by the change of relative demand and/or supply respectively or simultaneously (Chiu 2004)[6]. We postulate that, due to the change occurred in the condition of international trade, e.g., re-

[6]Further detail of Chiu's work, please refer to Chapter 3, section 3.1

duction in tariff or change in regulations, caused by the establishment or modification of Free Trade Agreement (FTA) between the two countries, the induced change might affect the relative labour demand and supply simultaneously or respectively, which might impose change on the coefficient in the Mincerian structure.

1.3.5.3. Labour Mobility

Another phenomenon related to FTA is the labour mobility between Taiwan and China. The inflow / outflow of labour, by the theory quoted in Chapter 3, should be influential to the equilibrium wage in domestic labour markets in Taiwan, which in turn would cause the education return altered. In chapter 3, the PSFD dataset covers the data from 1999 to 2011, during which Taiwanese labour market started to experience its domestic labour outflow toward other countries e.g., China.

Be that as it may, we won't be able to take the labour mobility into our discussion directly, for a rather straightforward reason: up till 2015, there is not a single credible data source keeping record for Taiwanese labour outflow toward China, available in any database or institute in either side of Taiwan Strait. Many scholars as well as official statistical institutes in both Taiwan and China claim to derive cross sectional estimates of such Taiwanese labour population in China, yet their estimates vary from three hundred thousand to two million. For one, Zhu et al in 2013 estabished their calculation upon the official figure of Taiwanese labour populated in greater Shanghai region that reaches 0.45 million, and they believed there should be over 0.5 million Taiwanese labour populated in the whole China (Zhu et al. 2013). On the other hand, according to the official statistics announced by Directorate-General of Budget, Accounting and Statistics of Taiwanese Executive Yuan, the labour force in 2013 is approximately 11.5 million in Taiwan. With that being said, if Zhu et al's estimate is to be trusted, there are approximately 4.4% of the Taiwanese labour force working in China in 2013. Such size is not as large as it sounds, but not small enough to be entirely overlooked either.

Though seemingly unrelated, another indirect evidence might demonstrate how the Taiwanese labour working in China might increase over time. Given the geographical distance between China and Taiwan, many of the Taiwanese labours would travel back and forth between the two countries on a regular basis, therefore, would be classified as part of Taiwanese visitor's composition into China. In Figure 1.13, we include the data collected and recorded by Mainland Affairs Council in Taiwan, which shows the annual Taiwanese visitors to China e.g., tourists, business travelers

and so on, demonstrating an increasing pattern over the years, from some 4 hundred thousands in the late 80s, to some 5.3 millions in 2014 (Mainland-Affairs-Council 2014). Nevertheless, the percentage of travelling workers is not publicly available, hence it might seem conjectural by saying Taiwanese labour working in China based on the increasing numbers of Taiwanese visitors into China over the years. As Dai (2010) describes, however, such percentage is in fact increasing over the years, hence this can be regarded as circumstantial evidence supporting the increasing number of Taiwanese labour in China (Dai 2010).

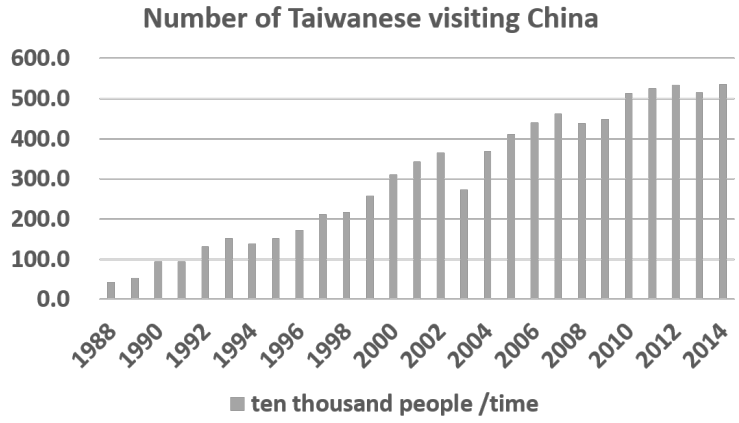


Figure 1.13: Number of Taiwanese visiting China 1988-2014(Mainland-Affairs-Council 2014)

With similar logic, Chinese labour flow injected into Taiwanese labour market should also affect equilibrium wage in Taiwanese labour market. Nonetheless, due to the highly protective regulation such as Employment Service Act and Labour Standards Act, Taiwanese employers can only hire foreign employees providing the fact that employers should make sure such recruitment "would not hinder the employment of local labours, labour standards thereof would not be compromised, and the development of domestic economy and social peacefulness would not be undermined" (Executive-Yuan 1992). That said, due to the unspoken political awkwardness between China and Taiwan, Chinese labours, white and blue collars alike, are still by and large prohibited to work in Taiwan, at least not legally. Most Chinese workers who do work legally in Taiwan have to acquire Taiwanese citizenship (mostly by marriage), before they could be employed by Taiwanese employers. The next figure includes the annual accumulated level of Chinese spouses living in Taiwan. In 2014, the number of Chinese spouse living in Taiwan reaches more than 3 hundred thousand, approximately equivalent to 2.8% of the level of Taiwanese total labour force. Readers could take such 2.8% as a form of upper bound of Chinese workers in Taiwan, since not all the Chinese spouse get to work in Taiwan(National-Immigration

Agency 2015).

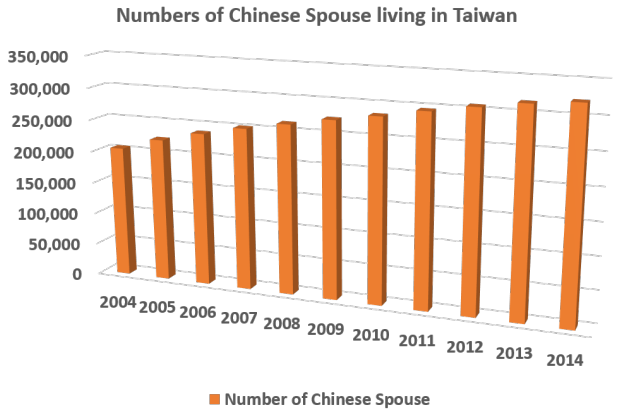


Figure 1.14: Number of Chinese Spouse Living in Taiwan 2004∼2014 (National-Immigration Agency 2015)

To shortly sum up from above, given the size of the labour inflow/outflow compared to the labour force, though we could not deny their theoretical impacts on wage, it should be less influential than other macro policies, e.g., FTA policies, or real estate related regulation changes that would have impact to the whole labour force. We would discuss the theoretical implication of such international labour mobility in Chapter 3.

To recapitulate, Chapter 3 contributes to the existing empirical literature on the analysis of Taiwanese Mincerian structure by not only the inclusion of a new variable, viz., the industrial investment in real property as to see if there is spill-over or crowding out effect on wage, but also by examining the robustness thereof, by administering two different estimators, e.g., the cross-sectional, and the QR estimator. The Mincerian regression will be separately administered on three different Taiwanese cohorts so to see if the education return is indeed decreasing, i.e., the diploma inflation would deteriorate wages, causing the younger cohort to suffer from lower education returns as observed in France by Chauvel (2010). Lastly, the structural break points were chosen at the time when Taiwan experiences improvement in its average export price (especially charged to China) as the local tariff (in China) decreases in accordance with its entry into WTO as a member state in 2002, and its Bilateral Trade Agreement with People's Republic of China (PRC) in 2009. Ergo, the impact of FTA on Taiwanese labour is tested yet again, albeit differently as opposed to that would be done in Chapter 2, but on the marginal impact on the wage of Taiwanese labour via the determining factors.

1.4. A Comparison between Taiwan and the UK

1.4.1. Motivation

Continued from the preceding chapter, Chapter 4 attempts to compare how the same wage determining factors would have similar or different impact on the wages in the UK[7]. In Chapter 3, similar to what has been found by Chauvel(2010) in French cohorts, a cumulative effect in education is corroborated in Taiwanese data, i.e., the education return being lower for younger cohorts(Chauvel 2010). Also it is substantiated that the speculative industrial indebtedness in the real property tends to be so large and of negative marginal impact on wages, that it could offset the education marginal return for the youngest cohort. Would similar result be empirically concluded in the United Kingdom? If same factors having impact on wage in the UK, there might be some factors done right in the existing system of the UK, from which the Taiwanese government could learn. Lastly, in Chapter 3, two break points are selected, when the relative labour supply (for educated workers relative to uneducated ones) presumably was influenced by the changes in relative labour demand and supply on a international scale. Similar break points were chosen to examine if the changes of context within the framework of international trade,i.e., Free Trade Agreement (FTA), would have significant empirical impact on wage via the aforementioned factors, and weather such structural break could be consistent with the real world occurrences. The key questions posed in Chapter 4 are: How are the wage determinants (e.g., education attainment, industrial investment in real estate) affecting the UK labour force, in a similar or different ways as opposed to their Taiwanese counterparts? And how do such impacts change at different structural breaks?

To start with, as shown in Figure 1.15, according to the statistics provided by the Office for National Statistics (ONS), the real monthly wage demonstrates an upward long term trend since 1991 (increasing from roughly £1100 per month in real term by 1991, up to £1615 per month at the of 2008), which is different from the downward trend in Taiwan noted in Chapter 3 (Office-For-National-Statisics 2015)[8]. From Figure 1.16, it is not difficult to locate the same period, when the

[7]At first glance, comparing the United Kingdom to Taiwan might look like comparing apples to oranges. However, both possessing traits of a small open economy, the UK and Taiwan respectively neighbor to a large economic entity in geographical sense. For Taiwan, its long love-hate relationship with the People's Republic of China (PRC) and the ambiguity in its foreign policy toward THE PRC caused by the rotation of political parties in the office beget its current dependency and self-alienation to PRC. On the other hand, being a crucial member of the European Union (EU), one of the largest aggregate economies in the world, the UK seems to inherently retain "Churchill's three circles" approach on its foreign/economic policy toward the rest of the EU states, begetting alienated ambiguity with the EU states, which might not be too far-fetched to be compared with the term between Taiwan and PRC.

[8]The ONS data of labour earning is originally recorded in nominal term and on weekly basis, but has been adjusted into monthly real wage according to the Consumer Price Index also provided

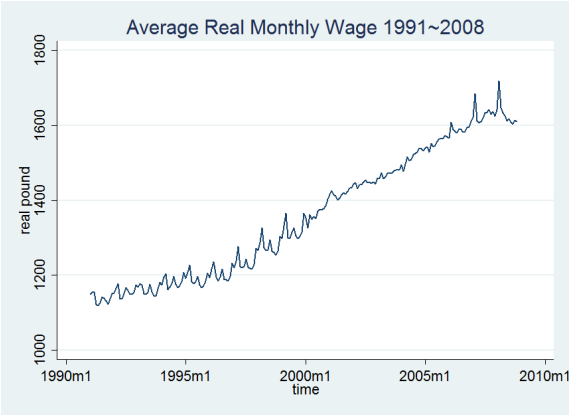


Figure 1.15: Average Real Monthly Wage 1991∼2013(Office-For-National-Statisics 2015)

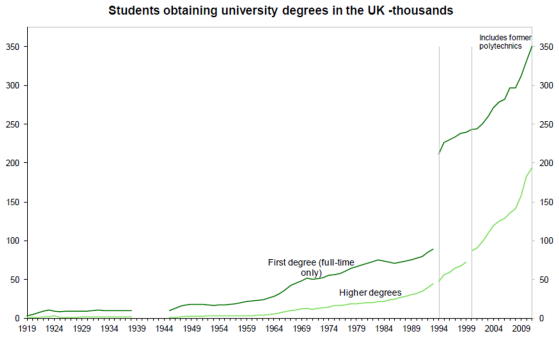


Figure 1.16: Student Obtaining university degrees in the UK (thousands) 1919∼2010 (Bolton 2012)

numbers of educated labour (students obtaining first degrees and higher) appears to retain its upward growing trend, while the number of first degree obtainment experiences an even higher upsurge, growing from fewer than 80,000 in 1991, up to more than 200,000 after the inclusion of polytechnics in 1994 (granted by the "Further and Higher Education Act 1992"), and reaches nearly 350,000 in the end of 2009. The trend of higher degree experiences a stronger upsurge at 2000 rather than 1994, due to a change in the treatment to the students qualifying from a 'dormant' status [9] (Bolton 2012, Huw 1997). The upward trends simultaneously observed in both Figure 1.15 and 1.16 within the same period could be in intuitive accordance with what been unravelled by Barro and Lee (2013): human capital, particularly that attained through education, is a critical determinant of economic progress, in turn increases an economy's output and service, and has a strong impact on income distribution(Barro & Lee 2001). Such a symmetric pattern contrasts with the asymmetry between the downward trend of real monthly wage and the upward trend of numbers of graduates of higher education in Taiwan from last chapter. It might anecdotically implies education attainment, as a crucial determinant among all the factors in the wage determination structure, faces little if no negative impact from other factors.

Except for the increase in absolute numbers of first and higher degrees as shown in Figure 1.16, it is also observable from the education structure of the labour force, which is derived from the British Household Panel Survey, that the relative ratio of first and higher degree obtainments increases as time being during the period from 1991 to 2008, i.e., the skill structure of the labour force in the UK gradually adjusts

by ONS, so that it is similar to its Taiwanese counterpart from Chapter 3.

[9]Since the year 2000, the regulation in the UK changes so that even if a student is not actively studying for their qualification, whcih may be due to an administrative delay between completion and award, would still be counted as students.

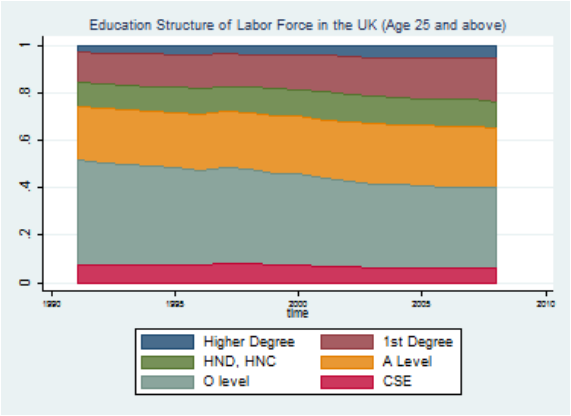


Figure 1.17: Education Structure of Labour Force in the UK 1991∼2008(University-Of-Essex 2010)

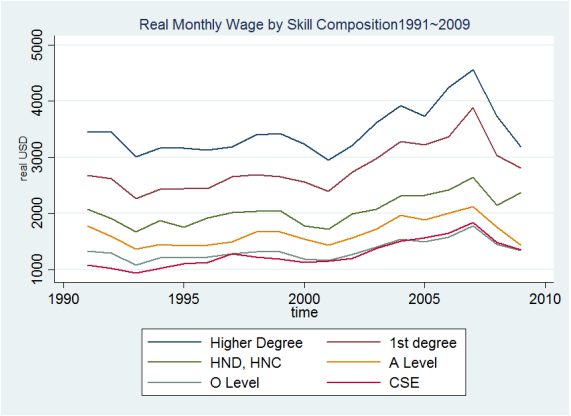


Figure 1.18: Real Monthly Wage by Skill Composition1991∼2009 (University-Of-Essex 2010)

upward (from 15% in 1991 to 23% in 2008), as presented in Figure 1.17(University-Of-Essex 2010)[10]. Also, by comparing Figure 1.17 to its Taiwanese counterpart in the last chapter, the portion of Higher education experiences a larger increase proportionately (11.1% in January, 1999 to 26.7% in 2010 Dec.) in the Taiwanese labour force, while such expansion in the UK seems milder.

What are the implications of such growth? One possible outcome could be the "education inflation effect," articulated by Chauvel (2005), which should be defined as "declining return to educational investment" (Chauvel 2005). In Chapter 3, the descriptive statistic in Taiwan as well as the empirical result of cohort analysis demonstrate that the return of education investment decreases in Taiwan. Would similar education inflation be of strong influence on the wage of the labour force in the UK? As discussed in the following subsection1.4.2, different literature using different variables, samples, ur econometric methods would very likely derive different result estimated. Taking one of the UK Mincerian literature who examines the education return over the years, such as produced by Walker and Zhu (2001), the education return estimated with OLS estimator is decreasing for male from 9.2% to 8.5% from 1993 to 2000, whereas that for female fluctuate over 7.5%. Be that as it may, such trend is not similarly observed if breaking down to different qualifications, subjects, while such decreasing pattern is now longer observable if estimated with their Quantile Regression estimator(Walker & Zhu 2001). In the work derived by Devereux and Fan, their estimated education returns for both UK-born male and female (both born between the year 1958 and 1982, and aged between 25 and 50) are about 6% between 1997 to 2009 (Devereux & Fan 2011). If education return estimated by different methods could be roughly compared, we might be able to

[10]Readers should be aware of the difference in terms of data source between Figure 1.16 and 1.17, the former is quoted from Bolton (2012), where the statistics is the absolute number of education attainment, provided by the Higher Education Statistics Agency (HESA), while the latter is summarised from the BHPS data set.

have a wild guess that education return in the UK might be decreasing over time, though such conjecture is yet to be corroborated, hopefully by this thesis, while such pattern might be consistent with the argument made by Montenegro and Patrinos in their report, namely, the world-average return of schooling is observed to be decreasing from 14.4% in 1980-1985, down to 9.9% in 2006-2010, while the average years of schooling has been increasing from 7.3% in 1980-1985 to 10.7% in 2006-2010 (Montenegro & Patrinos 2013).

From Figure 1.18, the average monthly wages at each education attainment level, fluctuate over time but, the inflation effect is not as obviously observed in Taiwanese counterpart (see the introduction section of Chapter 3), for the difference between the wage trend of higher education(first degree and higher) and that of lower education level tend to retain its width. Nevertheless, it would be too presumed to conclude that there is no such inflation effect in education attainment or to argue such effect is relatively lower than that in Taiwan without taking other variables into account.

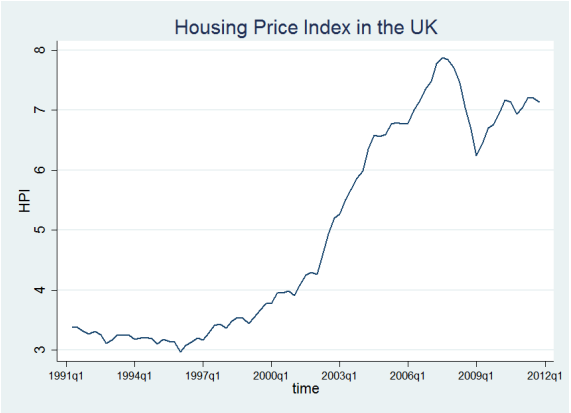


Figure 1.19: Quarterly UK Housing Price Index 1991∼2013(Nationwide 2014, National-Archive 2014)

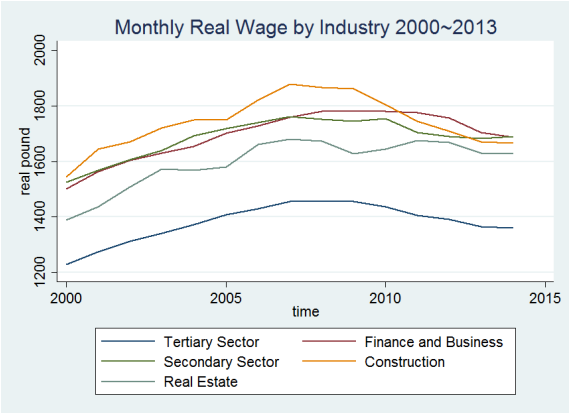


Figure 1.20: Monthly Real Wage by Industry 2000∼2013(Office-For-National-Statisics 2015)

Another factor that has been included and significantly imposing negative impact on the wage of younger cohorts in Taiwanese analysis, is the industrial indebtedness for real property, allegedly for arbitrage purpose. In Chapter 4, a similar attempt is made as to examine whether such investment in real property have impact on labour's wage, within the Mincerian structure. Though as some theoretical economists, e.g., Glaeser and Gyourko (2007) would argue, that the no arbitrage conditions should exist in the real estate market due to the existence of "unobserved costs of home owning such as maintenance, risk aversion and the high volatility of housing prices," which would "compromise short-term attempts to arbitrage." Hence, they conclude real property should not be narrowly understood as a financial

good(Glaeser & Gyourko 2007). Others such as Connock (2002) differ, corroborating that there is serial correlation in the housing price time series, collected from Nationwide and Halifax price surveys. Such correlation in price allows arbitrage behavior in the market, yet as Connock admits, that due to sundry factors, e.g., market imperfection, transaction costs, and institutional factors, individuals might not be able to arbitrage from real estate market any more than corporations from non-real-estate-related industries would(Connock 2002). In Figure 4.2, the Housing Price Index is the ratio between average housing price in the UK and the median household income. It appears that the ratio experiences an upsurge after 2002, and continues growing until the latter half of 2008 when the globally notorious financial crisis deteriorated in the UK. Be that as it may, as the BHPS data set applied in Chapter 4 only covers 18 waves through 1991 to the second quarter of 2009, the period when HPI does plummeting might be included yet not necessarily implying the impact on wage thereof would be recorded. Still, one might argue that the upward going HPI trend in the UK bears a resemblance to that in Taiwan, while the latter being more than twice as high as the former. With the trend of HPI being shown, nevertheless, empirical economists could not concur with one another on the validity of bubble in the UK real estate market. Cameron et al. (2006) could not find evidence from their dynamic panel data model of British regional house prices between 1972 and 2003(Cameron et al. 2006). Opposite conclusions are also proposed by statisticians such as Zhou and Sornette (2003), who "unearth the unmistakable signatures (log-periodicity and power law super-exponential acceleration) of a strong unsustainable bubble" in the UK (Zhou & Sornette 2003). Being equivalently debatable, a "housing boom," i.e., an expansion in the housing market, might have an ambiguous impact on labour wages, and would be differently summarized by one analyst as opposed to others. Such a boom may have positive impact on the wage via a positive spill-over effect, proliferating from real estate related industries onto other industries(Iacoviello & Neri 2010). In Figure 1.20, the trends of monthly wages over time are compared between industries, which is captured from ONS. With all the wages on upward trends up till 2009, the construction industry appears to be of highest among the selected sectors/industries for the periods of interest. This might be regarded as prima facie evidence supporting the validity of the spill-over effect. Such a pattern is otherwise not observable in Taiwanese statistic, where the finance industry remains growing as opposed to the rest decreasing as time being(Office-For-National-Statisics 2015).

For Chapter 4, we would study period from 1991 to 2009, which includes the periods of time that are of analytical interest to this chapter. From Figure 4.2, we could see the housing price-income ratio in the UK start to soar in 2003, This data set serves as the source for the following variables, e.g., education attainment years, working experiences, and characteristic variables (University-Of-Essex 2010). That said, Our

selected period of time does not only include the boom of the UK housing market starting from 2003 and ending by the financial crisis in 2008, but also the two EU enlargements happening in 1995 and 2005 respectively, that purportedly affect the change in relative demand and supply of the UK labour market. Similar changes within the context of EU is less observable after 2005. That is to say, in Chapter 4, we would concentrate our analytical scope one the aforesaid period, albeit there is a similar upsurge in the UK housing market, if not higher in the latter period.

1.4.2. Mincerian Equation

As stated in previous section, Ordinary Least Squares (OLS) is one of the most common approach in Mincerian wage analysis. In his cross national comparison, Psacharopoulos (1985) has applied the Mincerian structure onto over 60 countries, in which he discovers the education return in the UK from 1971 to 1978, to be differently distributed among education level in the social education and private education. His empirical result concludes that in the UK for the given period, there is more significant over-education in social education as the education return is lower for the higher education in many years, but not in the private education (Psacharopoulos 1985). Psacharopoulos's empirical work is one of the earliest empirical finding that demonstrate evidence for the over education in the UK. Harmon and Walker (1995) has made their attempt to account for a variety source of bias associated with OLS such as ability bias and measurement error. By introducing instrument variables such as exogenous changes in the educational distribution of individuals caused by the raising of the minimum school-leaving age in the United Kingdom, and Mill's ratio to account for self selection bias (Harmon & Walker 1995). Trostel et al. (2002) has administered a Mincerian OLS estimator on micro data of 28 countries from 1985 to 1995, while instrument variables such as spouse's and parents' schooling are included, yet not making significant difference in the estimated UK result, showing no evidence in the rising in rate of return from 1985 to 1995 (Trostel et al. 2002). In more recent works, such as done by Harmon et al. (2003), Dearden et al.(2006) and Denny and O'Sullivan (2007), OLS estimators often serve as benchmarks for comparison with other estimators, which would be mentioned in the following passage (Harmon et al. 2003, Dearden et al. 2006, Denny & O'Sullivan 2007).

As mentioned in the previous section, Quantile Regression (QR) is often applied into the Mincerian analysis as a method to address how the unobserved abilities would have influence on education return on wage. With such an approach, Martins and Pereira (2004) administer a QR estimator on data collected from 16 countries,

within which the UK data is derived from the Family Expenditure Survey, and derive robust results showing education return is growing with income quantiles, serving as a proxy of unobserved abilities. They conclude that education might be a factor that widens income disparity (Martins & Pereira 2004). Similarly. Walker and Zu (2001), also find supportive empirical evidence to such statement with their own version of a QR estimator using the Labour Force Survey data (Walker & Zhu 2001). Nevertheless, Denny and O'Sullivan (2007) disprove the aforesaid results and corroborate from British National Child Development Survey, that the education return decreases as quantile of income increases, suggesting education in the UK functions as a substitute for unobserved ability, viz., education appears to be more beneficial for people with less ability than those with higher ability, implying that the benignity in the popularization of UK education has been demonstrated to be bona fide (Denny & O'Sullivan 2007). In this part of thesis, so to achieve comparability between the results in chapter 3 and 4, the Cross Sectional, and Quantile Regression estimators would be administered, in the hope to derive robustness thereof, and see if the results are in accordance with other literature.

As disclosed in Chapter 4, we would take the result of Quantile Regression Estimator as our primary evidence to support our argument. Hence we would focus the comparison in this subsection primarily upon the Mincerian literature using the Quantile Regression Estimator, as mentioned above. For one, in Martins and Pereira (2004)'s quantile Regression model, their discussion lacks of the differences in terms of different periods, or between different cohorts. Also, our Quantile Regression estimator incorporate instrument variable such as housing price index for our novel variable to the Mincerian structure. In the work of Walker and Zhu (2001), though using mother's education as an instrument to the education attainment years of each interviewee, their Quantile Regression estimated result serve more of a supplementary result, focusing on only the basic Mincerian education return for different years. That said, it lacks the discussion and comparison of other variables over the years, nor does it include instrument into the Mincerian Structure. Such omission can also applied to the work of Denny and O'sullivan (2007), in which they focus on the comparison on education return among different income levels, yet also lacks of discussions between different cohort/periods, or the application of instruments. This is where we believe we could make differences and contribution with our Quantile Regression results.

1.4.3. Education policy

From Figures 1.16 and 1.17, higher education in the UK appears to be in expansion. Nonetheless, different education policies might have direct or indirect impact on the education structure of the labour force over time. Some empirical economists

have attempted to discuss the implication of education policy in the Mincerian wage structure. For instance, Dutta et al. (1999) derive cross sectional estimates from their international data of 18 OECD countries (including the UK, in 1990 and 1995 respectively), substantiating that the education returns of different disciplines by and large would not be affected by the policy that increases education fees, which purportedly decreases the incentive of receiving further education. From their observation on the increasing student participation rate, they further argue that there might be a combination of an easing of rationing and an increased demand for skilled graduates. Lastly, based on the insignificance of a dummy indicator for the expansion of graduate output since 1985, they observe that there was no evidence of this: the said dummy was positive but insignificant. With that being said, they argue that such anecdotal evidence implies the oversupply might only be starting to appear in its early stages when high returns lead to an eventual oversupply followed by a period of poor returns (Dutta et al. 1999). Being inspiring to many succeeding researchers as it seems, their OLS-estimated model did not tackle with industrial differences in their discussion, and their data include only cross sectional results in 1990 and 1995, which might seem a bit out-dated and less relevant to more recent situations.

Denny and Harmon (2000) have exploited an unusual education reform that reduces the cost of schooling largely in Ireland in the late 1960s. Such policy implementation would increase the aggregate level of schooling, but might have different effects across different family background. This interaction of educational reform and family background generates a set of instrumental variables that are used to estimate the return to schooling allowing for the endogeneity of schooling, and derived a higher estimates by 7% than the OLS estimates(Denny & Harmon 2000). Though their choice of IV being inspiring, we would argue that their choice of OLS estimator is less informative to provide estimates at different income levels. Also, we could not see how education return and the marginal impact from other wage determining factors that purportedly affected by education policies, would change over time, or among different cohorts either. The last part of this thesis also incorporates dummy indicators of education policy in the UK as instrument variables.

1.4.4. Housing Market

As mentioned in previous section, in Chapter 4, a proxy variable is introduced so to measure the industrial investment in real property, purportedly induced by housing bubble, just as what is done in Chapter 3. Such an attempt is made to examine whether there is a crowding out of investment, which would undermine labour wages. Limited empirical literature has attempted to tackle the causality

between the boom in the housing market and the labour wage in the UK. Bover et al. (1989) test the interaction between wages, the labour market and the housing market in the UK. As part of a broader range of conclusions regarding wage determination they corroborate that differences in regional house prices to earnings ratios play an important role in determining net migration, and hence, causing a 'cost-of-living' effect on the domestic labour wage in the UK(Bover et al. 1989). Duffy et al. (2005) further postulate and examine the empirical possibilities of the housing boom in Ireland functioning as a deterrence that drives the potential skilled immigrants away since the house price becomes so high that it is less affordable for these immigrants who are in the household formation age group, thereby decrease the relative labour supply, hence the relative wage might increase (Duffy et al. 2005).**Among the empirical Mincerian literature analysing wage determining factors in the UK context, we find little researchers attempting to utilize variables to measure the impact of housing market, via factors such as corporate real estate investment upon wage. That is why we believe by adding a novel variable of industrial real estate investment that is related with housing price index, could be deemed as our innovative contribution to the existing Mincerian literature analysing the UK context.**

1.4.5. Change in the International Context

In light of wage determining factors of the Mincerian structure, a limited literature postulates the external impact on the domestic labour market. Zorlu and Hartog (2005) extend the theoretical framework of Altonji and Card (1991), and analyze the impact of immigrants on native wages in the UK. They, nonetheless could not find significant impacts on the wage, nor dominant robust patterns of substitution and complementarity (Zorlu & Hartog 2005, Altonji & Card 1991). With the data collected from International Social Survey Programme (ISSP), 1995, Denny et al. (2002) has examined the return of schooling in the Mincerian structure, in a cross-country context, while controlling factors of relative labour demand and supply, as well as policy factors. They discovered that the measures of openness such as trade volume and measures of protection of local labour both raise the return to schooling, while net inflows of foreign investment are associated with lower schooling returns, which is inconsistent with the evidence that investment is complementary to skill labour (Denny et al. 2002). **Recent studies tend to focus on the the wage disparity between immigrants and native, while the Mincerian return of education serves as a primary explanatory framework(Lindley 2009, Chiswick & Miller 2008). That is to say, our work by no means should be deemed as the first to utilize Mincerian structure involving the UK within an international context. But we are convinced that our work in chapter 4 differentiates itself with its application of Quantile Regression**

estimator using our choice of novel variable and instruments.

In this final part of thesis, the segmented sector wage model derived by Mincer (1976) is applied, so to explore how the wage determinant within the Mincerian structure would be affected by the change in the labour market caused externally, to wit, the immigrant (skilled or nonskilled) labours entrance due to the expansion of European Union (EU) at 1995 and 2005 respectively, which might cause the education structure of the domestic labour market in the UK to change accordingly.

In conclusion, Chapter 4 of this thesis does not only serve as a benchmark of example for comparison analysis with Taiwan, but also complement the existing empirical literature with the inclusion of new explanatory variables, viz., proxy variables of industrial investment in real property, test of structural break point for the external change in relative labour supply, into the Mincerian wage structure.

Chapter 2

Unemployment, Economic Growth, and Trade: Empirical Application of Okun's Law in Taiwan

Taiwan has long been recognized as an economic entity highly dependent on its international trade. This chapter thus makes innovation via examining if cyclical export gap is in fact beneficial to the local unemployment rate. Inspired by an empirical Okun analysis by Tien (2010), chapter 2 establishes an Autoregressive Distributed Lag (ADL) framework of Okun coefficients, while cyclical export gap is added as an extra explanatory variable so to examine if Dutt et al.'s prediction can be statistically supported with Taiwanese data. Instead of treating this variable as a static ratio as in Tien's work, this chapter makes an innovative contribution by using both Hodrick-Prescott filter and Holt-Winters de-seasonal smoothing respectively, attempting to capture the cyclical fluctuation of export, introducing it into the Okun structure. Furthermore, following Tien's approach, the Chow test is applied and indicates that there is "shock" that would create structural changes, at 1990q1 when Taiwan re-initiated Trade with China, and at 2002q1, when Taiwan joined WTO as a member country. These two break points are selected differently when compared with those chosen in Tien's work, so to further examine Dutt et al's theoretical prediction. This chapter could thereby make a contribution by verifying the industrial restructuring when the export price between Taiwan and China is improved at certain break points.

2.1. Theoretical Framework

The following part of the Chapter aims to provide theoretical explanations of the interactions between GDP growth rate and unemployment rate, and that between export gap and unemployment rate, via adapting theoretical results from the exist-

ing literature. The former is often observed to be negatively correlated in different contexts and times. Still, the interactions between GDP growth rate and unemployment could be derived differently with various theoretical framework and thus diversely interpreted by one author as opposed to another. This Chapter examines the applicability of existing general framework of the neo-classical model to Taiwanese data since 1981. In different sub-periodd positive correlation might be observed and would have to be otherwise explained by the following two possible scenarios: 1) a creative destruction effect that tends to happen during economic expansion (Aghion & Howitt 2005), and 2) non-standard employment. This Chapter aims to distinguish the more likely theoretical explanation to address different sub periods accordingly. Lastly, adding cyclical export gap into the common bilateral structure between cyclical GDP gap rate and unemployment rate is supplemented by the theoretical result by Dutt et al. in 2009, which incorporates the long-established Heckscher–Ohlin model with the searching theory, as to explain the interactions between trade exports and short term frictional unemployment.

2.1.1. the Relation between GDP Growth and Unemployment

2.1.1.1. Negative correlation: Neoclassical framework

GDP growth and unemployment is negatively correlated, which can be derived from the following neo-classical framework adapted from Xu and Gong 2007 (Xu & Gong 2007):
Assume production (Y) is a Cobb-Douglas function of capital input (K) and Labour input (L):

$$Y = F(K, L) = K^{\alpha} L^{\beta} \tag{2.1}$$

So the growth rate of production ($\dot{y}$) can be deducted from the chain rule as follows:

$$\dot{y} = \frac{1}{Y}\frac{dY}{dt} = \alpha\frac{1}{K}\frac{dK}{dt} + \beta\frac{1}{L}\frac{dL}{dt} \tag{2.2}$$

where $\alpha = \frac{\frac{\partial F}{F}}{\frac{\partial K}{K}}$ is the production flexibility of capital and $\beta = \frac{\frac{\partial F}{F}}{\frac{\partial L}{L}}$ is the production flexibility of labour. If assuming:

$$K = \sigma Y \tag{2.3}$$

where $\sigma > 1$ is the capital-production ratio
And from equation 2.3 it can be further rewritten as:

$$\frac{1}{K}\frac{dK}{dt} = \frac{1}{\sigma}\frac{d\sigma}{dt} + \frac{1}{Y}\frac{dY}{dt} \tag{2.4}$$

By inputting the above result back to equation 2.2:

$$(1-\alpha)\dot{y} = \frac{\alpha}{\sigma}\frac{d\sigma}{dt} + \beta\frac{1}{L}\frac{dL}{dt} \tag{2.5}$$

On the other hand, the unemployment rate (u) can be defined as follows:

$$u \ = 1 - \frac{L}{N} \tag{2.6}$$

where 0<u<1, L is the amount of labour being employed, and N being the amount of labour force.

From equation 2.6, by rearranging it with similar logic, the growth rate of labour could further be derived as:

$$\frac{1}{L}\frac{dL}{dt} \ = \frac{1}{N}\ \frac{dN}{dt} - \frac{1}{1-u}\frac{du}{dt} \tag{2.7}$$

Ergo, by inputting the result of equation 2.7 back to equation 2.5, the relation between the unemployment rate and the production growth rate can be rearranged as follows:

$$\frac{1}{1-u}\frac{du}{dt} = \dot{n} + \frac{\alpha}{\beta}\frac{1}{\sigma}\frac{d\sigma}{dt} - \ \frac{1-\alpha}{\beta}\dot{y} \tag{2.8}$$

where $\dot{n} = \frac{1}{N}\frac{dN}{dt}$ is the growth rate of labour force.
From equation 2.8 it is not difficult to discover, ceteris paribus, the growth rate of production is negatively correlated with unemployment over time. **Hence we may expect to observe the GDP coefficient in the following regression model to be negative.**

2.1.1.2. Positive Correlation: Philippe Aghion and Peter Howitt (2004)

The aforementioned framework depicts the relationship between unemployment rate and GDP growth to be negative while holding everything else to be constant. Nonetheless, Aghion and Howitt (2004) have included the factors that address technological progression and its effect on the relationship in between.

$$u \ = 1 - p(v)\frac{\Gamma}{g} \tag{2.9}$$

Where u is the unemployment rate, Γ is the life cycle of production unit, g is the GDP growth rate (or production growth rate), and p (v) is the job creation rate. Accordingly, the "creative destruction effect" caused by technological improvement would decrease Γ and u thus increases, while holding all other variables constant, signifying the process of technological progression would create new jobs while de-

stroying old ones. In this formula, the GDP growth rate and unemployment rate are positively correlated, i.e., when the creative destruction effect starts to kick in, new industries adopting new technologies would start to replace the old ones, requiring fewer jobs with increased marginal productivity, thus expanding the cyclical unemployment gap. **Ipso facto, if the GDP coefficients in the regression model demonstrate positive correlation are to be observed, we might be able to postulate such correlation is caused by the creative destruction effect.**

2.1.1.3. Positive Correlation: Non-Standard Employment

As described by Kalleberg (2000), non-standard employment such as part-time work, temporary help agency, contract company employment, short-term and contingent work, and independent contracting have become increasingly prominent ways of organizing work in recent years (Kalleberg 2000). According to Tien (2010), non-standard employment in Taiwan could be traced back as early as 1999, when the Ministry of Economic Affairs of Taiwan started to officially classify Dispatched Work as a new category in the classification of industry, while it latter became a focus for development in tertiary industries, determined by the Council for Economic Planning and Development(Tien 2010).

Recent discussions have extended such a concept, and describe firms showing a tendency in hiring more "temporary workers" during the recession to split the work available amongst skilled workers who were paid at a premium wage level. Such phenomena have not been so rarely observed in the United States, Europe and increasingly often in East Asia.[1] Methods such as hiring dispatched workers or short-contract employees, or sending workers for unpaid leave have become increasingly common in Taiwan over the past decade, which decreases working hours per labor and the labor cost involved, while maintaining even increased short run employment level. **With that being said, we may expect to find positive correlation for the GDP coefficient in the regression model, especially during the period when non-standard employment became more salient.**

2.1.2. The relation between export change and unemployment

Ceteris paribus, the connection between export and unemployment is often regarded as intuitively implied: once the export price is improved as the bilateral trade be-

[1] This is possible while wage is not fixed in the labour market, as Mankiw points out, real wage might not be in line with productivity as suggested by classic theory, due to reasons such as: 1) relevant measure of wages is total compensation, while some data includes only cash wages, 2) real wages are deflated using a consumption deflator, rather than an output deflator, 3) Heterogeneity among workers, 4) Cobb-Douglas assumption of constant factor shares is not perfect(Mankiw 2006).

tween two countries is initiated, GDP of both countries would increase respectively, followed by the domestic employment level rising, and the rest should operate as depicted in Section 2.1.1.1. Ergo, we might expect a negative correlation between export and unemployment rate[2].

Be that as it may, the connection between export changes and unemployment might be differently described based on different theoretical framework.[3]

The following framework follows the establishment of Dutt et al. (2009) whose primary innovation is to utilize the standard uni-sector Pissarides style search model, and elaborate it into a two-sector Hecksher Ohlin international trade model. With that being said, it is their unique intention to describe structural unemployment caused by industrial re-structuring effect that happens when the economy experiences improvements upon the terms of trade, with search-match theoretical mechanisms.

Consider an economy that produces two type of goods, X and Y, and the labour market corresponds to a standard Pissarides (2000) style search model embedded in a two sector set-up (Pissarides 2000). A producing unit in the intermediate goods production is a job-worker match. New producing pairs are created at a rate determined by a matching function of two measures of labour market participation, vacancies and unemployment:

$$M_i(v_i L_i, u_i L_i) \ = m_i \ v_i^{\gamma} u_i^{1-\gamma} L_i = m_i \theta_i^{\gamma} u_i L_i \tag{2.10}$$

where $0<\gamma<1$, and
θ is the market tightness, can be further expressed as: $\theta = \frac{v_i}{u_i}$;
v_i is the vacancy rate
γ is the parameter capturing the vacancy intensity of the Cobb-Douglas matching function
u_i is the unemployment rate for sector i

In Dutt, Mitra and Ranjan's theoretical derivation, the relative price will increase in favour of the good with comparative advantage in the Ricardian world, where countries can only be differentiated by different levels of technology, and corresponding comparative advantage in different sectors. The following equation is adapted from their result, assuming good X is with comparative advantage and

[2]for further theoretical discussion, refer to Feenstra's work(Feenstra 2003).

[3]For instance, based on the assumption of homogeneity in labour market, Janiak (2007) provided a different theoretical conclusion in which job creation is larger than job destruction due to the openness of international trade (Janiak 2007).

shall be exported:

$$(1-\varphi)p_x h_x = (b + \frac{\beta\delta\theta}{1-\beta} + \frac{(\rho+\lambda)\delta}{(1-\beta)m\theta^{\gamma-1}})(\frac{K(\lambda+m\theta_i^{\gamma})}{Lm\theta_i^{\gamma}})^{-\varphi} \tag{2.11}$$

where φ is factor intensity
p_x is the price of export good x
h_x is the is X sector's total factor productivity (TFP) parameter
b is the numéraire benefit unemployed workers received in each sector
β is the bargaining power of workers through a process of Nash bargaining between the worker and the entrepreneur
δ is the recruitment cost in the sector
λ is the match broken rate
γ is the elasticity of vacancy rate in the Cobb-Douglas matching function
m is a scale parameter in the Cobb-Douglas matching function
L is the labour force in the economy
K is the total capital in the economy
ρ is the discount factor; $0 < \rho < 1$
k=$\frac{K}{(1-u)L}$is capital–labour ratio

When relative price $\frac{p_x}{p_y}$ increases, implying either p_x increases or p_y decreases, which increases market tightness θ for both sector: in a capital intensive industry where both capital and labour swamp in, the vacancy rate v_x growing slower than the unemployment rate u_x since it is the capital intensive industry, hence θ decreases. In the labour intensive industry, both capital and labour flow outward, yet the vacancy rate v_y decreases faster than unemployment rate u_x as the lower labour-capital ratio in the labour intensive sector y implies a larger unemployment rate if the productivity level decreases by an equivalent amount. Also, the labor interflow from y to x might not be able to efficiently communicate and match all unemployed labours in sector y to sector x, for the latter being capital intensive (A graphical expression is fiven in Fig. 2.1). In the two-factor Heckscher-Ohlin world (where the two sectors have different factor intensities $\varphi_x \neq \varphi_y$),for the capital-abundant country, there is an expansion of the capital-intensive export (with comparative-advantage) sector accompanied by a shrinking of the labour-intensive import-competing (with comparative-disadvantage) sector. This leads to an increase in economy-wide demand for capital relative to labour for both sectors. This is observed from equation 2.12:

$$k_x = (\frac{\varphi_y}{\varphi_x})^{\frac{\varphi_y}{\varphi_x-\varphi_y}}(\frac{1-\varphi_x}{1-\varphi_y})^{\frac{\varphi_y-1}{\varphi_x-\varphi_y}}(\frac{h_x p_x}{h_y p_y})^{\frac{1}{\varphi_y-\varphi_x}}$$
$$k_y = (\frac{\varphi_y}{\varphi_x})^{\frac{\varphi_x}{\varphi_x-\varphi_y}}(\frac{1-\varphi_x}{1-\varphi_y})^{\frac{\varphi_x-1}{\varphi_x-\varphi_y}}(\frac{h_x p_x}{h_y p_y})^{\frac{1}{\varphi_y-\varphi_x}} \tag{2.12}$$

In their model, the capital earning r for both sector is endogenously determined as follows:

$$r = p_i h_i \varphi_i k_i^{\varphi_i - 1} \tag{2.13}$$

$$w = b + \frac{\beta}{1-\beta}(\delta_i \theta_i + \frac{\rho + \lambda_i \delta_i}{m_i \theta_i^{\gamma-1}}) \tag{2.14}$$

and the steady state unemployment rate for each sector i is:

$$\hat{u}_i = \frac{\lambda_i}{\lambda_i + m_i \theta_i^{\gamma}} \tag{2.15}$$

As k decreases in both sectors, the consequent net effect is capital earning r increased as shown in equation 2.13, wages w lowered for both sectors as shown in equation 2.14 since θ decreases for both sectors, and overall steady state unemployment would thereby be increased in a capital abundant country as shown in equation 2.15. The reverse effect occurs in a labour-abundant country. This result is a modified version of the Stolper-Samuelson theorem: the wage falls, the rental on capital rises and the unemployment rate rises in the capital abundant country, after international trade is opened[4]. A visualized depiction is available below:

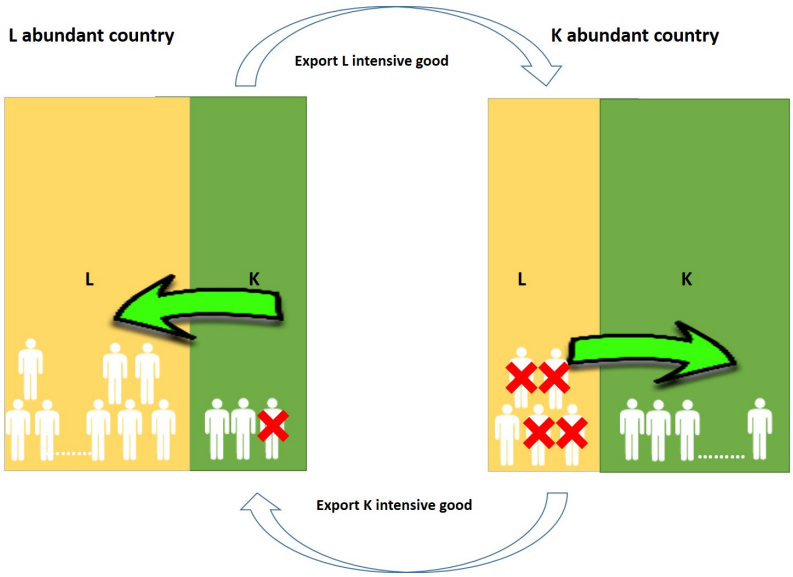


Figure 2.1: Hecksher-Ohlin Framework

[4]For more comprehensive proof, please see the work of Dutt et al.(Dutt et al. 2009)

Thus, from the earlier theoretical result, if as seen in Figure 2.2[5], a relative capital-intensive country, say, Taiwan, opens up trade or encounters any form of external events (pushing the relative price $\frac{P_x}{P_y}$ up) that increases the bilateral trade flow (Q_x increases relative to Q_y) with a then labour intensive partner, e.g., China, it might be expected that domestic unemployment should have increased corresponding to trade growth. As the unemployment rate increases due to the reallocation of factors, this is often described as industrial re-structuring effect, which has been empirically estimated and confirmed by Xin(2005) and Huang and Chung (2008)(Xin 2005, Hwang & Chung 2008).

This chapter intends to examine if the coefficient in Taiwanese Okun structure would experience structural breaks when terms of trade improved. Two break points of time are chosen: the first quarter of 1990, when Taiwanese re-initiated trade with Mainland China, and the first quarter in 2002, when Taiwan joined the World Trade Organization (WTO), one month after the admission of China to WTO. For the first break point, the theoretical framework would predict the export coefficient to be positive afterward, as the commercial interactions e.g., bilateral trade, indirect investment might increase (but partially allowed by both governments), yet for the second breakpoint, the impact might be less obvious. Though the Taiwanese government admits that such multilateral trade association by and large has been utilized as more of a stepping stone to the an improved bilateral trade with China at a better term, i.e., tariff China charges upon Taiwanese goods on average decreases the pre-WTO level: 32%∼43% down to 10%, which is the preferential tariff for WTO members(Yen et al. 2003). **With that being said, the export coefficient after the second break point might show a similar positive correlation as after the first one.** Nevertheless, as the WTO is a multilateral trade association including some 160 member states, some of which might be relative capital abundant and some labour abundant, such trade liberalization might be related with a decreasing unemployment rate since according to Dutt et al's theory, Taiwan might become the labor abundant country and experience the aforementioned industry restructuring effect reversely: **employment in labour intensive sector increases at a faster pace than the destruction of the capital intensive sector, while the export coefficient might be negative, meaning the export gap causing the unemployment gap decrease.**Hence the structural break at the second break point (2002q1) might be less obvious than the first one (1990q1).

To sum up,table 2.1 lists the predictions made by the aforementioned of direction

[5]Figure 2.2 presents a measurement of relative capital abundance (i.e., gross capital divided by employed labour) of different countries (or a group of countries, i.e., WTO) as time being, based on which the countries could be determined as relatively capital-abundant or relatively labour-abundant when compared with other country. For instance, in 1990, Taiwan is relatively capital abundant than China. The data for Taiwan is captured from Central Bank of Taiwan for the gross capital, and National Statistics for annual statistics of labour, whereas those for the rest of the countries are adapted from World Bank database. For further definition of the measurement, please see Leamer's work (Leamer 1980).

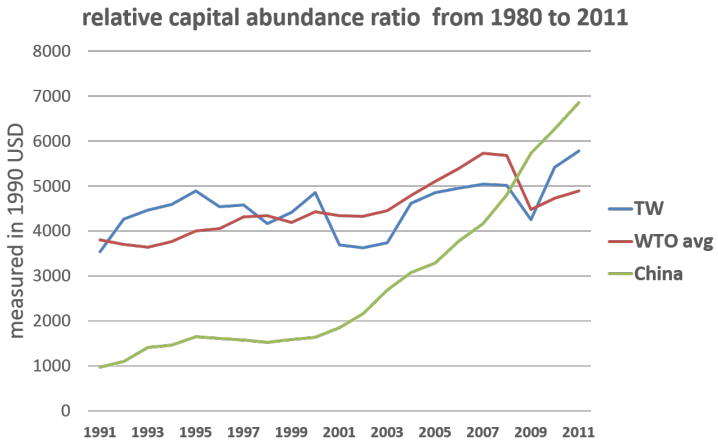


Figure 2.2: relative capital abundance ratio from 1991 to 2011 (World-Bank 2014, Central-Bank-Of-Taiwan 2014*b*, National-Statistics 2014)

of the coefficients in the empirical model: β_{GDP} is the marginal impact of GDP gap upon current unemployment gap, and β_{export} is the marginal impact of export gap upon current unemployment gap.

Table 2.1: Summary of Theoretical Prediction

	Theoretical Prediction on the direction of coefficient
Neoclassical framework	$\beta_{GDP}<0$ & $\beta_{export}<0$
Philippe Aghion and Peter Howitt	$\beta_{GDP}>0$
Non-Standard Employment	$\beta_{GDP}>0$
Dutt et al.	$\beta_{export}>0$ (obvious in 1990q1, but less in 2002q1)

2.2. Data Source and Arrangement

2.2.1. Data Source

The data applied in the following model is collected from PC-Axis data base, which is a Macro statistical data base established by National Statistics, Directorate-General of Budget, Accounting and Statistics, Executive Yuan. From the data base, the three variables collected are: unemployment rate, real Gross Domestic Product (GDP), and real Exports on quarterly basis from 1981q1 to 2011q3. The unemployment rate is the ratio between number of the unemployed, i.e., citizens out of employment but actively looking for a job, measured in percentage points. The GDP is an aggregate measure of national production equal to the sum of the gross values added of all residents, institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs.) Calculated in the expenditure approach, the export is the part of the GDP that includes commodities and services provided to places outside Taiwan. Both GDP and exports are measured in real New Taiwanese Dollars, while setting 2006 as the base year for

inflation adjustment. Also, due to the fact that both GDP and exports are recorded quarterly in the database, the monthly unemployment rate is taking a quarterly average, so that it is consistent with GDP and exports. Also, the data starts from 1981q1 since it is from that point of time when the export data start being recorded.

In this chapter, two different filtering techniques would be applied onto the data, the reasons and methods thereof are described in further detail in section 2.2.2 and 2.2.3 respectively.

2.2.2. Hodrick–Prescott filter

In the theoretical framework of search and match literature, unemployment rate is determined by the labour market tightness. Among the literature, relevant theoretical conclusion describes the frictional unemployment that is most likely to occur in the short run. In the theoretical model presented in the previous section, Dutt. et al borrows the conceptual dynamic in the search and match model and describes how short run unemployment rate could be affected by a change in export. For empirical measure, we believe such short run unemployment change should be estimated with the short run cyclical component, de-trended from the quarterly unemployment in the original data set. One of the most common approaches among empirical analyses of the Okun coefficient is the Hodrick-Prescott filter. The following part describes how the H-P filter is adopted[6]

$$\min \sum_{t=1}^{T} [(u_t - \hat{u}_t)^2 + \lambda((\hat{u}_{t+1} - \hat{u}_t) - (\hat{u}_t - \hat{u}_{t-1}))^2] \tag{2.16}$$

u_t: Original time series of unemployment rate data
$\hat{u}_t$: a smoothed trend component
and let $u_t^* = u_t - \hat{u}_t$: deviation from trend, i.e., cyclical component

By solving the minimization problem in equation 2.16, it is possible to find $\hat{u}_t$, and $u_t - \hat{u}_t$ for each period.

$$\min \sum_{t=1}^{T} [(y_t - \hat{y}_t)^2 + \lambda((\hat{y}_{t+1} - \hat{y}_t) - (\hat{y}_t - \hat{y}_{t-1}))^2] \tag{2.17}$$

y_t: Original time series of real GDP
$\hat{y}_t$: a smoothed trend component
and according to defition of output gap in Tien (201) let $y_t^* = (y_t - \hat{y}_t)/\hat{y}_t \times 100$: percentage deviation from trend, i.e., cyclical component of real GDP

[6]Although the use of HP filter has been subject to heavy criticism, as Ravn and Uhlig demonstrate, it is likely that the HP filter will remain one of the standard methods for detrending, hence it is applied here. (Ravn & Uhlig 2002).

By solving the aforementioned minimization problem, it is possible to find $\hat{y}_t$, and $y_t - \hat{y}_t$ for each period.

Also, repeat the same method on export data:

$$\min \sum_{t=1}^{T} [(export_t - \hat{export}_t)^2 + \lambda((\hat{export}_{t+1} - \hat{export}_t) - (\hat{export}_t - \hat{export}_{t-1}))^2] \tag{2.18}$$

$export_t$: Original time series of real exports

$\hat{export}_t$: a smoothed trend component

and let $export_t^* = (export_t - \hat{export}_t)/\hat{export}_t \times 100$: percentage deviation from trend, i.e., cyclical component of real exports [7]

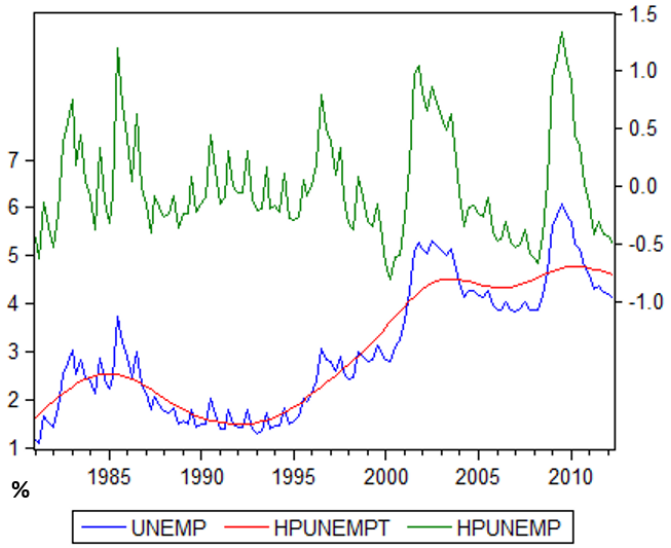


Figure 2.3: Quarterly Unemployment rate, the Filtered Trend and Cyclical component of Taiwan from 1980 to 2012

Also, as obvious from the Figure 2.3, Figure 2.4 and Figure 2.5 above, we could observe a trend in the unemployment rates the real GDP, and the real exports. Such observations are verified by Augmented Dickey Fuller tests[8].

2.2.3. Addressing Seasonality: Holt-Winters Seasonal-Smoothing

The H-P filter, though commonly applied in Taiwanese empirical literature of Okun coefficients analysis, is in fact often questioned by econometricians. One of the many issues raised is its incapability to address seasonality. Taiwanese empirical economists might either fail to identify and thus address this issue such as Chiang

[7] As suggested by Hodrick and Prescott, the λ is set to be equal to 1600, which is specifically applicable for quarterly data(Hodrick & Prescott 1997).

[8] See Appendix .1.1, Appendix .1.2, and Appendix .1.3

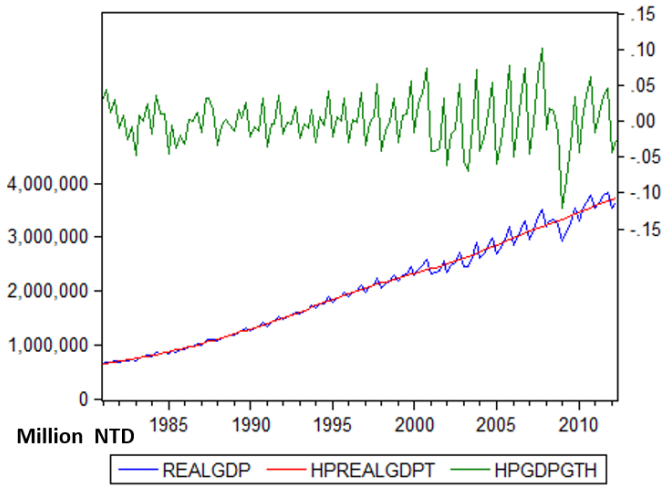


Figure 2.4: Quarterly Real GDP, the Filtered Trend and Cyclical growth of Taiwan from 1980 to 2012

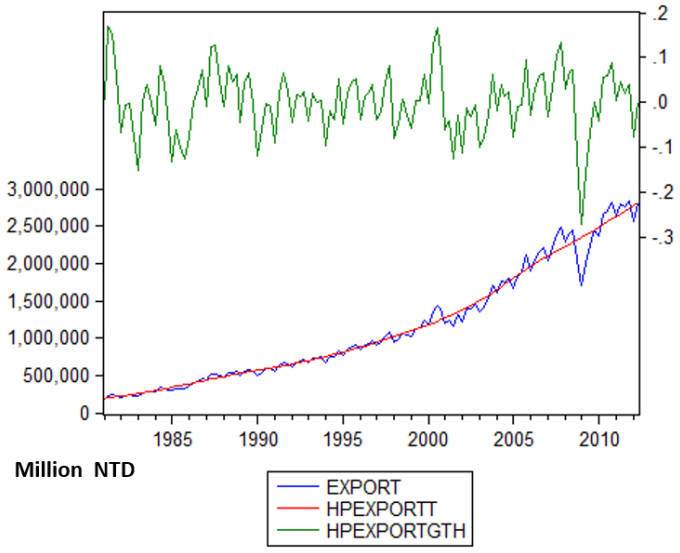


Figure 2.5: Quarterly Real Exports, the Filtered Trend and Cyclical growth of Taiwan from 1980 to 2012

(2007), or as Tien (2010), takes the seasonally adjusted data directly from database before applying the HP filter. To address this issue, this chapter intends to make a different attempt by removing seasonality from the cyclical component before executing empirical analysis. From the original data below in Figure 2.6, it is obvious that there might be seasonality in both real GDP and real exports, which shall be taken into account in the following passage with the Holt-Winters seasonal smoothing technique. We would utilize this technique to derive an estimated trend including seasonality, and using the same method as in the HP case, removing the now seasonally adjusted trend from the time series data, and focus on the remaining component without seasonality.

The Holt-Winters smoothing is an exponential smoothing method that generates a smoothed trend while incorporating a seasonal adjustment. The principle behind it is as follows:

$$\begin{aligned} L_t &= \alpha \frac{y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + b_{t-1}) \\ b_t &= \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \\ S_t &= \gamma \frac{y_t}{L_t} + (1-\gamma)S_{t-s} \\ F_{t+k} &= (L_t + kb_t)S_{t+k-s} \end{aligned} \tag{2.19}$$

where L_t is the smoothed observation (level) at time t,
y_t is the observation at time t,
s is the length of the seasonal cycle, b_t is the trend factor at time t,
S_t is the seasonal factor, picking up the differences between the current level and the data at that time in the seasonal cycle,
and F_{t+k} is the forecast k periods from time t, while α ,β, and γ are calibrated by software as to derive an optimal smoothed trend[9].
The result is demonstrated in Figure 2.6

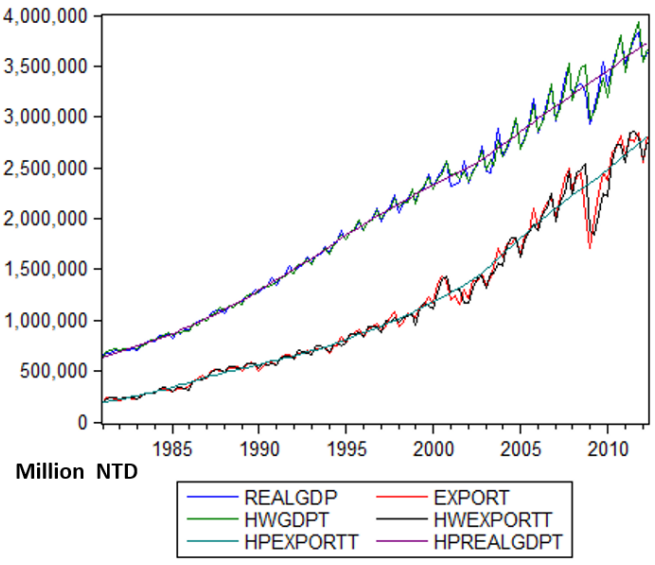


Figure 2.6: The H-P Filtered Trends and HW De-seasonal trends of Taiwanese Quarterly Real GDP, and Real Exports from 1980 to 2012

The seasonally-smoothed estimates for GDP and export are denoted as y_{hw} and $export_{hw}$ respectively, and by applying the same logic in the H-P filter case, the "de-seasonal" growth rate of GDP (written as HWsrGDPth in the following table)

[9] α ,β, and γ for GDP is 0.763, 0.037, and 1; whereas those for exports is 0.895, 0 and 1 respectively.

and that of export, HWsexportgth[10]:

$$\begin{aligned} HWsrGDPth &= (y - y_{hw})/y_{hw} \times 100 \\ HWsexportgth &= (export - export_{hw})/export_{hw} \times 100 \end{aligned} \tag{2.20}$$

Readers are suggested to pay attention to the following fact. This chapter follows Tien's work by adding the export variable into the Okun structure. Nevertheless, instead of directly taking the static ratio between export and GDP of the previous period as an indicator of openness of trade, we attempt to measure the cyclical export gap, a la measurement of GDP gap, by using the aforementioned filter and smoothing technique respectively. Such an attempt is motivated by our interest in identifying whether the unemployment gap might be partially Granger-caused by the export gap. This is also one of our innovative contributions to the existing Okun literature, for being the first to the add export gap into the Okun structure.

2.3. Empirical Results

2.3.1. Basic ADL model

The following part applies the Autoregressive Distributed Lag model[11], measuring how current unemployment is affected by its lag terms, the lag terms of GDP growth (noted as the GDP coefficients in the following sections), as shown in equation 2.21, whereas adding cyclical export gap in equation 2.22. Readers are suggested to pay attention to the fact that, the coefficients "$\beta_{1,i}$" here are not the Okun coefficient applied and defined by most literature of Okun coefficient, but the coefficients that describe the marginal correlation of GDP growth with unemployment, applying the Okun structure. The coefficients "$\beta_{1,i}$" would be referred as "GDP coefficients" in the following sections. In a similar expression, the coefficient describes the marginal correlation between cyclical export gap and unemployment rate would be referred to "export coefficients." The results are derived from the original, unfiltered data in first difference, the HP-filtered dataset, and the Holt-Winters de-seasonal dataset as

[10]Likewise, the "de-seasonal" growth rates of the two variables are also stationary, as shown via the result of Augmented Dicky-Fuller test in Appendix .1.4 and Appendix .1.5

[11]In time series analysis, the Ordinary Least Square (OLS) estimator sometimes is not the Best Linear Unbiased Estimator (BLUE) for two reasons. 1): serial correlation of the residual terms, and 2) heteroskedasticity. With the Breush-Godfrey LM test, the first problem is diagnosed for each of the following models and proved to be suffering from an issue of serial correlation as shown from Appendix .2.1 to Appendix .2.11. Also, the heteroskedasticity is tested to exist by White's General Test (the p-value is 0.457 in average for all models). This is why the following models are modified by applying Newey-West Heteroskedastic-and-Autocorrelation-Consistent Standard Errors. Hence the estimates derived are still consistent and efficient

to see if the result is of robustness[12]:

$$u_t^* = \gamma_1 + \sum_{i=1}^{p} \alpha_{1,i} u_{t-i}^* + \sum_{i=1}^{p} \beta_{1,i} y_{t-i}^* + \epsilon \tag{2.21}$$

$$u_t^* = \gamma_1 + \sum_{i=1}^{p} \alpha_{1,i} u_{t-i}^* + \sum_{i=1}^{p} \beta_{1,i} y_{t-i}^* + \sum_{i=1}^{p} \delta_{1,i} export_{t-i}^* + \epsilon \tag{2.22}$$

The coefficient in the first difference model, albeit seemingly similar, should be interpreted differently than in the HP-filtered model and that of the HW de-seasonal model. For the first difference model, the y^* represents the natural log differences between the real GDP in the current period($y_t = \ln Y_t$) and that in the previous period($y_{t-1} = \ln Y_{t-1}$), which is an approximation of $\frac{Y_t - Y_{t-1}}{Y_{t-1}}$. Hence the coefficients could be explained as follows: taking from the second row, first column in Table 2.2, for every 1% change in the most recent GDP gap (defined as the gap between current GDP and that in last period), it means an average unemployment gap would decrease by a 0.0448 percentage point. Nonetheless, from the third column, same row, the coefficient in the HP-filtered model means for every 1% change of current GDP gap (defined as the gap between current GDP and potential GDP), the unemployment gap would be reduced by a 0.0385 percentage point.[13]

From Table 2.3, the F statistics for the de-seasonal ADL model support that the lag terms of unemployment rates (F=94.98 without exports, F=129.61 with exports), the lag terms of de-seasonal GDP growth (F=8.83 without export gap, and F=3.59 with export gap), and the lag terms of de-seasonal export gap (F=3.9 with exports) all Granger-cause the current level of cyclical unemployment rate respectively, the result of such coincides with that of the HP-filtered model and that of the original model[14].

The values of $\bar{R}^2$ of the three data sets support adding an export gap as an independent variable, but imply better performance for the HP data ($\bar{R}^2$ increases from 0.844 without export to 0.858 with export) and HW de-seasonal data ($\bar{R}^2$ increases from 0.838 without export to 0.85 with export) than that of unfiltered data ($\hat{R}^2$ increases from 0.611 without export to 0.636 with export).

[12]As suggested by Gonzalo and Pitarakis (2002) and by Ivanov and Kilian (2005), the lag order is decided to be 5 for unemployment, de-trended GDP growth and cyclical export gap, according to the result of Information Criteria as shown in Appendix .3.1 and Appendix .3.2.(Gonzalo & Pitarakis 2002, Ivanov & Kilian 2005)

[13]The following tables in this sections are all adjusted to be comparable with the results derived by empirical papers such as Tien (2010) and Chiang (2006).

[14]In Table 2.3, for Unfiltered ADL Model, F of unemployment =118754 without export and 903.89 with export gap, F of GDP =12.3 without export gap and 5.33 with export gap, and F of export gap =4.15 with export gap. For HP ADL Model, F of unemployment =49.02 without export gap and 51.89 with export gap, F of GDP =10.67 without export gap and 2.87 with export gap, and F of export gap =3.76 with export gap

From Table 2.2, among the three data sets, GDP coefficients appear to be almost identical in terms of directions for each terms but differentiated at a significant level, whether or not export gap is included. In both unfiltered and HP datasets, the GDP coefficients presents some terms negative (ranging from -0.0448 to -0.019 percentage point) supporting neo-classical prediction, and some positive (ranging form 0.0241 to 0.0481 percentage point) that could be evidence of either creative destruction effect, or non-standard employment. Whereas in the HW de-seasonal dataset, GDP coefficients (ranging from -0.0542 to -0.0235 percentage point) appear to be more consistent with neo-classical prediction with statistical significance. As for export gap, the coefficients (ranging from –0.011 to -0.0089 percentage point for the significant negative terms, and ranging from 0.0093 to 0.0185 for significant positive terms) appear to be more supportive to the conclusion of Dutt et al.
Though the results are seemingly mixed across lag terms, from which a pattern might be drawn across different models: **the first term of GDP coefficients, or contemporaneous impact as Moosa (1997) describes, tends to be significantly negative, ranging from -0.02 to -0.05 percentage points, which is very close to those estimated by Tien (2010), ranging between -0.038 and -0.052 percentage points.** However, GDP coefficients start to be positive as lag term increases, which we postulate as a delayed impact caused by either creative destruction effect or non-standard employment. Such delayed impact is never emphasized or discussed in Tien's work. There seems to be a similar pattern in export coefficients: negative contemporaneous impact, which seem to be accordance with the neo-classical model, but there also appears to be a positive delayed impact in the latter terms, which we intend to regard as evidence of industrial re-structuring as Dutt et al. depict in their theoretical framework. Also, the size of export coefficient seems to be slightly smaller yet reasonably comparable in general with respect to GDP coefficients at corresponding lag terms. Such pattern demonstrates that adding the export gap into the Okun structure would not violate or overthrow Okun's law, i.e., the empirical interaction between output gap and unemployment gap remain significantly correlated.

Nonetheless, readers might be worried of the degree of confidence being not high enough, hence there is a potential danger of over-interpretation. The factors causing so might be several and shall be elaborated as follows. Firstly, even though it is pre-determined to be 5 lag terms by SIC and BIC as shown in Appendix .3.1 and Appendix .3.2, the models seem to have more lag terms than in those established by other Taiwanese empirical papers, e.g., Tien (2010) and Chiang (2007). Such choice might work as a double-edged sword: it might allow us to examine the aforementioned delayed impact, be it positive or negative, but at the same time, spreading the variation of the regressand, i.e., the current unemployment gap, onto more lag terms so that the significant level of each term might be reduced. Sec-

ondly, Since 2002, the Taiwanese labour outflow to China started to increase. By 2013, the estimated Taiwanese workers in the greater Shanghai region alone reaches 0.45 million, and over 0.5 million if including other industrial regions in China (Zhu et al. 2013). A good portion of such outflow is still counted as Taiwanese labour, as the headquarters of the corporations theis portion of labour force work for still are registered and located in Taiwan, hence the productivity contributed by these corporations is still counted as Taiwanese GDP, yet the employment (both directly and indirectly) created by them would be less relevant to the Taiwanese local labour market. Hence the interaction between Taiwanese output gap and employment gap might be less significant (Tien 2010). Lastly, our novel attempt by adding export gap into the original Okun structure would also abate the significant level of GDP coefficients. Such pattern could be observed in Table 2.2. The significant levels of the afore-established models, albeit not as strong and exclusive so to deny all other alternative theories, still support the afore-listed theoretical inductions.

Table 2.2: ADL Model of Unfiltered Data, HP Data, De-seasonal Data

	Unfiltered ADL Model	Unfiltered ADL Model with Export	HP ADL Model	HP ADL Model with Export	De-seasonal ADL Model	De-seasonal ADL Model with Export
Unemployment Gap						
L1.	0.277**	0.251*	0.852***	0.924***	0.817***	0.822***
	(0.124)	(0.146)	(0.084)	(0.091)	(0.068)	(0.072)
L2.	-0.093	-0.00816	-0.131	-0.137	-0.0373	-0.0516
	(0.081)	(0.084)	(0.102)	(0.095)	(0.075)	(0.088)
L3.	-0.133	-0.146*	-0.0643	-0.153*	-0.141*	-0.0843
	(0.088)	(0.086)	(0.090)	(0.084)	(0.075)	(0.080)
L4.	0.555***	0.536***	0.653***	0.688***	0.738***	0.760***
	(0.094)	(0.097)	(0.107)	(0.107)	(0.101)	(0.115)
L5.	-0.296***	-0.213**	-0.490***	-0.501***	-0.652***	-0.713***
	(0.098)	(0.106)	(0.074)	(0.076)	(0.093)	(0.096)
GDP Gap						
L1.	-0.04481***	-0.02308	-0.03853***	-0.02296*	-0.05422***	-0.03705***
	(0.01286)	(0.01741)	(0.00937)	(0.01353)	(0.01022)	(0.01154)
L2.	-0.02081*	-0.01505	-0.00059	-0.01.241	-0.03152***	-0.03394***
	(0.01091)	(0.01271)	(0.00674)	(0.01103)	(0.00826)	(0.01253)
L3.	-0.00423	-0.00266	0.02409***	0.01823	-0.01292	-0.01575
	(0.00969)	(0.01264)	(0.00732)	(0.01114)	(0.01004)	(0.01093)
L4.	-0.00893	-.0.02362*	0.00388	-.0.01909*	-0.00501	-.0.02348*
	(0.01097)	(0.01262)	(0.00684)	(0.01134)	(0.01025)	(0.01241)
L5.	0.03566***	0.01649	0.04814***	0.04807***	0.01605	-0.00624
	(0.01088)	(0.01515)	(0.01035)	(0.01578)	(0.01208)	(0.01304)
Export Gap						
L1.		-0.00694		-0.00563		-0.00885*
		(0.00613)		(0.00597)		(0.00470)
L2.		-0.00399		0.0039		0.00028
		(0.00561)		(0.00651)		(0.00542)
L3.		-0.00316		-0.00027		-0.00148
		(0.00617)		(0.00637)		(0.00561)
L4.		0.01341**		0.01854***		0.01608***
		(0.00593)		(0.00553)		(0.00488)
L5.		0.00778		-0.01084*		0.00934**
		(0.00517)		(0.00600)		(0.00376)
Adjusted R2	0.611	0.636	0.844	0.858	0.838	0.85
legend: * p<0.05 ** p<0.01 *** p<0.001						

Table 2.3: F-statistics of Unfiltered Data, HP Data, De-seasonal Data

	Unfiltered ADL Model	Unfiltered ADL Model with Export	HP ADL Model	HP ADL Model with Export	De-seasonal ADL Model	De-seasonal ADL Model with Export
Unmeployment	$F_{(5,109)}$=118754 Prob=0.0000	$F_{(5,104)}$=903.89 Prob=0.0000	$F_{(5,110)}$=49.02 Prob=0.0000	$F_{(5,105)}$=51.89 Prob=0.0000	$F_{(5,110)}$=94.98 Prob=0.0000	$F_{(5,105)}$=129.61 Prob=0.0000
GDP	$F_{(5,109)}$=12.30 Prob=0.0000	$F_{(5,104)}$=5.33 Prob=0.0002	$F_{(5,110)}$=10.67 Prob=0.0000	$F_{(5,105)}$=2.87 Prob=0.0181	$F_{(5,110)}$=8.83 Prob=0.0000	$F_{(5,105)}$=3.59 Prob=0.049
Export		$F_{(5,104)}$=4.15 Prob=0.0018		$F_{(5,105)}$=3.76 Prob=0.0036		$F_{(5,105)}$=3.90 Prob=0.0028

2.3.2. Break Date Analysis: 1990q1 and 2002q1

As Hansen (2001) explains, "structural changes (breaks) is a statement about parameters which only have meaning in the context of a model." Ipso facto, the breaks could refer to a change of a mean value, variance, or regression coefficients (Hansen 2001). After the long-term trend has been decomposed, the remaining short term irregularities, i.e., cyclical component (with or without seasonalities) are included within the ADL model, whereas the coefficient thereof might still experience differences, i.e., different interaction between variables before/after a certain given date. For time series analysis, the Chow test has been widely adapted to detect a structural change at a given break date after which the coefficients of explanatory variables are significantly different. If in fact, exports from Taiwan to the rest of the world is explanatory as it appears in the model, then it might be discernible that the GDP coefficients, and the coefficients of the export gap (i.e, the the impact of the variables upon unemployment) might have significantly changed after the break dates, when Taiwan re-initiated its trade with Mainland China in February of 1990, or when Taiwan's application as a WTO member was finally approved in January of 2002, according to the H-O prediction proposed by Dutt et al. Such approach follows what has been done in Tien's work, though the two break points are selected differently. This is deliberately done so as to further verify Dutt et al's theoretical prediction. Hence the earlier ADL model is re-established as follows:

$$\begin{aligned} u_t^* =& \gamma_1 + \alpha_1 u_{t-1}^* + \sum_{i=1}^{p} \beta_{1,i} y_{t-i}^* + \sum_{i=1}^{p} \delta_{1,i} export_{t-i}^* + \gamma_2 OPEN_{t-i+1} + \alpha_2 OPEN_{t-1} u_{t-1}^* \\ &+ \sum_{i=1}^{p} \beta_{2,i} OPEN_{t-i+1} y_{t-i}^* + \sum_{i=1}^{p} \delta_{2,i} OPEN_{t-i+1} export_{t-i}^* + \gamma_3 WTO_{t-i+1} + \\ &\alpha_3 WTO_{t-1} u_{t-1}^* + \sum_{i=1}^{p} \beta_{3,i} WTO_{t-i+1} y_{t-i}^* + \sum_{i=1}^{p} \delta_{3,i} WTO_{t-i+1} export_{t-i}^* + \epsilon \end{aligned} \tag{2.23}$$

The model attempts to divide the time axis into three sub-periods: A) before 1990q1, B) between 1990q1 and 2002q1, and C) after 2002q1 with the dummy variables:

$$OPEN_t = 1 \; if \; the \; date \; is \; between \; 1990q1 \; and \; 2002q1, \; and$$
$$0, \; otherwise$$

$$WTO_t = 1 \; if \; the \; date \; is \; after \; 2002q1, \; and$$
$$0, \; otherwise$$

Before 1990q1 ($OPEN_t$ and WTO_t are both 0) the regression can be rearranged into:

$$u_t^* = \gamma_1 + \alpha_1 u_{t-1}^* + \sum_{i=1}^{p} \beta_{1,i} y_{t-i}^* + \sum_{i=1}^{p} \delta_{1,i} export_{t-i}^* + \epsilon \tag{2.24}$$

Between 1990q1 and 2002q1 ($OPEN_t$=1 and $WTO_t = 0$):

$$u_t^* = \gamma_1 + \gamma_2 + (\alpha_1 + \alpha_2) u_{t-1}^* + \sum_{i=1}^{p} (\beta_{1,i} + \beta_{2,i}) y_{t-i}^* + \sum_{i=1}^{p} (\delta_{1,i} + \delta_{2,i}) export_{t-i}^* + \epsilon \tag{2.25}$$

And after 2002q1 ($OPEN_t$ =0 and $WTO_t = 1$):

$$u_t^* = \gamma_1 + \gamma_3 + (\alpha_1 + \alpha_3) u_{t-1}^* + \sum_{i=1}^{p} (\beta_{1,i} + \beta_{3,i}) y_{t-i}^* + \sum_{i=1}^{p} (\delta_{1,i} + \delta_{3,i}) export_{t-i}^* + \epsilon \tag{2.26}$$

In short, the Chow test statistic would test the null hypothesis H_0: the coefficient (γ_2) of dummy variable ($OPEN_t$) that indicates the assumed break date at 1990q1, and those of its interactive terms with unemployment rate ($\alpha_{2,i}$ where i = 1$\sim$ p) are all zero against the alterative H_1: at least one of them is non-zero. Such test is reproduced for cyclical GDP growth ($\beta_{2,i}$ where i = 1$\sim$ p) and cyclical trade growth ($\delta_{2,i}$ where i = 1$\sim$ p), and also, testing H_0: the coefficient (γ_3) for a different dummy variable (WTO_t), that indicates the assumed break date at 2002q1, and those of its interactive terms with unemployment rate ($\alpha_{3,i}$ where i = 1$\sim$ p) are all zero, against the alterative H_1: at least one of them is non-zero. And such test is reproduced for cyclical GDP growth ($\beta_{3,i}$ where i = 1$\sim$ p) and cyclical trade growth ($\delta_{3,i}$ where i = 1$\sim$ p).

2.3.2.1. HP Dataset

From Table 2.5 Chow statistics of HP dataset imply the auto-correlated coefficients of unemployment (F=5.25 for OPEN, and F=5.75 for WTO) and the coefficients of export (F=4.5 for OPEN and F=4.32 for WTO) do experience structural changes at 1990q1 and 2002q1, but not significant for that of GDP coefficients (F=1.29 for OPEN and F=1.71 for WTO). Also $\bar{R}^2$ increases from 0.858 to 0.907, implying that

explanatory power is enhanced due to adding structural changing dummy indicators of time and the interaction terms.

Before 1990q1, the aforementioned pattern (negative contemporaneous impact and positive delayed impact) is still observable, albeit less significant than in the full sample models. In this subperiod, the significantly positive GDP coefficient (0.0701) supports the creative destruction effect proposed by Aghion and Howitt, which is more likely to happen in the expansion period, when Hsinchu Science and Industrial Park was built and entrepreneurs were encouraged to invest in high-technology intensive industries with high added-value, e.g., IC industry or similar ones producing electronic goods, that require relatively high-skilled workers rather than unskilled ones, and the unemployment rate thus increases as the gross domestic production level sours. The significantly negative export coefficients (-0.0211 and -0.0287) seem to verify neo-classical prediction. Nonetheless, it also appears to be in accordance with the H-O prediction of Dutt et al., since in the same sub-period, the major partner of international trade are capital abundant countries such as United States and Japan, to which Taiwan inevitably assumed the role as a relative labour abundant country exporting the electronic components that required intensive labour with relatively less skill (as opposed to their counterparts in the U.S. and Japan) rather than capital investment.

In the next sub-period between 1990q1 and 2002q1, the aforementioned pattern is similarly less significant than in the full sample models. In this sub-period, the significant GDP coefficient (0.0016) is smaller implying less sensitivity of unemployment to GDP change. During the time, the Taiwanese government annulled the restriction on both overseas investment and overseas employment of Taiwanese worker in Mainland China. This effectively consumed the possible unmatched unemployed to the Chinese domestic market. On the other hand, the significant terms for export coefficient are now positive (0.0049 and 0.0142), and thus support the H-O prediction made by Dutt et al. This is the time when Taiwan starts to assume the role as the capital abundant country, utilizing the accumulated earning from previous years, and largely invests it in capital intensive industry, exporting capital intensive goods.

For the last sub-period after 2002q1, none of the GDP coefficient is significant, and the significant export coefficients become larger and remain positive (0.0294 and 0.0121), further supporting the H-O prediction made by Dutt et al.: after entering the WTO, Taiwan could trade with those WTO member countries, at a price free from tariff. Nonetheless, from Figure 2.2, the relative capital abundance ratio of Taiwan is slightly higher than WTO average around 2000 and even lower after 2000, which might not be as consistent as theoretical prediction. Hence the significant

positive terms in export coefficients might still be under the influence of Taiwanese growing dependence on the bilateral trade with its largest and closest neighboring trade partner, China. By 2002q1, the average tariff China charges upon Taiwanese export decreases from the pre-WTO level: 32%∼43% down to 10%, the preferential tariff for WTO members. Such improvements on terms of trade might be the factor hidden behind these positive coefficients (Yen et al. 2003).

In short, the aforementioned pattern appears to exist in each sub-period, yet might not be statistically verified. This might be the result of a smaller sample size in each sub-period model[15]. Be that as it may, the significant terms still are comparable in terms of size with the contemporaneous impact (ranging from -0.004 - 0.07) estimated by Tien (2010). Also, they appear in accordance with the theories, and the real Taiwanese industrial circumstances and changes of the export price.

[15]Though drastically decreased, the sample size of each subperiod is larger than 30, which as Corder and Foreman (2009) points out, could be considered as the minimum sample size to use for parametric statistical models (Corder & Foreman 2009)

Table 2.4: HP Dataset Sub-period Analysis

	HP ADL Model	Before 1990q1	1990q1 ∼2002q1	After 2002q1
Unemployment Gap				
L1.	0.924***	0.279	0.969	0.997
	(0.091)	(0.202)		
L2.	-0.137	-0.463*	-0.035	0.096
	(0.095)	(0.266)		
L3.	-0.153*	-0.185	-0.435	0.047
	(0.084)	(0.193)		
L4.	0.688***	0.088	0.575	0.3
	(0.107)	(0.210)		
L5.	-0.501***	-0.22	-0.466	-0.39
	(0.076)	(0.162)		
GDP Gap				
L1.	-0.0230*	-0.0007	-0.0485	-0.0627
	(0.0135)	(0.0314)		
L2.	-0.0124	-0.02656	-0.0223	-0.0394
	(0.0110)	(0.0429)		
L3.	0.0182	0.0701*	0.0016*	0.0126
	(0.0111)	(0.0357)		
L4.	-0.0191*	0.0085	-0.0299	-0.0054
	(0.0113)	(0.00320)		
L5.	0.0481***	0.0423	0.0361	0.07524
	(0.0158)	(0.0273)		
Export Gap				
L1.	-0.0056	-0.0031	0.0009	0.00929
	(0.006)	(0.0117)		
L2.	0.0039	-0.0211**	0.0049**	0.0294**
	(0.0070)	(0.0094)		
L3.	-0.00027	-0.0287**	0.0142**	0.0121**
	(0.006)	(0.0124)		
L4.	0.0185***	-0.0121	0.0169	0.0070
	(0.006)	(0.0127)		
L5.	-0.0108*	-0.0109	-0.0147	-0.0176
	(0.0060)	(0.0151)		
Adjusted R2	0.858	0.907		
legend: * p<0.05 ** p<0.01 *** p<0.001				

Table 2.5: HP dataset Chow Statistics

Chow Statistics	OPEN=0	WTO=0
Unemployment	$F_{(6,73)}$=5.25	$F_{(6,73)}$=5.75
	Prob=0.0002	Prob=0.0001
GDP	$F_{(6,73)}$=1.29	$F_{(6,73)}$=1.71
	Prob=0.2738	Prob=0.1318
Export	$F_{(6,73)}$=4.50	$F_{(6,73)}$=4.32
	Prob=0.0006	Prob=0.0009

Table 2.6: HW Dataset Sub-period Analysis

	De-seasonal ADL Model	Before 1990q1	1990q1 $\sim$ 2002q1	After 2002q1
Unemployment Gap				
L1.	0.822***	0.521**	0.757	0.837
	(0.0716)	(0.2340)		
L2.	-0.0516	-0.0731	-0.012	0.151
	(0.0883)	(0.1390)		
L3.	-0.0843	-0.212	-0.06	-0.197
	(0.0796)	(0.1990)		
L4.	0.760***	0.832***	0.669	0.537
	(0.1150)	(0.2360)		
L5.	-0.713***	-0.245	-0.851	-0.508
	(0.0956)	(0.2380)		
GDP Gap				
L1.	-0.0371***	-0.0292	-0.0282	-0.0633
	(0.0115)	(0.0294)		
L2.	-0.0339***	-0.0638	-0.0229	-0.0463
	(0.0125)	(0.0681)		
L3.	-0.0158	-0.0235	-0.0126	-0.0487
	(0.0109)	(0.0556)		
L4.	-0.0234*	0.0011	-0.0119	-0.0217
	(0.0124)	(0.0356)		
L5.	-0.0062	-0.0119	-0.0038	-0.0181
	(0.0130)	(0.0502)		
Export Gap				
L1.	-0.0089*	-0.0018	-0.0137	-0.0015
	(0.0047)	(0.01635)		
L2.	0.0003	-0.0077	-0.0049	0.0124
	(0.0054)	(0.0364)		
L3.	-0.0015	-0.0368	0.0039	0.0152
	(0.0056)	(0.00229)		
L4.	0.0161***	-0.0045	0.0119	0.0130
	(0.0049)	(0.021910)		
L5.	0.0093**	0.0008	0.0065	0.0131
	(0.0037)	(0.0119)		
Adjusted R2	0.85	0.849		
legend: *p<0.05 **p<0.01 ***p<0.001				

2.3.2.2. HW dataset

The result of the Chow test in the HW data set, however, shows little significance and hence could not support structural change at these assumed dates, while $\bar{R}^2$ decreases from 0.850 to 0.849, though the result for export gap supports the H-O prediction to a certain level. Hence in the de-seasonal data set, the structural change is less observable in a statistic sense as it was in the HP-filtered data set. One of the possible reasons being so is the removal of seasonality. The interaction occurring between cyclical gaps might have been contributed by a seasonal component (out of the total cyclical component) in a larger amount. The structural change, i.e., the different patterns of interactions before/after certain assumed dates, might thus be more obvious in the HP dataset (the cyclical gaps with seasonality), and less so in the HW datset as the statistical power might decrease more easily in the latter dataset as sample size decreases after removing the more relevant (seasonal) components.[16]. With that being said, such interaction would become less statistically significant once the seasonal component is removed as in the HW dataset.

On the other hand, reasons such as smaller sample size in each sub-period compared to the full-size model, and number of lag terms could as well cause the significant level of decrease in the HW dataset. That said, we could not establish our proposed theoretical induction on a robust foundation: The HP models appear to demonstrate statistical significance supporting theoretical explanations and be in accordance with real world incidents, while the HW models could not achieve an equivalent significant level, though the size of the impact of both datasets are comparable with the contemporaneous impact estimated by Tien (2010). In sum, The sub-period analysis, albeit lacks the robustness among different datasets as shown in the full-sample models, still possesses credibility insofar as the conclusion is drawn from the HP models.

2.4. Conclusion

To conclude, the GDP coefficient shows more robustness between the two data sets, insofar as the full-sample models to be discussed. Also, the size of GDP coefficients estimated are close to the contemporaneous impact of GDP gap estimated by Taiwanese empirical economist, Tien (2010), while the size of export coefficients are comparable as well.

[16]Such statement could be true given the fact that Taiwanese employment tends to demonstrate seasonal patterns over the years, e.g., increasing entry level labor supply in the "graduation season" (June∼August), switching from one job to another after receiving the annual bonus at the end of Chinese new year, while corporations might adjust their optimal employment level whilst the labour supply is at a higher amplitude.

In the original ADL model, the negative correlation (be it contemporaneous impact or those of the latter lag terms) could be explained by neo-classical theory. **One of the innovative contributions made by this chapter is adding the cyclical export gap as an extra explanatory variable. Such attempt also demonstrates robustness between different datasets.** The positive correlation could be explained by **Dutt el al.'s H-O prediction, or industrial restructuring effect** as Xin (2005) describes, in which Taiwan assumes the role as a capital-abundant country and exporting capital-intensive goods. As for structural change, this chapter has examined and verified that, at 1990q1 when Taiwan and China re-initiated international trade, and at 2002q1 when Taiwan joined WTO as a member country, the export coefficients experience structural change (from -0.0211 and -0.0287 percentage point before 1999q1 to 0.0049 and 0.0142 percentage point after 1990q1, and 0.0294 and 0.0121 after 2002q1) coincide with the H-O prediction proposed by Dutt et al. The stronger impact of export upon unemployment after 2002q1 can be a result of not only to Taiwan's increasing access to trade partner countries (or the decreasing tariff of exports to those countries) under the WTO framework, but more likely, due to the further increasing trade between China under the WTO framework. **With that being said, the chapter makes a contribution by discovering significant result as a circumstantial evidence, further verifying the industrial restructuring effect happening to the Taiwanese economy that Xin (2005), and Huang and Chung (2008) claim respectively, especially while the export price is improved in accordance with the change of FTA conditions.**

Since 1990, i.e., the first breakpoint, the tariff charged upon Taiwanese export to China ranged from 32% to 43% on average, whereas after joining the WTO e.g., the second break point, the tariff on average decreases down to 10%, which is a common standard for a developing country as a WTO member(CIER 2009). From Figure 2.7 and Figure 2.8, it is observable that after circa 2002, Taiwanese exports to China increases largely on both an absolute and relative basis. From Tables 2.4 and 2.5, the impact of exports on unemployment starts to demonstrate a positive correlation in an more obvious way as time being (from one break point to another), along with export share increases, while such increase is contributed largely by the exports to China. Needless to say, Taiwan joining the WTO per se in many way, viz., politically, economically, or in terms of international trade, is merely a further enhancement of the bilateral trade between China and Taiwan. **This chapter concludes that the larger positive export coefficients in the HP model after the second break point, might be circumstantial evidence showing that China, among all other Taiwanese trade partners, might remain the**

most influential in regards to the local employment of Taiwan.[17]**.Hence, it might be considered as a contribution made by this chapter to the existing Taiwanese empirical labour literature, showing partial evidence of China's influence on Taiwanese cyclical unemployment changes, by adding a novel measurement of export gap that is never added into the Okun structure elsewhere.**

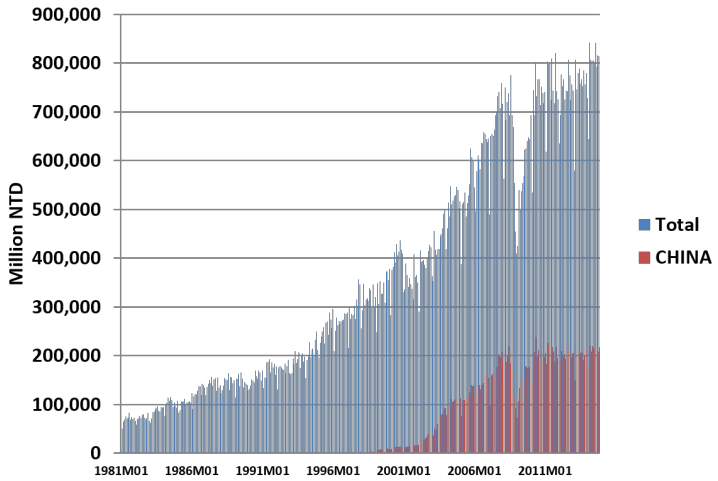


Figure 2.7: Taiwanese Total Export and Export to China (National-Statistics 2013)

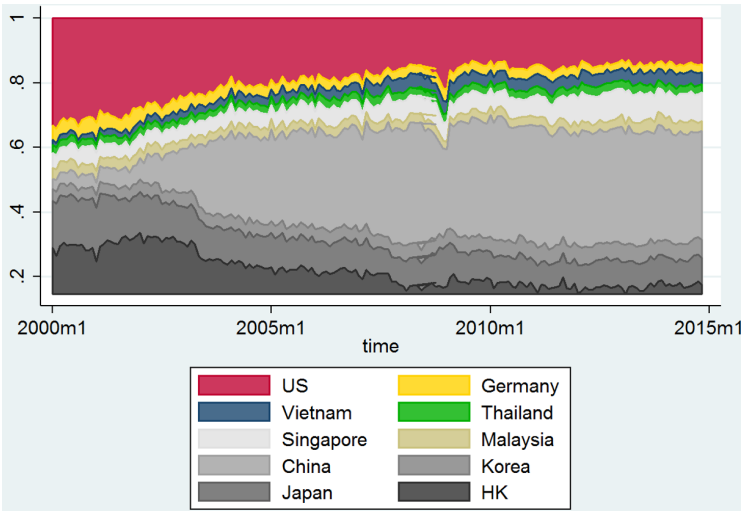


Figure 2.8: Composition of Export of Taiwanese Top 10 Trade Partners (National-Statistics 2013)

[17]Of course such a conclusion would sound nonsensical by the empirical result alone, as it could be the consequence of increasing export with other WTO members, who also assume the role as labour abundant countries. However, from Fig 2.8, it is noticeable that among the top 10 trade partners, China was the most powerful labour abundant candidate during the said time, though we could not deny that other countries such as Thailand, Malaysia and Vietnam might assume the same role and thereby amplify such impact. Still, the size of the export share of these countries are not comparable with that of China, while the majority of international business conducted by Taiwanese enterprises then was either targeting the Chinese market, or with Chinese counterparts

Nevertheless, such structural change is not significant in HW datasets, **hence the robustness of such a claim is limited.** One possible reason of being so might be the **removal of seasonality,** which might function as an important reminder to Taiwanese labour macro-economists, that the fluctuation of Taiwanese unemployment could be affected by the seasonal component to a large degree, hence the statistical power might decreases more easily as sample size decreases after removing the more relevant (seasonal) components. It might be worthwhile for future empirical economists interested in Taiwanese data to apply a different de-trending method e.g., simply use moving average or other possible candidates of filters that more effectively address seasonality.

Even though out-sample forecast is not derived from the ADL framework, it might not be unwise to think differently as opposed to how it is supposed to be so benign in the officials' minds, about the recently established free trade agreement between China and Taiwan, Economic Cooperation Framework Agreement (ECFA). As shown from the previous results, the export gap promoted by free trade might in fact be positively correlated with domestic unemployment. As presented from Figure 1.4, export is positively and closely related to GDP in Taiwan. As cyclical GDP growth is observed to be positive, there is a chance that higher GDP in the short run causes a higher unemployment rate, which can be explained by either non-standard employment or creative destruction especially in the expansion periods, while both of them might be observed in the HP data set. These are very likely to be the times when the cyclical export component grows with GDP, and has a positive impact on cyclical unemployment, as suggested by H-O prediction of Dutt et al. This might explain the continuing flaming animosity against the post-ECFA, bilateral international trade between Taiwan and China; net exports might grow along with GDP, yet the unemployment rate increases.

Nonetheless, in another possible scenario, the capital labour ratio of China has increased rapidly since the mid 2000s, which might allow China to assume a new role as the capital intensive country in this play-off, while the political climate, the structure of the labour market, and education system in Taiwan hinders this country to adapt to its new role as a relative labour intensive country in the coming future. Such possibility of role-switching is not measured in this Chapter but might be of interest to future analysis in relevant academe.

Chapter 3

Empirical Analysis on factors of Taiwanese wage determination

This chapter attempts to analyse the impact of different Taiwanese government policies which affect wage determining factors. For the past two decades, the expanding education policy has been implemented regardless of the parties in administration alteration. Also, the Taiwanese government maintained a tolerant policy regarding the expansion of the real-estate market bubble. Starting with the cross-sectional estimates to test the validity of several instruments, and then the quantile regression estimator, this chapter finds partial evidence supporting negative effects from the expanding education policy and the tolerant policy regarding the expansion of the real-estate market bubble on the wage determining factors on the younger generation of the Taiwanese population. Their education return appears to be lower and the crowding-out effect of corporation indebtedness on real property appears to work negatively on wage. Lastly, the government has often openly referred to the preferential bilateral free trade agreement between Taiwan and China, known as the Economic Cooperation Framework Agreement (ECFA), as the long-waited solution to boost education returns as well as creating a positive spill-over effect from housing market prosperity. The chapter finds little evidence to either support or defy such a statement.

In this chapter, we intend to follow the wage determining structure established by Mincer (1974) while a novel variable is added so as to discuss how different policies implemented by the Taiwanese government might be influential to different wage determining factors, e.g., education return or corporate real estate investment. Our strategy is first to establish an expanded version of Micerian wage structure, implementing it onto the whole sample, and then each cohort respectively so as to examine if the younger generation is indeed suffering from lower education returns, or if this drawback is caused by other wage determining factors. Secondly, we then implement sub-period analysis by segmenting the full-sample PSFD dataset into 3 smaller samples of different periods, and examine whether the coefficients experience

significant changes. The sub-periods are segmented by the time points when the terms of trade of Taiwan purportedly experiences improvement: 2002 when Taiwan joined the WTO as a member country and 2009, when the bilateral trade agreement, i.e., ECFA was implemented.

3.1. Theoretical Framework

First, let us review how Mincerian wage determining structure works.

3.1.1. Mincerian Equation

In the following human capital function:
$h(s,x) = h(\cdot)e^(\beta_1 S + \beta_2 X + \beta_3 X^2)$
which follows the Mincerian human capital structure, where $h(\cdot)$ is a function of an individual's characteristics regardless the accumulation of education and working experience, i.e., age, gender and so on. The empirical effect of these characteristics remain undetermined ex ante i.e.,

$$\begin{aligned} \frac{\partial h}{\partial age} &= h_{age} \lesseqgtr 0; \\ \frac{\partial h}{\partial gender} &= h_{gender} \lesseqgtr 0 \end{aligned} \tag{3.1}$$

The primary structure of the above human capital function, and that of the following empirical regression adapts the standard Mincerian Equation from Mincer's Accounting-identity model, which is summarized as follows(Mincer 1974):
Let P_t be the potential earnings of an individual at age t, with s years of education, and k the ratio of costs of training investment:

$$\begin{aligned} P_t &= \prod_{j=0}^{t-1}(1+\rho_j k_j)P_0 \\ \ln P_t = \ln P_0 \ + \ s\ln(1+\delta_1) &+ \sum_{j=s}^{t-1}\ln(1+\rho_l k_j) \\ &\approx \ln P_0 + S\delta_1 + \rho_l \sum_{j=s}^{t-1} k_j \end{aligned} \tag{3.2}$$

Given a constant rate of return to schooling δ_1 for j=1...s, and a constant rate of return to training investment ρ_l
By following Mincer's linear assumption of declining rate of post=schooling investment $k_{s+x} = k(1-\frac{x}{T})$, x=T-s, with T being the length of work life and x the amount of work experience after schooling, then

$$\ln Y(s,x) \approx \ln P_{x+s} - k(1-\frac{x}{T}) =$$
$$[\ln P_0 - k] + s\delta_1 + \rho_l \sum_{j=s}^{t-1} k_j + \frac{kx}{T} \Rightarrow \tag{3.3}$$
$$\ln Y(s,x) = [\ln P_0 - k] + s\delta_1 + (\rho_l k + \frac{\rho_l k}{2T} + \frac{k}{T})x - \frac{\rho_l k}{2T}x^2$$

By expressing the terms that do not change along with s and x, i.e., $\ln P_0 - k$ with the human capital function, we could derive a common structure of Mincerian wage equation as follows:

$$\ln W = \beta_0 + \beta_1 education + \beta_2 experience + \beta_3 experience^2 + \beta_4 gender + \beta_5 age + \\ + \epsilon \tag{3.4}$$

3.1.2. Education Returns, and the Demand and Supply in the Labour Market

In addition, this chapter also attempts to apply sub-period analysis via examining the changes in education return as ex-post evidence to the change in the demand and supply of labour market, and whether it is in accordance with policies implemented by the Taiwanese government that may have influence on the supply and demand of domestic labour. With this approach we might be able to evaluate the net effect of these policies. The principles connecting the supply and demand for labour with educational return is elaborated as follows. In Mincer's theoretical model in 1976,

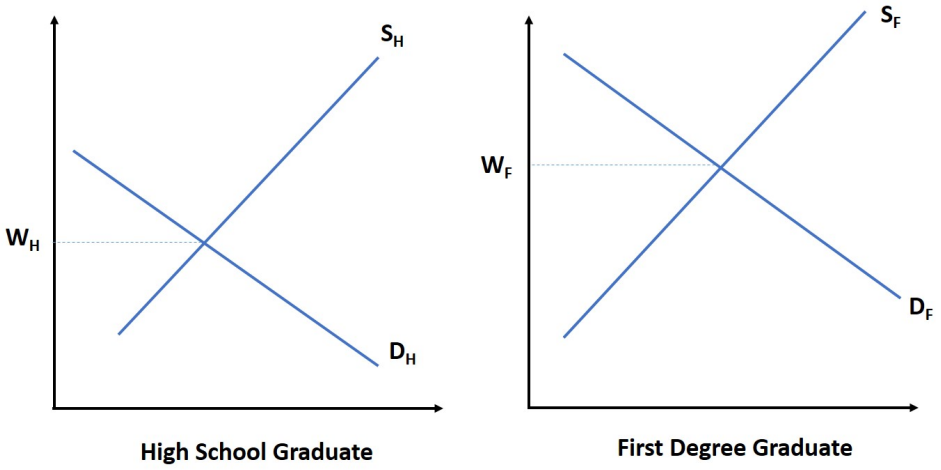


Figure 3.1: Labor Demand and Supply of High School Graduates only and First Degree Graduates Sector(Chiu 2004)

he proposed that the labour interflow would occur between the covered sector and the uncovered due to the wage differences, which would yet again change the wage premium between sectors (Mincer 1976).

Let's Assume the wage level in equilibrium in a labour market of high school graduate is w_H, while that in the first degree graduate is w_F , as shown in the in Figure 4.1. Let us follow Chiu's application of Mincer's work (2004)further assume $w_F > w_H$, and define the education return $R_s = \frac{W_F - W_H}{W_H}$ is the proportional premium a employee could earn, should she decide to complete a first degree and thereby join the first degree graduate labor market. Also, let us define the relative labour supply as the ratio between current labour supply in the first degree market, to that in the high school graduate market, and define the relative labour demand as the same ratio, but in terms of labour demand(Chiu 2004).

Ceteris paribus, education return (R) could be improved via two routes: 1) decrease in relative labour supply (rightward movement of labour supply curve in the high school graduate market S_H or leftward movement of labour supply curve in the first degree market S_F), or 2) increase in relative labour demand (leftward movement of labour demand curve in the high school graduate market D_H or rightward movement of labour demand curve in the first degree market D_F). Similarly, education return would experience a decrease if relative labour demand decreases, or relative labour supply increases. Be that as it may, the change in education return would be ambiguous if the relative labour supply and relative labour demand move in the same direction. To wit, given the presence of increasing educated labour supply due to an educational expansion policy, if the following empirical results show the education return decreases albeit an increase in relative demand of educated workers, it might mean the relative demand changes by a smaller amount than relative supply does. Likewise, if increasing education returns are to be observed, albeit the presence of increasingly educated workers, it means the relative demand changes by a larger amount than relative supply.By theory, other factors such as international labour mobility between Taiwan and China could also have influence on equilibrium wage in each sector, and thus change the education return accordingly. When the number of Chinese labours working in Taiwan increases, due to the protective regulation within Taiwan, such injection is limited not only in terms of its size as explained in Section 1.3.5, but only allowed in un-skilled sectors, provided they acquired Taiwanese citizenship. The education return is more likely to increase when the unskilled labour supply increases due to such injection, if such impact is dominantly effective as opposed to other factors. Nonetheless, the labour outflow from Taiwan into China might have ambiguous impact on education return, since labour from both skilled and unskilled sectors would be attracted outward, and no credible data source by far could determine which sector has stronger leakage than the other. That is to say, given the size of the leakage estimated (as disclosed in Section 1.3.5, by 2013 equivalent to 4.4% of the labour force) we would argue such impact, albeit theoretically more direct, might be of less impact than that caused by other policies or factors.

3.1.3. Novel Wage Determining Factor: Corporate Real Estate Investment

As mentioned earlier, in this chapter we also attempt to expand the existing Mincerian wage determining structure by adding a novel variable, i.e., industrial real estate investment. Such attempt is made to discuss whether the prosperity in the housing market encouraged by the Taiwanese government would have a positive spill-over impact on wage as claimed by government officials via such determining factor, or there might be negative impact as such industrial investment could be crowding out the investment that could have been used in the corporate production process. For the latter effect, A simple theoretical dynamic is proposed below. Assume the wage $\hat{w}$ is determined by the production function of firms that are as many as to achieve competitive equilibrium in an economy:

The production function in per capita terms is:

$$y = k^{\alpha}[hL]^{1-\alpha} \tag{3.5}$$

A representative firm in this economy has two ways to gain profit: 1) sell its production at price P, and 2) using the remaining capital, i.e., the amount of capital that is not used in the production function $K_F = \bar{K} - K_y$ to invest in the real estate market. The production function follows the form as Cobb-Douglas Function with labour input (L), whereas the profit from the real estate investment is uncertain, due to the nature of the market. The profit is thus expressed in expectation, $\theta \in [0, 1]$ is the probability of better yields in the real estate market ($r_{F,H}$) and 1- θ is the probability of low yields, i.e.,($r_{F,L}$).

$$\max_{x} \qquad \pi = PY - wL - r_y K_y + [\theta(1 + r_{F,H})K_F + (1 - \theta)(1 + r_{F,L})K_F] - K_F$$

$$\text{subject to} \quad y = K_y^{\alpha}[hL]^{1-\alpha};\ K_y + K_F = \bar{K};$$

So, in this partial static competitive factor market equilibrium, by F.O.C, $\frac{\partial \pi}{\partial L} = 0$ it implies that real wage equals to marginal Productivity of Labour:

$$\frac{w}{p} = MPL = h(1 - \alpha)L^{-\alpha}(\bar{K} - K_F)^{\alpha} \tag{3.6}$$

and since $\frac{\partial}{\partial K_F}\frac{w}{P} < 0$ it implies if more capital is used to invest in the real estate market, it would reduce the real wage in equilibrium.

Also, by F.O.C, $\frac{\partial \pi}{\partial K_F} = 0$, the optimal level of Capital is:

$$K_F = \bar{K} - [\frac{r_y + \theta(r_{F,H} - r_{F,L})}{P\alpha}]^{\frac{1}{\alpha-1}} \tag{3.7}$$

so it is discernible that if the probability of high yields (e.g., real estate bubble) increases, the higher the interest premium $(r_{F,H} - r_{F,L})$ is, or the higher the marginal cost of capital employment in the production r_y is, K_F would increase, i.e., more capital would be shifted to the more profitable investment target.

Ergo, we intend to expand the existing Mincerian structure by adding the extra factor, i.e., the industrial real estate investment, in the following manner[1]:

$$\begin{aligned}\ln W =& \beta_0 + \beta_1 education + \beta_2 experience + \beta_3 experience^2 + \beta_4 gender + \beta_5 age + \\ & \beta_6 realestateinvestment + \epsilon\end{aligned} \tag{3.8}$$

3.2. Data

3.2.1. Primary Data

The data of Taiwan is collected from one of the surveys directed by the Survey Research Data Archive (SRDA). The Panel Study of Family Dynamics (PSFD) is a large-scale research project led by Dr. Cyrus C. Y. Chu of the Institute of Economics, Academia Sinica. This panel study began in 1998 involving local experts as well as foreign academia in various specialties such as economics, sociology, psychology, anthropology and statistics (SRDA 2012).

The PSFD database collects data from Taiwanese citizens with a registered citizenship that meets the designated range of age. The population of each Cohort out of the total population of Taiwan of the same age groups are: CohortI: 5,334,745, CohortII: 5,614,305, and Cohort III 3,932,935, out of which the data were drawn via "three-stage stratified random sampling method" respectively: at the first stage residential regions e.g., city, county, town were chosen, before the smaller region (village, or neighborhood by postcode) were drawn at the second stage. Lastly, individuals were randomly selected from the second stage pool. Conducted on an annual basis, the PSFD is a Longitudinal database that purportedly traces a repeated pool of individuals through the passage of time. Nevertheless, as Yu (2005) argues, the sample attrition rate, i.e., the rate that interviewee left the sample for reasons e.g., disease, relocation, or simply loss if incentive to continue, is worryingly

[1]Such expansion does not suggest there should be a theoretical connection between education return and industrial real estate investment, nor does it imply a complete theoretical framework including both is established. We hereby expand the Mincerian structure by such inclusion of the novel variable so as to examine the policies that directly/indirectly affect the labour market in Taiwan.

high: by 2005, the sample attrition rates for Cohort I and II were: 31.89% 29.86% respectively (Yu 2005). Whenever a new cohort is introduced into the database, the actual number of interviewees would be expanded to prevent failure of meeting the intended sample size[2]. For Cohort I, the response rate is 52.2%, that for Cohort II is 47.3% and that for Cohort III is 53.51%.

3.2.2. Variables

3.2.2.1. Education

Due to the limitation of the survey, the total years of education (including early years, primary, secondary, further education and higher education) is not available but thus approximated by the average year of each level of education attained.[3]

3.2.2.2. Working experience

As for the working experience, it is also an important variable often assumed to a have non-linear relationship with earning in the Mincer equation (Mincer 1974). Here we follow one of the two approaches taken by Chuang and Lin (2011), applying the actual experience, measured in years, rather than the potential experience. As Miller concludes from his empirical analysis, potential experience (labour market experience with or without a job) or age though often taken as proxies for actual working experience, might fall short of the later. Demographic groups such as married women, among others, usually have noncontinuous labour market histories, making both age and potential experience overestimating their work related experience (Miller 1993).In the PSFD dataset, the start / end date of employment spell is recorded in detail for each job the interviewee has in their employment history. The employment spell (actual working experience) would later be summed and measured in years before inclusion into the regression.

3.2.2.3. Characteristic Variables

Individual variables such as age and gender are included. Age is the physical age of each interviewee when the survey was taken place presented as integer number, while gender is a dummy indicator, 0 if the interviewee is female, and 1 if he is male. With regard to the inclusion of gender, it is true that many literature on education return such as Angrist and Kruger(1991) Straiger and Stock (1997), Card (1995), Ichino and Winter-Ebmer (1998) to name a few, tend to segment the data, and thus focus on a uni-gender sub group. It surely allows researcher to focus on their research

[2]In metropolitan cities e.g., Taipei, Kaoshiung, the "expansion ratio," i.e., the actual numbers of interviewees divided by the intended number of interviewees is 2, while that for the rest of regions is 1.5.

[3]For instance, the number of years spent in education if the highest qualification is high school, than the education years would be 12= 18 (the age when Taiwanese students normally take finish high school) - 6(the starting age of early year education).

questions intended such as the selection of instruments, or comparison between different estimators. Be that as it may, Taiwanese empirical economists such as Fu(1996), Chen (2002), Chen and Kuan (2006), and Chuang and Lai(2008, 2011), still include gender into their analytical framework, so to address and demonstrate gender wage gap with statistical significance(Fu 1996, Chen 2002, Chen & Kuan 2006, Chuang & W. 2008, Chuang & Lai 2011). Inter alia, Chen and Kuan (2006) was one of the earliest Taiwanese empirical paper that utilize Quantile Regression Estimator, and discovered the gender difference in labour participation rate to be bona fide(Chen & Kuan 2006). Also, one of our key reference, that is, Chuang and Lai(2011) has utilized gender as a variable to estimate the participation probability in their Heckman two-step analysis, which we also adapt in our empirical model. That said, the chapter would include the gender as a determining factor into the wage structure so to not fail to identify part of the variation in wage caused thereof, albeit not homing in on the gender issue. Lastly, though it seems tempting to simplify the analysis by dropping out a gender group, it would inevitably cause a great decrease in terms of sample size. Given the size of PSFD, especially when we segment the data into different cohorts, it would be less preferable to reduce the sample size down to half so that the result might be less significant, and from which we thus might fail to draw any meaningful conclusion.

3.2.2.4. Industrial Investment on Real Estate Property

The industrial average investment on real estate property is included as to examine whether the substitution of capital would have negative impact on labour earning. Among all sorts of corporate real estate investment, we believe it is those made for speculation purpose, i.e., properties bought as an investment target in the company's financial portfolio and sold so to earn possible arbitrage profit, would serve as a negative wage determining factor . With that being said, in this chapter we hope to derive a proxy estimate that identifies such speculative investment out of those spent on fixed cost expenditure e.g., factories, branches, and buildings of subsidiaries which are spent to expand the productivity of the corporate operation. To do so, we attempt to include a housing price index as an instrument for the corporate investment in the first stage, while the fitted value of such investment might capture the variation of the financial resource allocation related with the housing price changes[4]

Also, since the anonymity of PSFD data set prohibits researchers to have direct observation on the real estate investment of the corporation where the interviewees work, an industrial average property (including land and buildings) indebtedness made by corporations, that is classified and recorded on a monthly basis

[4]since as Connock (2002) suggests, arbitrage investment in real property, follows the rule of thumb of arbitrage, i.e., buying a property at a lower price and selling at at a higher one. That said, this type of speculative investment might be more price sensitive than other fixed cost expenditures.

by the Central Bank of Taiwan would be applied as a proxy of industrial investment(Central-Bank-Of-Taiwan 2014*a*). The value would be divided by the number of firms and corporations legally registered in the Department of Commerce, Ministry of Economic Affairs. Hence the result is an approximation of property investment at company level, and would be merged with the PSFD data set by industry code(covering 24 different industrial categories in the Taiwanese Standard Industrial Classification of All Economic Activities, which takes the International Standard Industrial Classification of All Economic Activities, as primary reference), and then by the interview date (DGBA 2014).

Moreover, a moving average is taken between the value of current month, i.e., the month the interview is taken, and those of the following 2 months. It is done so since purchasing real estate investment, given the nature of its value per unit being so high and the amount of relevant legal documents involved, unlike other durable goods, might in fact take longer periods to be completed.

Attention should also be paid to the fact that it is the natural logarithm of the property investment being taken before inclusion into the Mincerian Equation. Hence the coefficient β_n should be interpreted as the marginal effect being β_n % of wage with respect to 1% increase of property investment.

3.2.3. Possible Candidates of Instrument Variables

As put by Becker,"observers are themselves primarily successful college graduates and, therefore, naturally biased toward the view that ability is a major cause of the high earnings received by college graduate" (Becker 1964). Empirical researchers have attempted to minimize the undeniable "ability bias," i.e., educated people have earning not only because they went to school, but their "latent abilities" (e.g., intelligence, efficiency, self-discipline) are generally higher than those who did not achieve as high in terms of education attainment. In short, there would be endogeneity of education, which tends to cause the Mincerian estimates to be upward-biased.

To address such issue, one of the common methods applied by empirical economists is to use Instrument Variables (IV), which should be correlated with individual's education attainment, but not with any observable/unobservable characteristic that affects wage level after controlling for education. The theoretical reasoning is adapted from Wooldridge's methods in 2002 and presented as follows (Wooldridge 2002):
let

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + u_i \tag{3.9}$$

$$E(u) = 0, \ and \ Cov(x_j, u) = 0, \ \forall j \neq k \tag{3.10}$$

where $x_1, x_2, \ldots x_{k-1}$ are exogenous variables, but x_k is suffered with endogenoity to some level. Hence, $Cov(x_k, u) \neq 0$ would cause the estimator of OLS to be inconsistent. The instrument variables z_i that satisfy the following two conditions will be needed: (1) Relevance: $corr(z_i, x_i) \neq 0$ (2) Exogeneity:$corr(z_i, u_i) = 0$

Using the instrument variable, the following "first stage estimator" can be estimated:

$$x_k = \delta_0 + \delta_1 z_1 + v_i \tag{3.11}$$

since z_i is uncorrelated with the residual ${}_u i$, the predicted value $\hat{x}_i = \delta_0 + \delta_1 z_1$ is uncorrelated with the residual ${}_u i$ for i =1, ... ,n

Then, in the second stage, let's replace x_i with the predicted value $\hat{x}_i =$ in the previous regression as follows:

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k \hat{x}_i + u_i \tag{3.12}$$

In the following subsections, we would include several possible candidates of IVs. Each of them can plausibly address issue of endogenouty, and would be included for different endogenous variables respectively.

3.2.3.1. IV: Education Attainment

The choices of instrument variables in the Mincerian wage analysis varies. For instance, Angrist and Kruger has the season within a year in which the interviewees were born as IV (Angrist & Krueger 1991). Alternatively, Card (1995) applies the distance from interviewee's neighborhood to the nearest school as IV of education attainment (Card 1995).

In this chapter, the instrument variable follows the work of Ichino and Winter-Ebmer, using dummy indicators of time as instrument variables (Ichino & Winter-Ebmer 1998). The following design also follows the work of Harmon and Walker, applying the transformation of regulation for the compulsory education in UK as instrument variables (Harmon & Walker 1995).

As for the Taiwanese data set, similar dummy indicators of time are selected, yet for different reasons. The dummy variable R1987=1 if the interviewee went to school between 1987 and 1999, and 0 otherwise, whereas dummy variable R1999=1 if the

interviewee went to school after 1999, and 0 otherwise. In 1987, Martial Law was abolished. The primary results include the liberation over the regulation of newspapers, magazines and book publication, and the liberation of formation of new political parties. The abolition undoubtedly can be regarded as an important milestone signifying a point of time ever since when the social atmosphere in Taiwan evolved unceasingly toward democracy. The quality of education is improved as the concepts such as freedom of speech, humanistic education, gender equality, academic freedom, and awareness of the impropriety of corporal punishment are replacing the second-to-none militarism, and becoming central in educational policy (Wu 1998). Another important transitional point of Taiwanese education happens in 1999, when the "one outline, multiple textbook edition" policy is enacted. The further empowerment of textbook selection allowed for a great variety of content for the curriculums of different schools, thus inevitably there was significant impact upon the contents of entrance exams of senior high school and that of university, thereby having non-neglectable impact upon the educational attainment (Huang 1999). [5]

3.2.3.2. IV: House Price Index

The HPI in this chapter applies the one defined by the Construction and Planning Agency (CPA) of the Minister of the Interior, Taiwan, that is, the House Price to income ratio, which is a quotient between the average local house price and the gross annual income at the median, (i.e., 50th percentile)(Construction/Planning-Agency 2014).

Be that as it may, another plausible metric to assess housing bubble that is akin to our HPI is the housing price-to-rent ratio. Such metric measures the ratio between purchasing price and rental price of a property in average at a specific time and in a specific place, intended to reflect the relative cost of owning versus renting (Himmelberg et al. 2005). Nevertheless, such data is not equivalently available in Taiwan,In

[5]Other variables such as Raising of School Leaving Age (ROSLA) could be potential IVs that allows us to account for the said endogeneity related with ability bias, in the method applied by literature such as Harmon and Walker. (Harmon & Walker 1995). However, due to the ROSLA in Taiwan changes in 1968, when only the oldest interviewee in the oldest cohort (cohort I, born between 1953 and 1964) would be affected, but the dummy indicator thereof would have identical result on the majority of the cohort and the younger cohort II and III. A dummy indicator of birth quarter could be another choice of IV, as been chosen by Angrist and Krueger, who conclude that the educational attainment for student born in the first half of the year would be shorter than those born in the second half, as the Compulsory Education Law regulated that students (in the U.S.) could only leave the school (e.g., dropping out) once he/she reaches age 16 (Angrist & Krueger 1991). Nevertheless, due to the lack of information concerning interviewee's precise timing of birth, such IV would not be feasible in this analysis. Moreover, since the 9-year compulsory education implemented in Taiwan prohibit voluntary drop out, such IV might be less influential in Taiwan. Also, such choice of IV, as Bound and Jaeger argue, might be weak, yet associated with earnings or other labor market outcomes existed for cohorts that were not bound by compulsory school attendance laws That is to say, such IV is not as independent to the dependant variable as it ought to be(Bound & Jaeger 1996).

the database constructed by the Taiwanese ministry of domestic affair, the average rental price is not available in the form of time series, but only recorded on annual basis, national-wise (no county / municipal level data), for only a decade. Other private databases have similar issues. The reason behind so might be controversially sundry, but that per se explains why Taiwanese empirical scholars would utilize alternative such as the HPI defined previously instead, which has been available for decades, or derive sampling statistics from their own research questionnaire.

3.2.3.3. IV: regional code

As Chan (2008) articulates, the educational expenditures of Taiwan has been distributed differently amongst the different regional governments, which is largely related to factors e.g, population size, regional tax revenue, and the development of local economy (Chan 2008). With that being said, the regional disparities of these aforementioned factors might cause differences in terms of education expenditure at each level of local government spending, and in different regions (Chan 2008, Chang et al. 2009). Chen et al. (2009) also points out the fact that even though almost all government entities been setting educational expenditure at more than 20% of their total spending, in some extreme cases, some local governments could spend as much as 53.55% and as low as 26.32% of their government expenditure respectively. Such difference could be indicate affects on the quality of education provision, resource of education allocation, willingness of continuation of higher education, and thereby causing regional disparities in terms of education attainment years. Another way to observe the differences in terms of education resource allocation, is the numbers of education institutes of each region. In the following charts, the numbers of universities and senior high schools are presented respectively. Readers might notice that the numbers of universities appear to be biased toward metropolitan areas, e.g., Taipei city, Kaohsiung City and Taichung City, while it seems less observable the same regional disparity also exists for senior high schools.

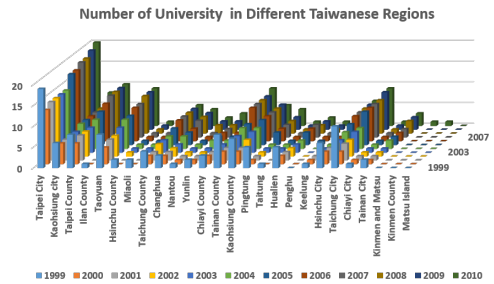


Figure 3.2: Number of University in Different Taiwanese Regions 1999-2010(DGBA 2014)

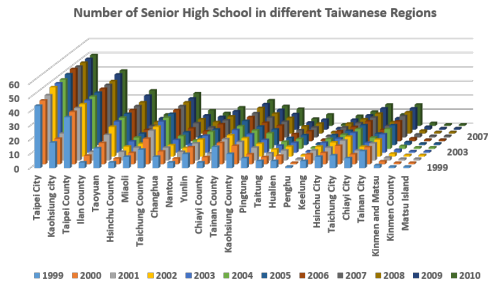


Figure 3.3: Number of High School in Different Taiwanese Region 1999-2010(of Education 2015)

That said, we could thus be convinced that the education attainment years might be correlated with regional variation, and hence, the regional code should be included as an instrument for education attainment.

The residential code of interviewees in Taiwan are rearranged in accordance with HPI, i.e., the 3-digit region code is re-divided into 21 groups so to be consistent with the data collected from the CPA.

3.2.4. Inverse Mills ratio

Another issue that has often been raised in the analysis of Mincerian education return is the selection bias. To address that, this chapter follows the approach applied by Heckman's two stage correction model, adding a modification term, e.g., Inverse Mills ratio, derived by a first-stage probit model to estimate the labour participation rate (Heckman 1979):

$$z_i^* = \omega_i \gamma + u_i \tag{3.13}$$

and

$$z_i = \begin{cases} 1, & if z_i^* > 0 \\ 0, & if z_i^* \leq 0 \end{cases} \tag{3.14}$$

where ω_i is the individuals's characteristic, e.g., gender (=1 for male, and 0 for female), age, years of education attainment, dummy indicator of having children or not (=1 if having any child, and 0 otherwise), dummy indicator of residence (=1 if living in urban area, and 0 if living in rural area)[6]. The inverse Mills ratio would be included in both cross-Sectional estimates and Quantile Regression estimator, and denoted as Λ.

3.2.5. Data Segmentation

To compare the coefficient across cohorts, THE PSFD dataset would be further segmented into 3 different cohorts: the first cohort is those who were born between 1953 and 1964 (Cohort I), second between 1965 and 1976 (Cohort II), and last from 1977 to 1983 (cohort III)[7]. Similarly, in the hope to examine how free trade agreement

[6]For Taiwanese dataset, the definition of rural and urban area follows the up-to-date definition of administrative district in Taiwan, which is the "Institutional Reform of Five Municipalities in Taiwan, where Taipei County, Taichung County, Tainan County, Kaohsiung County were then classified as part of their neighboring cities, hence for those who lives in these area would thus be classified as urban resident.

[7]Such segmentation is confined with the natural limit of the Taiwanese PSFD dataset, in which the survey had been separately conducted upon three different cohort groups: the survey started in 1999, including only Cohort I. Cohort II was latter included in 2003, and followed by Cohort

would cause any differences upon the education return with its impact on domestic labour market, the Mincerian coefficients would be compared within the same country in different periods. The dataset is segmented into 3 different subperiods, before 2002, between 2002 and 2009, and after 2009 respectively: 2002 is the time when Taiwan was accepted as a member state to the World Trade Organization (WTO), which is an organization that supervises and liberalizes international trade, further replacing the General Agreement on Tariffs and Trade (GATT)since January 1995(World-Trade-Organization 2014). Compared to the EU, the WTO appears to be a more lenient entity with less legal binding power yet has a more inclusive pool of members. How would such acceptance cause differences to Taiwanese educational return? In the year 2009, a seemingly promising Free Trade Agreement became operative between Taiwan and Mainland China. The Economic Cooperation Framework Agreement (ECFA) might not only signal a closer trade connection between the two countries, but also a more welcoming labour market with ever-growing friendliness toward Taiwanese excessive labour supply. How would such FTA affect the Mincerian return?

3.3. Descriptive Statistics

Cohort	I:1953∼1964	II:1965∼1976	III:1977∼1983	Total
RealwageUSD	1638.35	1469.01	1136.65	1415.43
Eduyear	10.62	13.03	14.47	11.91
Exp	24.85	15.80	8.894	24.07
AvgproploanUSD	122947.7	178809.3	166173.44	120697.88
HPI	6.358	6.367	7.066	6.499
Illiteracy	0.167	0.00755	0.194	0.335
Elementary	0.191	0.0115	0.00194	0.0898
Juniorhigh	0.153	0.125	0.0384	0.0814
Seniorhigh	0.0580	0.0412	0.0145	0.0289
vocational	0.218	0.361	0.209	0.181
College	0.1000	0.251	0.282	0.147
University	0.0877	0.148	0.159	0.0948
Higher	0.0215	0.0553	0.100	0.0414
N	6948	5193	4371	16512

Table 3.1: Mean of Different Cohorts in Taiwan

The following tables summarize the statistics of the PSFD data set. Table 3.1 is the means of the variables in different cohort respectively. It is obvious that real monthly wage (measured in USD) decreases for younger cohorts. Given the fact that the age when answering the survey is essentially higher for older cohorts than younger ones, this is consistent with the "common sense" prevailing among the Taiwanese labour market: worker's wage increases in his/her age, which is in accordance with his/her position, and experience accumulated over the years. On the

III, which was included in 2009.

other hand, education attainment years (Eduyear in the table) is increasing, which is consistent with the higher education expansionary policy implemented since 1994[8], hence part of Cohort II and all of Cohort III would be receiving education after the expansion. Experience is consistent with common sense, increasing in age, hence decreasing in Cohort. The average industrial arbitrage investment in the housing market measured in USD (labeled as avgproloanUSD) demonstrates a hike at Cohort II, and slightly smaller for the younger generation, whilst Cohort I has the smallest average arbitrage investment. The average Housing Price Index faced by each interviewee at the location of their residence and at the time when he/she answered the survey. It is observable that HPI increases as the cohort gets younger. As for the education composition, i.e., the portion of the interviewees that achieve the corresponding degree out of the total sub-sample, it is obvious that the younger cohort has relatively more graduate finishing his/her degree at undergraduate/post-graduate level, while the portion of the sample that only finished high school or below decreases for the younger cohort. Once again, this is consistent with the higher education expansion policy over the years.

Period	Before 2002	2003 $\sim$ 2009	After 2009	Total
RealwageUSD	1742.94	1388.69	1335.34	1415.43
Eduyear	10.61	11.99	12.15	11.91
Exp	24.78	24.96	21.21	24.07
AvgproloanUSD	87866.318	111907.82	149689.76	120697.88
HPI	5.560	6.251	7.308	6.499
Iliteracy	0.360	0.445	0.0528	0.335
Elementary	0.146	0.0642	0.129	0.0898
Juniorhigh	0.117	0.0729	0.0877	0.0814
Seniorhigh	0.174	0.162	0.230	0.181
Vocational	0.0775	0.121	0.240	0.147
College	0.0432	0.0275	0.0267	0.0289
University	0.0657	0.0766	0.152	0.0948
Higher	0.0142	0.0300	0.0810	0.0414
N	2180	11613	5054	18847

Table 3.2: Mean of Taiwanese Dataset in Different Time Period

In Table 3.2, the means of variables in different periods are listed instead, in other words, the composition of each period might include different cohorts. It is obvious that the wages were decreasing over the decade, while education attainment years were increasing in time, which is consistent with the previous macro result. Experience decreases over time, which could result from the entrance of a younger generation into the survey. The average industrial arbitrage investment in housing

[8]For detail of the education expansion policy in 1994, please refer to footnote 1 in Chapter 1. We do not choose 1994 as our break point, since it is too close to 1999, albeit often considered as an important milestone in the development of education reformation, by researchers such as Wu (Wu 1998).

	Cohort I: 1953∼1964							
Education	Elementary & below	Juniorhigh	Seniorhigh	Vocational	College	University	Higher	total
RealwageUSD	1158.912	1316.01	1890.73	1407.98	1906.93	2504.91	5205.57	1638.35
Eduyear	6	9	12	12	14.22	16	18.17	10.62
Exp	26.80	24.25	24.18	23.81	23.65	23.05	22.30	24.85
AvgproploanUSD	88313.92	165135.13	88569.95	145994.58	135274.71	127153.93	70975.65	122947.71
HPI	6.11	6.12	6.64	6.52	6.54	6.90	7.36	6.36
N	1954	1072	446	1660	841	743	196	6912

Table 3.3: Mean at different education level Cohort I: 1953∼1964

	Cohort II: 1965∼1976							
Education	Elementary&below	Juniorhigh	Seniorhigh	Vocational	College	University	Higher	total
RealwageUSD	695.99	1124.47	2606.81	1195.57	1473.32	1808.43	2195.10	1469.01
Eduyear	6	9	12	12	14.25	16	18.17	13.03
Exp	19.40	20.65	17.02	17.23	14.67	11.15	10.55	15.80
AvgproploanUSD	94980.69	236291.29	211294.89	172677.73	189202.34	131522.51	141065.44	178809.32
HPI	6.023	6.08	6.08	6.20	6.51	6.73	6.82	6.37
N	63	620	191	1747	1372	843	315	5151

Table 3.4: Mean at different education level Cohort II: 1965∼1976

market measured in USD demonstrates an increasing pattern consistent with HPI. Such result is in accordance with the expanding housing bubble in Taiwan. The education composition once again, as time being, exhibits an increasing portion in higher education (first degree or higher) and decreasing in the rest (senior high, college, vocational, or below). This could be regarded as evidence to a shift of labour supply from the uneducated sector to educated sector, and is still consistent with the education expansion policy.

	Cohort III: 1977∼1983							
Education	Elementary &below	Juniorhigh	Seniorhigh	Vocational	College	University	Higher	total
RealwageUSD	1188.52	877.71	929.96	922.79	1029.76	1302.03	1523.77	1136.65
Eduyear	6	9	12	12	15.09	16	18.17	14.47
Exp	13.03	13.10	10.29	11.80	8.64	6.28	5.54	8.90
AvgproploanUSD	121206.91	86072.75	116591.27	129114.04	201666.23	227570.76	148647.34	166173.44
HPI	6.45	6.35	6.90	6.77	7.00	7.84	8.23	7.07
N	645	141	63	821	1343	829	514	4356

Table 3.5: Mean at different education level Cohort III: 1977∼1983

	Uneducated	Educated	Premium (%)
CohortI	1623.43	3068.63	89%
CohortII	1392.13	1913.61	37%
CohortIII	987.50	1386.90	40%

Table 3.6: Weighted average wage and Education premium for Cohorts

	Before 2002							
Education	Elementary&below	Juniorhigh	Seniorhigh	Vocational	College	University	Higher	total
RealwageUSD	975.75	1803.26	2746.34	1470.27	1921.95	2648.91	3867.58	1742.94
Eduyear	6	9	12	12	14.22	16	18.17	10.61
Exp	24.28	20.42	20.78	20.15	20.45	18.87	17.41	24.78
AvgproloanUSD	87626.97	105459.58	97892.85	119995.11	109273.32	113261.98	94127.85	87866.32
HPI	5.54	5.48	5.72	5.60	5.55	5.60	5.8	5.56
N	503	353	145	585	286	242	56	2170

Table 3.7: Mean at different education level Before 2002

Tables 3.3, 3.4 and 3.5 are the means of variables at different education levels, for different Cohorts. If the measurement of education return in Chiu (2004) is to be followed, then the premium is the percentage difference between wage between educated (university and above) and uneducated (Senior High School, Vocational, College and below), divided by the uneducated wage. It is easy to observe that the wage for both educated and uneducated decreases as the Cohorts get younger, while the wage premium also decreases from the eldest Cohort to younger Cohorts (II and III). Hence the extra amount of wage a labourer could earn by finishing a degree (first or postgraduate) decreases for the younger cohorts. The weighted average wage in real USD and the premium between education levels is listed in Table 3.6.

	2002∼2009							
Education	Elementary&below	Juniorhigh	Seniorhigh	Vocational	College	University	Higher	total
RealwageUSD	1204.68	1089.95	1978.80	1223.94	1434.61	1858.19	2594.60	1388.69
Eduyear	6	9	12	12	14.50	16	18.17	11.99
Exp	33.58	23.042	21.50	18.78	14.75	13.82	10.54	24.96
AvgproloanUSD	61018.74	165687.68	116080.75	143968.53	164353.31	156859.33	113632.82	111907.82
HPI	6.12	6.05	6.28	6.23	6.43	6.74	6.99	6.25
N	3917	1173	452	2500	1845	1272	442	11601

Table 3.8: Mean at different education level 2002∼2009

	After2009							
Education	Elementary&below	Juniorhigh	Seniorhigh	Vocational	College	University	Higher	total
RealwageUSD	645.79	1003.97	1104.51	1117.62	1272.39	1670.73	2134.47	1335.34
Eduyear	6	9	12	12	14.93	16	18.17	12.15
Exp	35.82	26.423823	23.68559	19.438627	14.138602	13.478343	9.9194215	21.211854
AvgproploanUSD	37683.04	175405.67	133679.85	161849.46	211592.16	181762.07	158401.6	149689.76
HPI	6.65	6.69	7.43	7.05	7.27	8.27	8.59	7.31
N	364	361	126	1210	1485	958	547	5051

Table 3.9: Mean at different education level After 2009

	Uneducated	Educated	Premium (%)
Before2002	1779.53	2877.92	62%
2003∼2009	1376.09	2048.09	49%
After 2009	1198.51	1839.28	53%

Table 3.10: Weighted average wage and Education premium for Different Periods

Tables 3.7, 3.8 and 3.9 are the means of variables at different education levels, for different periods. Again, it is perceivable that wage decreases for both educated and uneducated sector for the time being. The weighted average wage in real USD and the premium between education levels is listed in Table 3.10. The education premium seems to be decreasing from the first subperiod to second, and increasing by a smaller amount in the third subperiod.

Further empirical comparison of education return is included in the next section, with an explanation to follow.

3.4. Empirical Results

The following structure follows the standard Mincerian Equation adapted from both of Mincer's result,

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \\ &\beta_6 Property\ Loan + \beta_7 \Lambda + \epsilon\end{aligned} \tag{3.15}$$

the Left Hand Side (LHS) is the natural logarithm of monthly wage, measured in USD, adjusted for the price level. The Right hand side (RHS) includes the education attainment years of each interviewee, her actual working experience years, the quadratic term of that, and variables of characteristics such as: age and gender. Both education attainment years and industrial property investments are estimated via IVs as described in section 4.3.2 and 4.3.3. They nonetheless vary from one estimator to another, the choices as well as the reasons for those choices would be

elaborated in each subsection of the estimator. Also, as the dependant variable is a natural logarithm while some of the independent variables are not, it is often referred as a log-linear model, in which a one unit change in the independent variable, e.g., one extra year spent in education, would be associated with a 100 $\times\beta_1$ % change in the wage, ceteris paribus. Yet for the dependant variable that is in natural logarithm, say, a property loan, then it implies that a 1 % change in the property loan would cause β_6% change in wage, ceteris paribus.

We would proceed with our estimate in the following manner: first we run the Cross-sectional estimator, examine if it is plausible to include all the IVs, and determine which should be the most useful one, if not possible to include all. Secondly, we would execute the Quantile Regression estimator, using the IV that we choose from the Cross-estimated result, which could be regarded as a trial run testing IVs for the QR estimator.

3.4.1. Cross-Sectional Estimates

To start with, the cross-sectional regression for the Taiwanese dataset are expressed as follows,

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age \\ &+ \beta_5 gender + \beta_6 Property\ Loan + \beta_7 \Lambda + \epsilon\end{aligned} \tag{3.16}$$

where education attainment years are estimated with a dummy indicator of times for the abolition of Martial law in 1987, and that for the education reformation in 1999:

$$education\ year = \gamma_0 + \gamma_1 R1987 + \gamma_2 R1999 + \gamma_3 regioncode + u_1$$

and industrial property investment is estimated with the property loan of each industry the interviewee works in, using the House Price Index of the region where the interviewee resides at the time when she receives her most recent monthly wage, and the regional code per se, as to estimate the arbitrage investment in the real estate market of each industry:

$$Property\ Loan = \omega_0 + \omega_1 HPI + u_2$$

The next table summarizes the results of cross-sectional estimates, the first is the general estimator including all interviewees, followed by those for Cohort I to Cohort III, and the those for three sub-periods. Notice that for the cohort estimates, and for that of subperiods before 2002, the dummy indicator of time is not included,

simply to avoid multicollienearity.[9]

Lastly, since the PSFD is a repetitive survey including duplicate interviewees in different years, there might be a self correlation within each group (composed of the same individuals at different times). That is why in the following regression model in Table 3.11, the clustered robust standard error is applied instead. To compare with a model using a normal OLS standard error, in Table 3.12, it is observable that the coefficients estimated are the same with or without clustered robust standard error, while the standard error being smaller for the unclustered case, yet the difference in standard error is not big enough to affect the significance level.

[9]The reader should be aware of the fact that we have utilized the 2sls standard error in this 2sls model, which is a built-in choice in the Stata software. Similar choice of 2sls standard error is applied in the following QR estimator as well.

Table 3.11: Cross-Sectional Mincerian Regression

	general lnrwageUSD	CohortI lnrwageUSD	CohortII lnrwageUSD	CohortIII lnrwageUSD	Before2002 lnrwageUSD	2003∼2009 lnrwageUSD	After 2009 lnrwageUSD
eduyear	0.101***	0.193***	0.544***	0.00452	0.450	−0.210*	0.136***
	(0.0301)	(0.0426)	(0.184)	(0.422)	(0.392)	(0.201)	(0.0212)
exp	0.154***	−0.000448	0.236***	0.0405	−0.0633	0.284***	0.0560***
	(0.0171)	(0.0193)	(0.0412)	(0.219)	(0.301)	(0.0708)	(0.00614)
exp2	−0.00311***	0.000250	−0.000991	−0.00487	0.00207	−0.00727***	−0.000981***
	(0.000208)	(0.000277)	(0.00149)	(0.00521)	(0.00647)	(0.00194)	(0.0000971)
Age	0.00330	−0.0495*	−0.170***	0.409**	−0.275	0.0446	−0.000945
	(0.00976)	(0.0311)	(0.0510)	(0.231)	(0.334)	(0.0394)	(0.00518)
gender	0.653***	0.837***	0.860***	0.787**	3.829	1.355***	0.329***
	(0.0812)	(0.307)	(0.202)	(0.315)	(3.310)	(0.345)	(0.0449)
lnavgproploan	−1.109***	0.420	−0.296	−1.539***	1.036	−5.224***	0.0262
	(0.280)	(0.392)	(0.348)	(0.549)	(2.541)	(1.962)	(0.0512)
lambda	0.269	2.153*	0.572***	2.992***	15.41	−0.887	0.327
	(0.278)	(0.943)	(0.191)	(0.730)	(14.98)	(0.901)	(0.227)
_cons	15.62***	1.082	5.286	9.743*	−4.659	61.87***	4.074***
	(1.901)	(3.543)	(3.446)	(5.012)	(23.927)	(11.95)	(0.509)
eduyear							
R1987	2.884***				7.184*	2.934***	2.761***
	(0.0691)				(3.912)	(0.0815)	(0.146)
R1999	1.995***					2.174***	2.295***
	(0.0965)					(0.312)	(0.201)
regioncode	−0.156***	−0.222***	−0.133***	−0.134***	−0.190***	−0.163***	−0.133***
	(0.00865)	(0.0195)	(0.0102)	(0.0164)	(0.0601)	(0.00982)	(0.0204)
_cons	11.44***	12.04***	13.74***	15.16***	11.39***	11.58***	11.08***
	(0.0699)	(0.128)	(0.0842)	(0.103)	(0.411)	(0.0856)	(0.217)
1^{st} stage F statistic	6769.96						
lnavgproploan							
hpi	0.0131	0.0179	−0.00230	−0.0274	−0.0120	−0.0118	−0.000121
	(0.00971)	(0.0173)	(0.0184)	(0.0161)	(0.131)	(0.0172)	(0.0136)
_cons	10.93***	10.83***	11.04***	11.48***	10.87***	11.04***	11.12***
	(0.0631)	(0.201)	(0.208)	(0.142)	(0.697)	(0.142)	(0.0915)
1^{st} stage F statistic	70.64						
H-S statistic	4442.42						
N	9885	3566	3924	1994	406	6153	3326

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In terms of general regression, the education return is 0.101, implying the return for one extra year in Taiwan is 10.1 %)

Experience shows a similar trait (i.e., nonlinear, increasing) as concluded by Mincer (1974), and is of larger influence on wage than one year of education (15.4 %).

Characteristics such as gender seems to be significant in Taiwan (65.3%). It seems that there is quite a large wage gap due to gender differences. Age, on the other hand, seems insignificant in Taiwan when education and experience are included.

The average industrial property loan in Taiwan (labeled as lnavgrproploan) appears to have more of an impact with statistical significance (-1.109%) than other variables. In addition it is negative, consistent with theoretical anticipation that arbitrage investment is of negative impact, causing 1.109% decrease in wage for every 1% increase in arbitrage investment in the housing market per company.

For Cohort analysis, the education return of Cohorts are strongest in Cohort II: (19.3% for Cohort I, 54.4% for Cohort II, and in significant 0.452% for Cohort III). The differences between Cohorts in terms of education return is graphically presented in App .3a [10].

As for experience, the estimates seems only significant for Cohort II (23.6%), and there are no significant results to support nonlinearity. In terms of characteristic variables, age tends to be of negative impact for the older cohort and positive for younger generations (-4.95% for Cohort I, and -17.0% for Cohort II, but 40.9% for Cohort III). It might be concluded that once workers surpass a certain threshold age (Cohort II received their first survey in 2003, while the age ranged from 27 to 38) , then age becomes a disadvantage to wage, as opposed to the case in Cohort III, where age tended to be of higher explanatory power than that of even education. As for gender , it seems to be significantly consistent to have higher wage in all three Cohorts.

The only significant coefficient of property investment in Taiwan is negative for Cohort III (-1.539%), which is still consistent with the general result (-1.109%). Likewise, the differences between Cohorts in terms of property investment in Taiwan is graphically presented in App 3b.

In a similar attempt, for the cross-sectional estimates segmented into 3 different

[10]The figures map the estimated coefficient against cohorts so to compare the differences between different cohorts, also include the Upper Bound (UB) and Lower Bound(LB) of the 95% confidence interval

sub periods, the coefficients of education return are significant for the latter 2 sub-periods (-21% between 2003 and 2009, and 13.6% after 2009, please refer to App .4a). Though being significantly negative at a 95% level, it seems that in this subperiod, experience becomes of more influence upon wage (28.4% in second sub period). The estimates for experience are consistent with the non-linear, increasing nature concluded by Mincer (1974) for the last 2 sub-periods. Also, experience is still of stronger impact on wage than education, consistent with the general result. Furthermore, it seems experience is of less explanatory power after 2009.

In terms of characteristic variables, age appears to be of insignificant impact in Taiwan. Furthermore, the gender gap is still significantly obvious between male and female after 2002, but significantly smaller after 2009.

Also, average property investment appears to be significant only in the subperiod between 2002 and 2009, which is negative (-5.224%) and of highest influence among all variables. This result again is consistent with the general estimation, and supportive to the theoretical anticipation. A comparison between subperiods is available in App 4b.

Concerning the inclusion of inverse Mill's ratio, it does appears to be insignificant in the full sample and in those of sub-period analysis. However, the coefficient thereof in the different cohorts appear to be significantly correlated, implying the selection bias matters in the wage determining model when it is more homogenous in terms of age group within each cohort. That is why we believe it should be retained in the Cross-sectional model.[11]

Another seemingly worrying result lies in the difference in terms of IV between Cohort analysis and subperiod analysis. To be more specific, the only IV for education attainment years in the first stage left in the Cohort analysis is the regional code. Be that as it may, since we are only interested in comparing the coefficient estimated between different cohorts, or different sub-periods, but not comparing those in a particular Cohort, with those in a subperiod. Hence the consistency in terms of IVs is by and large intact, and thus we are able to compare the education return between cohorts (or between different periods) while taking a consistent account of the endogeniety hidden within.

[11] Another attempt on SE is to use a bootstrapping technique, which is not included since the result is similar: SE becoming larger but not affecting the significant level.

3.4.1.1. Validity Test of Instrument Variables

To assess the validity of the inclusion of instrument variables, we run tests for the correlation between instrument included and the endogenous variables, and the exogeneity of the instrument variables. For the correlation test, the first stage F statistics would be of reference, whereas over-identifying restrictions test would be applied to examine if including all instrument variables would violate the over-identification restriction. From Table 3.11, the first stage F statistics are included and demonstrate that, for the general pooled estimate, the F statistics are large enough to reject the null hypothesis H_0: all the coefficients of instrument variables for education attainment years equal 0, and the coefficient of the instrument variable (HPI) for property investment equals 0.

As for the over-identification restriction test, the Hansen-Sargan over-identification statistic is included (noted as H-S statistic in Table 3.11). As one could see, the H-S statistic is large enough to reject the null hypothesis H_0: the claim of over-identification is valid. Hence we should admit that, our choice of instrument variable might not be exogenous at the same time if all are included. Even though the statistical significance of the cross sectional estimate seems to be meaningful and economically explainable, and the first stage statistics support the correlation between instrument and endogenous variables, the over-identification H-S statistic would not support such choice of instrument. In the following section, ipso facto, the quantile regression estimator would be applied with less instruments.

By examining the significant level of the IVs in the first stage, one might conclude that all the IVs for the education attainment years seems to be significant for all cohorts and all subperiods. The IVs for property investment, albeit, does not demonstrate similar statistic significance.

One of the many criteria about inclusion of IVs is the significance level of their coefficients in the first stage regression. Based on this criteria, one might cast doubt on the inclusion of real estate investment coefficient, as they appear to be insignificant in Table 3.11. Nonetheless, since the HPI serves more than a IV to account for endogenity, but is included so as to capture the part in the industrial real estate investment that is due to arbitrage purpose, viz, most likely correlated with the fluctuation of housing market prices. It would be less compatible with the arbitrage investment this chapter intends to discuss. Also the first stage F statistic demonstrates that such inclusion is valid. That is why we intend to keep the HPI as the sole IV in the following QR estimator, albeit being insignificant in the first stage.

Another small attempt to test if our choice of instrument variable is valid, is the inclusion of lag term of HPI. Since in the housing market, the decision of transaction might not be made as fast as in other commodity markets, the correlation between

price and quantity demanded might be delayed. Hence in Table 3.12, we include a regression model with almost all the same variables as in previous ones, but adding one extra lag terms of the HPI in the first stage of property investment estimated. The result shows that the directions of the property investment coefficient remains, yet the magnitude differs, showing the estimates are sensitive to the inclusion of more HPI lag terms. Be that as it may, given the fact that the result of the over-identification test does not support that all the IVs are exogenous if all are included, we believe the number of IVs should be reduced, instead of adding another lag term. Also, in the first regression, adding an extra term does not change the significant level of the HPIs, which also implies it might be less helpful to the statistic significance by adding another term.

In brief, even though we manage to include several IVs, and conduct a validity test to justify such inclusion, we would still regard the estimates in the aforementioned cross-sectional model as less convincing, given the magnitude of estimates in each sub cohort and subperiod being incomparable with those estimated by other Taiwanese empirical economists (e.g., the estimates achieved by Chuang and Lai (2011) ranges from 11% to 9% in Cohort I and 11%to 7% in Cohort II), and the insignificant level of some IVs. The estimates of each cohort for instance, albeit plausible if compared with themselves, might still suffer from issues of over-identification, and failure of IV caused by decreasing sample size (education reform indicator dropping off). Hence we would take the result of cross-sectoinal estimates as an intermediate, indictive trial run, that help us to decide which IV to be included. This is why in the following Quantile Regression estimate, we would be motivated to decrease the number of IVs down to one (i.e., the HPI).

Table 3.12: Models of Alternative Approaches: non-Clustered SE, and extra Lag term of HPI

	Non-Clustered SE lnrwageUSD	Clustered SE lnrwageUSD	Lag term for HPI lnrwageUSD
eduyear	0.101***	0.101***	0.101***
	(0.0247)	(0.0301)	(0.00688)
exp	0.154***	0.154***	0.0447***
	(0.0142)	(0.0171)	(0.00483)
exp2	-0.00311***	-0.00311***	(0.000918***
	(0.000208)	(0.000208)	(0.0000736)
Age	0.0033	0.0033	0.0116***
	(0.00928)	(0.00976)	(0.00343)
gender	0.653***	0.653***	0.283***
	(0.0798)	(0.0812)	(0.0351)
lnavgproploan	-1.109***	-1.109***	-0.137**
	(0.178)	(0.280)	(0.0455)
lambda	0.269	0.269	(0.202
	(0.223)	(0.278)	(0.131)
_cons	15.62***	15.62***	3.243***
	(1.878)	(1.901)	(0.491)
eduyear			
R1987	2.884***	2.884***	2.917***
	(0.0638)	(0.0691)	(0.0723)
R1999	1.995***	1.995***	1.927***
	(0.09)	(0.965)	(0.101)
regioncode	-0.156***	-0.156***	-0.158***
	(0.00709)	(0.00865)	(0.00795)
_cons	11.44***	11.44***	11.49***
	(0.0619)	(0.0699)	(0.0692)
lnavgproploan			
hpi	0.0131	0.0131	-0.0228
	(0.00867)	(0.00971)	(0.0257)
L.hpi			0.0482
			(0.0313)
_cons	10.93***	10.93***	10.87***
	(0.0588)	(0.0631)	(0.0767)
N	9885	9885	8114
Standard errors in parentheses			
="* p<0.05	** p<0.01	** p<0.01	*** p<0.001"

3.4.2. Quantile Regression

The Quantile Regression (QR) estimator, introduced by Koenker and Bassett (1978) measures the marginal impact of explanatory variables upon dependent variable at any designated quantile (Koenker & Bassett 1978). The theoretical model is summarized as follows: Assume a random variable Y with cumulative distribution function F_Y, where θth quantile of Y is denoted as

$$Q_\theta(y) = F_Y^{-1}(\theta) = q_\theta, \ where \ \theta \in [0,1]. \tag{3.17}$$

the value of q_θ can be derived by the methods as follows:

$$q_\theta = argmin[\theta \int_{y \geq q_\theta} |y - q_\theta| dF_Y(y) + (1-\theta) \int_{y \leq q_\theta} |y - q_\theta| dF_Y(y)] \tag{3.18}$$

Now let both X and Y become random variables, a conditional distribution given X is as follows:

$$\hat{\beta}_\theta = argmin \frac{1}{T} [\theta \sum_{t:y_t > x_t\beta} |y_t - x_t'\beta| + (1-\theta) \sum_{t:y_t < x_t\beta} |y_t - x_t'\beta|] \tag{3.19}$$

where the conditional quantile of Y given X is expressed as $Q_\theta(Y|X) = F_{Y|X}^{-1}$, which is also a function of X. Hence it can be expressed as $Q_\theta(Y|X) = q_\theta(X)$. Given X=x, the conditional probability of y being less or equal to $q_\theta(X)$ is θ, and that of y being larger than $q_\theta(X)$ is $(1-\theta)$. Thus the equation (16) above can be further expressed as:

$$q_\theta(X) = argmin[\theta \int_{y \geq q_\theta(X)} |y - q_\theta(X)| dF_{Y|X=x}(y) + (1-\theta) \int_{y \leq q_\theta(X)} |y - q_\theta(X)| dF_{Y|X=x}(y)] \tag{3.20}$$

The amount of y being less or equal to $q_\theta(X)$ is θ , and that larger than o $q_\theta(X)$ is 1-θ, given different conditions of x, from which it is observable how Y is differently affected by x at differently θ. Assume a linear model as follows:

$$y_t = x_t'\beta + e_t \tag{3.21}$$

where x_t is a $k \times 1$ vector, composed by the t-th observation of k explanatory variables, β is a $k \times 1$ vector, as the coefficient for each explanatory variable, and e_t is the residual. The QR parameter can be thus estimated with the asymmetric weighted absolute errors as the following minimizing etimator:

$$\hat{\beta}_\theta = argmin \frac{1}{T} [\theta \sum_{t:y_t > x_t\beta} |y_t - x_t'\beta| + (1-\theta) \sum_{t:y_t < x_t\beta} |y_t - x_t'\beta|] \tag{3.22}$$

To include the estimator of property investment/ loan that functions as of capital,

the QR estimator is amended with the endogenous variable, i.e., property investment /loan, applying House Price Index and regional code as IVs. To achieve so, Chernozhukov and Hansen have proposed the following conditions as the foundation of Instrument Variable Quantile Regression (IVQR)(Chernozhukov & Hansen 2013):

(a) Potential Outcomes: Conditional on characteristics X and for each treatment choices d, $Y_d := q(d, X, U_d)$, where $\theta \mapsto q(d, X, \theta)$ is non-decreasing on [0,1] and left-continuous and U_d $U(0, 1)$ is the structural error term

(b) Independence: Conditional on X and for each d, U_d is independent of instrumental variables Z.

(c) Selection: D:=δ(Z,X,V) for some unknown function δ and random vector V.

(d) Rank Similarity: Conditional on (X,Z,V), U_D are identically distributed.

(e) Observed random vector consists of $Y := Y_D$, D, X and Z
Given the above condition (a) to (e) hold,

i)we would have $U := U_D$ with probability one,

$$Y = q(D, X, U), and U\ U(0, 1)|X, Z \tag{3.23}$$

ii) If the equation above holds and $\theta \mapsto q(d, \theta)$ is strictly increasing for each d, then for each $\theta \in (0, 1)$

$$P[Y \leqq (D, X, \theta)|X, Z] = \theta \tag{3.24}$$

iii) if the above two equations hold, then for any closed subset I of (0,1),

$$P(U \in I) \leq P[Y \in q(D, X, I)|X, Z] \tag{3.25}$$

where q(d,X,I) is the image of I under the mapping $\theta \mapsto q(d, x, \theta)$ In consequence, $\hat{\beta}_\theta$ could be thereby estimated while the issue of endogenouity been addressed with the amendment above. With HPI functioning as IV for the endogenous variable property loan in Taiwan dataset, the QR estimators are presented for the subperiods and cohorts previously assigned in the following pages:[12].

Hence, following the methods, the QR coefficients at each quantile can be esti-

[12]The first result implies a simultaneous equation model with nonseparable, normalized error U U(0.1) that is independent of Z, X. On the other hand, when $\theta \mapsto q(d, x, \theta)$ is strictly increasing, The second Result is a conditional moment restriction requiring Y being non-atomic conditional on X and Z, implied from both the first result and the fact that y $\leq (D, X, \theta)$ is equivalent to U $\leq \theta$ when $q(D, X, \theta)$ is strictly increasing in θ

mated in the following Mincerian equation:

$$\ln W_{it} = \beta_0 + \beta_1 education\ year_{it} + \beta_2 experience_{it} + \beta_3 experience_{it}^2 + \beta_4 age_{it} + \beta_5 gender_{it} + \beta_6 Property\ Investment_{it} + \beta_7\ \Lambda_{it} + \epsilon_{it} \tag{3.26}$$

$$Real\ Esate\ Investment_{it} = \omega_0 + \delta_1 HPI_{it} + \sum_{t=n}^{N} \sigma_t region\ code_{it} + u_2$$

The following result shows the QR coefficient estimated at each quantile of wage. As commonly concluded in many basic neo-classical models, labour productivity should be positively correlated with wage level. With that being said, comparison on estimates of variables across different quantiles of income level is actually comparing those variables at different levels of productivity, latent capability or working efficiency, the last two of which are often difficult to be defined or measured. As for education return, if the education return coefficient increases as quantile being, then it might be regarded as supportive evidence that there is a strengthened effect of education attainment upon an individual's ability: individuals with higher abilities showing greater tendency in pursuing higher education attainment. Such relation has been concluded by empirical findings by Blackburn and Neumark in 1993, Ashenfelter and Rouse in 1998, and Pereira and Silva-Martins in 2002 (Blackburn & Neumark 1993, Ashenfelter & Rouse 1998, Pereira & Silva-Martins 2002). If this relation is observed, as Gianni De Fraja concludes, the wage gap between educated and uneducated might be widened (De Fraja 2002). Alternatively, if the education return is decreasing in quantiles, implying a supplementary effect of education to ability, i.e., individuals with lower abilities tend to have higher education returns. Brunello et al. empirically conclude such relation in data collected from 12 EU countries, whereas Denny and O'Sullivan conclude that education is supplementary to abilities in British data (Brunello et al. 2009, Denny & O'Sullivan 2007).

Similar to what was attempted in previous estimators, the following QR estimator would also be run on different cohorts and different sub-periods so as to examine if the coefficient experiences significant changes from one cohort or subperiod changes to another. Also, since this chapter focuses on addressing the implication of the Taiwanese government's policies in education and housing market upon factors that in part determine wage, the following passage will only tackle education return and the coefficient of average arbitrage property investment. Graphical attempts are also included in App .5 to .16 to present the differences of education return and arbitrage investment in the property market, having coefficient estimated mapping against the quantile. In each graph, the change of estimates of the 10th quantile to that of the 90th can be observed while the upper and lower bounds of the 95% confidence interval are also included in the tables and graph likewise.

To start, by comparing App .6 and App .7 the patterns seems consistent for the younger cohorts: education return decreases in quantile for Cohort II (ranging from 12.7% to 7.6%) and III (ranging from 10.1% to 2.2%), consistent with the supplementary result of Brunello et al. in EU countries, Denny and O'Sullivan in the UK, and also Chuang and Lai in 2011 (Chuang & Lai 2011). For that of Cohort I, it mildly increases as quantile increases (ranging from 8.4% to 10.6%), which significantly support the conclusion made by De Fraja, i.e., education attainment seems to be complementary to ability. The education return also hikes up in Cohort II, while Cohort III has the lowest education return, which is consistent with the previous two estimates.

The reason behind such different ability bias between cohorts, as described by Chuan and Lai(2011), could be elaborated as follows. Firstly, the connotation of education is different at different times. For the first cohort, they receive education during the 1960s and 1970s, when exam-oriented credentialism still dictated the education system, in which an unified, joint entrance exam was the only screening mechanism recruiting the more capable students. In comparison, post 1990s, the education system has a stronger connection with the industries, teaching professional skills required for the positions within these industries that the vocational graduate could fill in afterward. The education system back then had the tendency to allow competent individuals (endowed with higher latent abilities) to be rewarded with higher education return. That said, there might be an upward ability bias as we could observe in the result of Cohort I, implying that the education system back then, ipso facto, allowed individuals to strengthen their capability as workers via education investment. The education system in which the latter two Cohorts receive education, however, appears to be more generalized than its previous counterpart. Its all-around approach recruits students via multiple methods: entrance exam, special admission by recommendation or interview based on criteria other than monotonic academic performance. The liberal education indoctrinated to the latter two cohorts, include a more generalized curriculum (e.g., teaching freshmen science, mathematics, literature at a fundamental level) that might put more emphasis on helping less competent individuals to improve. With that being said, this type of education is "supplementary" and that is perhaps one of the reasons why we might be able to observe a downward ability bias along quantiles, as the education is more beneficial to the interviewees at lower quantiles (less capable).

Secondly, the industries where the first cohort work in are quite different than those for the latter two cohorts. First cohort employees entered the job market as early as in the mid-1970s, when the industries were still labour intensive, and re-

quired relatively simple, fundamental skills. This might explain why the early standardized education would become helpful to labour back then, and granted higher education return for more capable workers. On the other hand, younger generations face a different industrial structure where many of them are skill (knowledge) intensive, requiring more than a professional skill set (e.g., basic literacy of foreign language) , especially so for the labours in the tertiary sector, which is an increasing portion of Taiwanese industries in the 1990s. Education with a generalized, all-around approach could thus help labour to acquire these type of non-professional skills, which the less competent workers tend to lack or be relatively inferior at. This might be another reason why the education appears to be more supplementary to ability for the younger cohorts.

In terms of property investment, from App 8 to 10 , while that in Taiwan is significantly positive almost for all quantile in Cohort I(except for the highest quantile) and first half of Cohort II, while significantly negative for all quantiles in Cohort III. This once again supports the previous result, i.e., the youngest generation in Taiwan suffers from a wage loss while the industrial arbitrage investment in real estate market increases. The coefficient by and large shows a consistent pattern with respect to quantile: the coefficient decreases in quantile for Cohort I(ranging from 0.159% to 0.027%) and Cohort II (ranging from 0.108% to 0.022%), whereas the coefficient in Cohort III fluctuates in a small range (from -0.319% at the 20th quantile to -0.160% at the 30th quantile) with the 10th quantile being the lowest (-2.610%). So to shortly conclude, if the individual is more able, i.e., at higher quantile, then her wage seems less sensitive (or vulnerable) to impact caused by the arbitrage investment.

	TW QR coefficient Cohort I								
lnrwageUSD	10	20	30	40	50	60	70	80	90
eduyear	.0837215	.096488	.0960701	.0964286	.0970794	.1016084	.1057923	.1078317	.1058356
lower	.0717745	.0809412	.0872397	.0954276	.0937425	.0947562	.0981391	.0984285	.0906782
upper	.0952309	.1205884	.1122757	.1088954	.1046305	.1154009	.1176213	.1205854	.1199159
exp	.0430762	.0460872	.0482924	.0440632	.0486431	.050262	.0465865	.0238285	.013219
lower	.0281571	.0352056	.0336202	.0338329	.0397973	.0387026	.0189734	.0086322	-.0108017
upper	.064129	.061453	.0620956	.0558453	.0569732	.0579817	.0514537	.0476497	.0346647
exp^2	-.0007697	-.0008433	-.0008924	-.0008068	-.0008793	-.0008337	-.0007186	-.0002213	.0000818
lower	-.0012011	-.0011753	-.0012409	-.0010415	-.0011322	-.001087	-.0008172	-.0007566	-.0004258
upper	-.0004828	-.0006224	-.0005877	-.0005409	-.0006636	-.0006464	-.0001754	.0000589	.0005265
lnrproploan	.1585603	.1439077	.1372822	.0932007	.0590656	.043837	.0489828	.0311135	.0268528
lower	.1152633	.1190615	.1056558	.0578273	.0418813	.0310428	.0196623	.0170555	-.0035172
upper	.2115736	.1771158	.1723743	.1333599	.1051664	.0888693	.0913327	.0716916	.1054388
Age	-.0028627	-.0048871	-.0007337	.0030269	.0047528	.0030954	.0032657	-.0004773	-.0107159
lower	-.0149089	-.0270525	-.0182753	-.0075442	-.0014091	-.0089015	-.0076146	-.0098787	-.0234691
upper	.0092984	.0122223	.0055396	.0072583	.0128833	.0115612	.0109957	.0062955	.0003685
gender	.3725954	.4669974	.4492933	.4380672	.4203339	.4181064	.4284968	.4547619	.5163971
lower	.2680967	.3444572	.35782	.3955979	.3878004	.3893888	.3552302	.3886621	.3458643
upper	.4388207	.7636258	.6193566	.5976854	.5048142	.5960546	.594644	.6504839	.6070541
lambda	-.139423	.290667	.2699389	.2202717	.1651568	.1603816	.2362566	.2648341	.3692695
lower	-.5599362	-.1584893	.0767523	.1767782	.0495054	.0730622	-.0899269	-.0311143	.0265547
upper	.2550596	1.330155	.9353545	.8718396	.4986472	.8925164	.9153624	1.013095	.5645434
cons	3.672255	3.712234	3.734548	4.101602	4.356147	4.550333	4.548164	5.191876	5.940618
lower	2.982414	3.025785	3.147194	3.462208	3.534082	3.831872	4.263719	4.698615	4.838266
upper	4.308921	4.091492	4.245162	4.444423	4.62082	4.860616	5.006976	5.495907	6.395794
ehat	-.0666518	-.1134621	-.1142521	-.0665643	-.0178511	-.0068127	-.0102511	-.006799	.0035866
lower	-.1285596	-.160817	-.203547	-.1169635	-.0873863	-.0770227	-.0889225	-.0458185	-.1495383
upper	-.0135796	-.0798975	-.053194	-.0106012	.0063477	.0193263	.0282536	.0142068	.0879124
N	697	711	679	693	697	713	694	682	688

Table 3.13: TW QR coefficient Cohort I

	TW QR coefficient Cohort II								
lnrwageUSD	10	20	30	40	50	60	70	80	90
eduyear	.1271155	.1091193	.1007002	.1012481	.0944922	.0902299	.0860364	.0817495	.0757676
lower	.1067952	.1007362	.0937107	.089693	.0882056	.0815487	.073265	.0707032	.0597525
upper	.1342997	.1173478	.1116292	.1057246	.1027271	.0964276	.0891646	.0905092	.0864985
exp	.0560996	.0478557	.0388265	.0428095	.0473199	.046091	.0532964	.050859	.0481305
lower	.0339907	.0338257	.0295304	.0292964	.0343984	.0404092	.0435339	.0342553	.0343286
upper	.0805624	.0617345	.048956	.0531324	.0554652	.0588178	.0580898	.0549667	.0590318
exp^2	-.0017526	-.0015897	-.0012966	-.0013353	-.0014942	-.0014822	-.001676	-.0016295	-.0015837
lower	-.0026531	-.0021148	-.001705	-.0018351	-.0019041	-.0019465	-.0019406	-.0017044	-.0019114
upper	-.0011494	-.0011192	-.0009434	-.000926	-.0010687	-.0012438	-.001345	-.0009744	-.0011942
lnrproploan	.1077261	.0840537	.0554051	.067115	.0480503	.0315418	.0370037	.0010709	-.0222478
lower	.0586421	.0210695	.0182927	.0086971	.0134404	-.00079	.0007957	-.0593613	-.0827608
upper	.1899579	.1295481	.1012154	.1166953	.10585	.0919948	.1025084	.0884143	.0348746
Age	.0118876	.0164395	.0179596	.0162471	.0159762	.0161145	.0156927	.0161217	.0221413
lower	.0032879	.0070861	.0097964	.0089783	.0102418	.0074043	.0122731	.0077786	.0125589
upper	.0218036	.0205541	.0240613	.0247412	.0238397	.0245867	.0250184	.0276663	.0339687
gender	.4374903	.3772559	.3474208	.3060905	.2899825	.2774414	.278836	.2994468	.3278203
lower	.362632	.2865927	.2831265	.2507699	.247039	.2303254	.233842	.1893877	.2087717
upper	.5567798	.4350806	.403424	.3501026	.3121438	.316933	.3411266	.3265898	.3637421
lambda	.1545834	.1036628	.0407955	.0729517	.0589145	.0147539	.0296296	.0620722	-.0404282
lower	.0240476	-.0380764	-.0231313	.0016586	-.049716	-.029321	-.0239303	-.3604247	-.36559
upper	.6337922	.2241426	.1695944	.12454	.1320814	.1439537	.1384687	.0988417	.1569913
cons	2.941786	3.544673	4.039346	4.084336	4.414851	4.716233	4.784266	5.228309	5.481687
lower	2.032386	3.011276	3.526872	3.650771	3.781139	4.045491	4.136261	4.29122	4.820161
upper	3.47312	4.370778	4.438526	4.81674	4.837208	5.014901	5.151605	5.920158	6.09022
ehat	-.0966336	-.0770156	-.0499114	-.0700605	-.0454502	-.0284191	-.0515548	-.0116805	.0048698
lower	-.1898092	-.1313698	-.1067865	-.1333383	-.1282457	-.1119166	-.1322989	-.1262316	-.0607405
upper	-.0401482	-.0000556	.0054156	.0012058	.0045977	.0207698	.0100151	.0726823	.1004205
N	545	502	555	484	578	452	543	498	518

Table 3.14: TW QR coefficient Cohort II

	TW QR coefficient Cohort III								
lnrwageUSD	10	20	30	40	50	60	70	80	90
eduyear	.021826	.1009936	.0791099	.073184	.0652947	.0612068	.061506	.0468209	.042662
lower	-.2089698	.0462882	.0534211	.0500785	.0513057	.0523456	.0417659	.0343009	.0154389
upper	.2023002	.1445373	.1024264	.0913376	.0773257	.0796728	.0714929	.0667921	.0656025
exp	.2905262	.0675807	.0192493	.030864	.0330263	.0308103	.0213416	.0271769	.0125817
lower	.0363038	-.0077262	-.0105063	.011542	.0106847	-.0051772	-.0160644	-.0003738	-.0135459
upper	.6983705	.6349711	.0536276	.0496353	.0511152	.04818	.0605829	.0516536	.0494834
exp^2	-.0093744	-.0030559	-.0009206	-.0013618	-.0014907	-.0014608	-.0009941	-.0014286	-.000838
lower	-.0330096	-.0263389	-.0025448	-.0023647	-.0024379	-.002263	-.0028838	-.0025604	-.0023573
upper	.0070787	-.0002282	.0001541	-.0007105	-.0006535	.0000745	.000216	.0001129	.0001159
lnrproploan	-2.609548	-.3190097	-.1599603	-.1760191	-.206859	-.1881338	-.1692001	-.2283297	-.2142245
lower	-3.709278	-.5448661	-.2797382	-.2603351	-.247327	-.2444463	-.2606457	-.2799321	-.2788648
upper	-1.824766	-.2314056	-.1081487	-.1118347	-.1121631	-.1229091	-.0795241	-.1435175	-.0849985
Age	.8225268	.1576421	.0618719	.0481422	.0465916	.0522134	.0489188	.0485196	.0513763
lower	.533923	.0824467	.0276018	.0261336	.0268153	.0387662	.0393879	.0383482	.0379246
upper	1.185045	.212875	.0783772	.0607293	.0622479	.0614515	.0703032	.0612561	.0674603
gender	1.197412	.8257211	.5010241	.398126	.3119836	.272637	.2338304	.2576098	.290555
lower	-.5646301	.2290339	.3034325	.2134619	.1835755	.1634768	.1716513	.1776539	.1488441
upper	2.218688	1.064315	.8028472	.5262785	.4355622	.3575541	.3212452	.344913	.4012296
lambda	3.139019	3.675236	2.034451	1.170336	.6926828	.4475662	.2554517	.152597	.2381939
lower	1.605446	.7813675	.6634499	.2400222	.017735	-.1098187	-.2524569	-.3431468	-.4505823
upper	6.191057	4.443802	3.937854	2.228997	1.484756	.9501541	.7350616	.4859309	.7278302
cons	-6.030285	.8759141	4.104827	5.085157	5.763073	5.694499	5.848528	6.679412	6.727164
lower	-20.6199	-1.914593	3.461598	4.306611	4.649628	4.913496	5.071362	5.468413	5.526717
upper	11.21068	4.02214	5.558175	5.901449	6.321679	6.218345	6.686954	7.233075	7.577248
ehat	3.916601	.5164846	.2498858	.2383668	.2518993	.2296403	.1929787	.2517341	.2118493
lower	2.961656	.3810919	.190515	.1756183	.1471965	.15402	.0949353	.1384951	.086428
upper	5.447085	.8093708	.3737361	.3368944	.3100684	.2931291	.2831769	.3119407	.2847635
N	440	439	433	517	391	404	436	437	437

Table 3.15: TW QR coefficient Cohort III

Similarly, from the results presented in the graphs (from App .11 to .13), the education return is compared at different Quantiles for different periods. The significant level is improved as opposed to the previous estimates. The QR estimate seems quite stable across quantiles, aside from the exceptionally low estimate at the 90th quantile before 2002 and the 10th quantile between 2003 and 2009. It ranges from 12% to 17% before 2002, from 8.6% to 9.5% between 2003 and 2009, and 8.9% from 10.0% after 2009. The education return decrease during 2002 in the QR estimate coincides with that of the Cross-Sectional estimate, to wit, this could be a result of Taiwan's joining the WTO which increases either the uneducated labour demand caused by relatively capital abundant countries, or the educated labour supply as a good part of industry relocated overseas, and thus incorporates the educated labor supply on a global scale (or equivalently speaking the local educated labour demand decreases). Another possible scenario is the decrease of uneducated labour supply, which by theory would push the equilibrium wage in the uneducated sector upward, and shrinking the education return. This theoretical dynamic could be supported by the fact that Taiwanese labour outflow into China (in 2013 it is estimated to be equivalent to 4.4% of the Taiwanese labour force, though its composition in terms of education level remains unclear.) As we could see, the education return at almost every quantile appears to be higher in the first sub-period than those in the second sub-period, while there seems to be less obvious changes in education return at most quantile between the second and third sub-periods. The education return experiences slight increase at some quantiles and decrease at others with no specific pattern across quantiles. That said, the change is insufficient to support the claim made by the Taiwanese government: ECFA could have a beneficial impact to remedy the decreasing education return by expanding relative labour demand at a faster pace than relative labour supply expansion, we could not find consistent evidence to disavow such a claim for either.

In App .14, .15, and .16, the coefficient of average arbitrage investment is demonstrated likewise. Again, from the QR estimates that are significant, it is in general consistent with the result in QR cohort analysis, i.e., the wage of more-capable workers (at higher quantiles seem to have less incentive with respect to average arbitrage investment in the housing market. In 2002, from the significant quantiles for both before/after 2002 (the 10th, 20th, 30th, 40th, and 90th quantile), it is still reasonable to conclude that the majority of the quantiles are still growing (becomes more positive significantly). This might be the result of accelerating net outflow capital and financial resources from taiwan to the rest of the world[13], i.e., the outflow of capital and financial resource might increase the sensitivity of wage with respect to arbitrage investment. After 2009, however, the impact seems work-

[13] a good part of it, some 70 billion usd flows to countries such as China, and south-east asian countries (Hu et al. 2008).

	TW QR coefficient Period 1								
lnrwageUSD	10	20	30	40	50	60	70	80	90
eduyear	.119704	.1478797	.1377679	.1440855	.1532014	.1538908	.1539923	.1665215	.0777859
lower	.053592	.0949979	.0850886	.0732769	.0876558	.0899967	.0690522	.1136529	.026287
upper	.225642	.2010828	.171637	.1880459	.2218277	.2122259	.1946103	.2004438	.2092986
exp	.0206908	.0703614	.0710086	.0620899	.0592834	.0418352	.0434222	.0236142	-.0129069
lower	-.0336789	-.0134929	-.0190333	-.0005613	.0275773	.0052447	-.058303	-.1005598	-.1414133
upper	.113758	.1321796	.0921199	.0949233	.0962751	.0800781	.0730499	.0515799	.1035107
exp^2	-.0002726	-.0013367	-.0014881	-.0012319	-.0010308	-.0005749	-.0007102	-.0000959	.0006016
lower	-.0023495	-.0030123	-.0022272	-.0021053	-.0022524	-.0017483	-.0013491	-.0010317	-.001949
upper	.0009292	.0003765	.0005378	.0002571	-.0003621	.0003382	.0015189	.00261	.0037836
lnrproploan	.1228378	.0657771	.0912161	.063401	.0288574	.048696	.0579745	.0847125	.1010792
lower	.042334	.0266914	.0300928	.0101454	-.0793438	-.0727625	-.0227441	-.0133456	.0056512
upper	.2100275	.1845658	.1601437	.1449475	.123623	.1325906	.1412099	.1511084	.2458805
Age	-.0133927	-.0615707	-.0436608	-.0465847	-.0485447	-.0498657	-.0410451	-.0614605	-.0026487
lower	-.0972194	-.093761	-.0919895	-.0847128	-.109015	-.0898842	-.0940939	-.0996808	-.1058595
upper	.0257669	-.0093446	.0086907	.0103349	.0001296	.0107738	.038403	.0053846	.0534869
gender	.4922991	.9175192	.7953411	.8783918	.9162277	.9688913	1.018337	1.136642	.4649939
lower	.121764	.3727315	.3834427	.3541811	.3920087	.3541797	-.1515302	.4548542	.133824
upper	1.408396	1.396188	1.191419	1.338603	1.622803	1.507226	1.497067	1.553009	1.612973
lambda	.4844213	2.55032	2.297698	2.515426	2.79475	2.815075	3.002548	3.4341	-.0006831
lower	-1.79152	.2400646	.1353555	-.4426623	-.0641627	.0143537	-2.017438	.5199925	-1.806611
upper	5.204917	5.195471	4.242698	4.76965	6.156858	5.439116	5.163869	5.439009	5.800822
cons	3.924952	4.88244	4.37796	4.700659	4.888406	4.995824	4.576639	5.126626	5.723492
lower	1.841958	3.126345	3.517902	3.968205	3.80955	3.900435	3.580417	4.083196	3.576722
upper	5.034842	5.494526	5.577052	5.84436	5.585519	5.604834	6.107137	6.424416	7.916907
ehat	-.0231438	.0109881	-.0358902	-.0181152	.0311324	.0003165	-.0206037	-.065904	-.142131
lower	-.1989243	-.1517436	-.1282422	-.0926284	-.1211507	-.1009205	-.1478662	-.1913963	-.3054477
upper	.1349826	.0894114	.0732294	.0802798	.1869832	.1652263	.0755052	.0830171	.0623285
N	221	221	215	237	202	223	238	195	219

Table 3.16: TW QR coefficient Before 2002

ing in an opposite direction: for the quantiles change significantly, i.e., the 10th to 50th, the coefficient seems less influential than before, which could be the result of the increasing capital inflow into Taiwan.

Concerning the inclusion of inverse Mill's ratio (lambda) in the QR model. It appears that in each cohort, and in each subperiod, there are significant terms at several quantiles respectively. Hence, we might substantiate that the inclusion of the inverse mill's ratio address the sample selection bias to a certain level that it should not be discarded.

Lastly, by comparing one of our primary focused estimates, that is, education return, with that estimated by Chuang and Lai(2011), we gladly find out they are very close at each cohort (Their estimate for Cohort I is between 1% and 8%, and 11% to 7% for Cohort II, while they did not include data for Cohort III). One could argue that the Cross-Sectional estimate might suffer some level of bias caused by over-identification. Hence even though the cross-sectional comparison between cohorts is still similar to that of quantile regression, we can be more confident to establish our conclusion upon the QR estimates.

	TW QR coefficient Period 2								
lnrwageUSD	10	20	30	40	50	60	70	80	90
eduyear	.0378404	.0885497	.0910409	.0945138	.0968245	.0941987	.0942347	.0953994	.0855183
lower	.027265	.076252	.0844797	.0903721	.0921877	.0885223	.0885414	.0851615	.0788688
upper	.0673586	.1001826	.0985866	.1009278	.1027222	.099345	.0989488	.0983009	.0936532
exp	.701145	.0718768	.0432652	.0433829	.0421326	.0390503	.0395515	.0411361	.036461
lower	.644399	.0608386	.0400919	.0363478	.0393595	.0354208	.0332781	.0351843	.0312095
upper	.8377918	.1001685	.055658	.0495396	.0489358	.046216	.0476515	.0484127	.0488467
exp^2	-.0138312	-.0016408	-.000981	-.0009637	-.0008909	-.0007988	-.000755	-.0007336	-.000663
lower	-.0162665	-.0022539	-.001283	-.0011045	-.0010944	-.0009394	-.0008989	-.0009226	-.0009534
upper	-.0128864	-.0014095	-.0008655	-.000758	-.0008192	-.0006938	-.0006274	-.0005732	-.0005904
lnrproploan	.5227258	.2784249	.2168626	.1827212	.1456579	.1385418	.1061073	.0686688	.0265213
lower	.4040893	.2332059	.1647462	.1346756	.1125184	.1081665	.0607134	.0019398	-.0082398
upper	.6783587	.318848	.2351468	.2069227	.1693856	.1590258	.1259264	.1098268	.0621458
Age	.0697824	.0247231	.0190775	.0167127	.0145009	.0154784	.0133128	.0107887	.0140336
lower	.0512495	.0167205	.0124718	.0115044	.0103863	.0110543	.0089067	.0068881	.0063834
upper	.0903966	.0328486	.0256957	.0212995	.021074	.020719	.018562	.0165975	.0225757
gender	.2819027	.409861	.3606944	.3479373	.3166879	.3000207	.2942135	.3261251	.3489338
lower	.1433448	.3648709	.3295993	.311117	.2798976	.2721732	.2671612	.2641802	.2960279
upper	.4500818	.4454786	.3995714	.3842157	.3496532	.3327815	.3157106	.3413902	.4015727
lambda	-.5978558	-.0899159	-.0478108	-.0235201	-.0291305	-.0760317	-.0645426	-.0045797	-.0815216
lower	-1.246725	-.2277614	-.1242367	-.1085601	-.1584633	-.1599227	-.1429051	-.1665679	-.3258009
upper	.0684098	.2580704	.1415688	.0677076	.0549975	.0695966	.0237673	.0635394	.1205058
cons	-9.76914	1.493226	2.64211	3.080644	3.555452	3.755201	4.178452	4.615869	5.196579
lower	-11.52228	.9088412	2.39629	2.913729	3.260935	3.487501	3.928184	4.299466	4.73942
upper	-8.368942	2.037478	3.114801	3.522614	3.906384	4.059227	4.552783	5.235799	5.472074
ehat	-.7111242	-.3231258	-.2591571	-.2224413	-.1809927	-.1709103	-.1344002	-.0937141	-.0389253
lower	-.9338966	-.3850027	-.2898325	-.2551975	-.2146226	-.2014215	-.1567402	-.14894	-.0911183
upper	-.4587612	-.2395966	-.1815829	-.1565028	-.1391419	-.1344724	-.0791757	-.0072243	.0239978
N	1172	1201	1132	1166	1172	1163	1169	1183	1151

Table 3.17: TW QR coefficient 2003∼2009

	TW QR coefficient Period 3								
lnrwageUSD	10	20	30	40	50	60	70	80	90
eduyear	.093922	.0891517	.0922968	.0955939	.0950007	.093421	.0925232	.0954393	.1002328
lower	.0828307	.0790775	.0840078	.0884422	.0840947	.0827983	.080494	.0804627	.0856685
upper	.10809	.0972985	.1023889	.1034158	.1028132	.10037	.1030332	.1060866	.1084803
exp	.0281787	.0306795	.034262	.0340888	.0329092	.032323	.0300341	.0305144	.0372964
lower	.0166193	.0194113	.0239305	.021384	.0212253	.0216472	.0200472	.0194039	.0257458
upper	.0434012	.0427307	.0425691	.0413518	.0437955	.0400001	.0401337	.0432709	.0478907
exp^2	-.0007623	-.0008832	-.0009362	-.0008505	-.0007899	-.0007468	-.0006172	-.0005367	-.0005643
lower	-.0010935	-.0011388	-.001107	-.0009794	-.000986	-.0008791	-.0007483	-.0007642	-.0007496
upper	-.0005427	-.0006847	-.0007564	-.0006088	-.000585	-.0005578	-.0004487	-.0003072	-.0003359
lnrproploan	.1120463	.1222188	.0888026	.0743594	.0734347	.0629552	.0231285	.0266461	-.0420626
lower	.0566845	.0636322	.043063	.0215066	.0166612	-.0006806	-.0113378	-.0321512	-.0986946
upper	.2118779	.1428334	.1489935	.1127395	.1381487	.110661	.0735975	.0624923	.019199
Age	.0184154	.0215694	.0214496	.0205831	.0216629	.0218417	.0197563	.0188527	.0125892
lower	.0074831	.0121742	.0134171	.0137343	.0134005	.0112101	.0122834	.0061152	-.0001888
upper	.0300617	.0294692	.0298691	.0270934	.02854	.027224	.0252384	.0250935	.0180954
gender	.1665833	.2106232	.2018253	.1969071	.1988685	.2023156	.1658203	.2040981	.2191622
lower	.1232088	.1288328	.1604232	.1389492	.1215366	.1609013	.1176878	.1403054	.1470708
upper	.2377113	.2555889	.2493656	.2369427	.2581773	.2613412	.2358034	.2739701	.2939432
lambda	-.7662573	-.345031	-.2116144	-.1675714	-.2084417	-.2335856	-.3518419	-.2601118	-.2567302
lower	-.9964584	-.6961332	-.447669	-.4882922	-.476258	-.3985024	-.5323822	-.5615388	-.422859
upper	-.4033962	-.1030658	-.0588265	-.0240142	-.027722	-.0525019	-.030076	.0958903	.0021937
cons	3.630596	3.55078	3.841341	4.007095	4.085134	4.283439	4.832504	4.840194	5.606373
lower	2.187908	3.170278	3.058774	3.499498	3.487816	3.81265	4.272002	4.484492	5.163441
upper	4.164168	4.141373	4.388166	4.553315	4.673887	5.041866	5.194558	5.69667	6.167472
ehat	-.0627021	-.112804	-.074446	-.0602803	-.0641577	-.0587487	-.0162271	-.0363147	.0352217
lower	-.1797523	-.1318764	-.1511337	-.1063182	-.1327206	-.1141701	-.0835605	-.0930059	-.0449161
upper	.0185714	-.0292299	-.0049044	-.0017496	.0158491	.0370153	.0459629	.0557143	.136997
N	514	501	527	482	503	531	503	509	484

Table 3.18: TW QR coefficient After 2009

3.5. Conclusion

In conclusion, based on the QR estimates on which we have more confidence and would like to put more emphasis, education returns appear to be decreasing for the youngest generation, i.e., Cohort III. This supports the argument that the younger generation is burdened with lower education returns. As extrapolated before, one of the reasons behind such a negative impact might be the expansionary education policy. Even though the education expansion was initiated in 1994, which is a response to the "410 educational reform march" in April 10, 1994, the drop of education return is not directly reflected on the immediate cohort, i.e., Cohort II in the data. The effect is accumulated onto and much more observable in the latter cohort, such cumulative effect is similarly observed in Chauvel's study on survey data in France (Chauvel 2010). Though the cross-cohort decrease of education return does appear to be in accordance with the expansion education policy, the nature of cohort analysis hinders us in identifying that the education expansion policy is the sole factor causing the changes in labour market. Other factors such as industrial restructuring might also plausibly contribute to the change in labour demand at different education levels. Also, the QR estimates of education return seem to be higher prior 2002 than those of the later two subperiods, could also be interpreted as the result of uneducated Taiwanese labour outflow into China, though no such empirical record could confirm the number of and the composition of the education level in such outflow.

On the other hand, given the increase of the number of higher education graduates post 1990s which is caused by the expansion in education policy in the same period, it might not be mistaken to make the conjecture that education expansion policy is one of the key factors that has greatly influence education return.

The crowding out effect caused by arbitrage investment seems to be significantly influential on wage. Though it seems that the statistically significant marginal impact thereof on wage is small compared to those made by other variables, e.g., education, experience, the result is still alarming in the sense that a 1% increase in such arbitrage investment could cause a negative impact equivalent to 5% $\sim$ 10% of education return. the younger cohort actually suffers from the crowding out effect caused by the housing bubble. Lastly for the two break points at different times (2002:WTO, and 2009 ECFA), even though they opened up access to a larger market for Taiwanese industries, it seems the relative demand for educated workers is not necessarily growing as fast as the expansion of the educated labour supply that is caused by the expansion policy. As we can observe from QR estimates, the education return decreases for almost every quantile by 2002, while there are no strong differences by 2009. By all means we should not use our result to defy the claim made by the Taiwanese government, to wit, joining the FTA would improve ed-

ucation return, albeit we could not support such a statement with our finding either.

It deserves some attention, nonetheless, that the empirical results derived here could be somehow compromised for the following reasons. To start with, industry is not specified here, yet the indebtedness is aggregated at the industry level, hence the wage difference might retain some "industrial pattern," coming from industrial categorical differences, rather than the exploited effects from indebtedness. Secondly, the impact of FTAs might take a longer time to sink into wages, hence it might be worthwhile to take a look at the impact in the longer run, rather than at the given structural break point of time[14]. Lastly, the impact of technical progress is absent in this analysis. It might be of interest for future researchers to include measurements of technological improvement to see, how Taiwanese workers have benefited, (or suffered from the absence thereof).

If any policy recommendation to Taiwanese government could be derived from the conclusion, it would be that higher education expansion starts to become a negative factor to wages, hence it should be stopped and replaced with more focus on college, vocational school and so on. The tolerance policy against the housing bubble proves to be harmful and that an 1% increase for each company could be offseting $5\% \sim 10\%$ of the benefit brought by one year of education. The government should levy a higher, more inclusive taxation scheme upon the profit earned in real estate arbitrage. The current tax system on real estate in Taiwan is no-doubt one of the most relaxed schemes in the world, which does not effectively prohibit arbitrage speculation, but encourages it. The government could improve the wages of the younger generation, if they make a better attempt at limiting corporate arbitrage. Lastly, since relative demand for higher education is not really created by ECFA, maybe the Taiwanese government should utilize the chance provided by the Sunflower movement, i.e., not coming to an agreement with China on CSSTA, which might cause the relative demand in educated labour to decrease even more. After all, not all FTAs are beneficial for all parties involved, as put by Hecksher and Ohlin. sometimes it could be harmful to everyone in the economy. Sometimes it is not just about having as much access to the markets in the rest of the world, but the content of the agreement, and the people involved which matter most. For the younger generation, thanks to the expansion policy in higher education, many of them being classified as educated workers, ECFA is not surprisingly a questionable elixir for their stagnant wages, if not poison.

[14]In App ..9, an attempt of addressing on industrial fixed effect and how time should supplement the estimation is included.

Chapter 4

Comparison Analysis on factors of Mincerian Wage Determination between Taiwan and the UK

Building upon the preceding chapter, this chapter attempts to make a contribution by examining how wage determining factors (identically or similarly defined as in the previous chapter) would have a similar or different impact on wages in the UK. In much empirical literature utilizing the Mincerian wage determining structure, we found little evidence that corporate arbitrage real estate investment in the housing market being a determining factor. Based on the Quantile Regression estimates in the last chapter, we believe this is an important wage determining factor that should not be omitted, and thus we are motivated to utilize an approximated metric that similarly estimates the arbitrage investment, and have it included into our Mincerian model.

In the previous chapter, similar to what had been found by Chauvel (2010) in French cohorts, a cumulative effect in education is corroborated in Taiwanese data, i.e., the education returns are lower for younger cohorts (Chauvel 2010). Also it is substantiated that the speculative industrial indebtedness in the real property tends to be so large of a negative marginal impact on wage, that it could offset the education marginal return for the youngest Cohort. Would similar results be empirically concluded from the UK dataset?

If the same (or similarly defined) factors are applied in the UK data set, there might be some factors in the existing system of the UK, from which the Taiwanese government could learn. Lastly, in the previous chapter, two break points are selected, when the relative labour supply (for educated workers relative to uneducated ones) presumably were influenced by the changes in relative labour demand and supply on an international scale. Similar break points were chosen to examine if the changes of context within the framework of international trade, i.e., Free Trade Agreement

(FTA), would have a significant empirical impact on wage via the aforementioned factors, and whether such structural breaks could be consistent with the real world occurrences. The key questions posed in this chapter are: How are the wage determinants (e.g., education attainment, industrial investment in real estate) affecting the UK labour force, in a similar or different ways as opposed to their Taiwanese counterparts? And how does such impact change at different structural breaks?

In this chapter, we intend to follow the same approach taken in the last chapter as much as possible, utilizing the expanded Micerian wage determining structure so to discuss how similarly/ differently influential these wage determining factors, e.g., education return or corporative real estate investment would be in the UK's Mincerian wage equation. By establishing an expanded version of Micerian wage structure, we implement it onto the whole BHPS sample, and then onto each cohort (segmented in the manner as in Taiwanese dataset) respectively so to see if the pattern of education return as well as that of other wage determining factors across UK's cohorts are similar with that of Taiwan. Secondly, we would also implement sub-period analysis by segmenting the full-sample PSFD dataset into 3 smaller samples of different periods, and examine whether the coefficients experience significant changes before and after the terms of trade of the UK changed at: 1995 when Austria, Sweden, and Finland joined the EU as member states and 2005, when the A10 countries join the EU. With that being said, we attempt to examine if the education return as well as other wage-determining coefficients change in accordance with such change, and thus verifying the similar theoretical dynamics that seems to make sense in last chapter. Starting with the cross sectional estimator which serves more of an indicator of an intermediate result, we use the knowledge acquired from the result thereof into the implement of Quantile Regression Estimator, upon which we put more emphasis and confidence.

Compared with the previous chapter, not only using a similar research method, but we also strive to use similar variables as possible: education attainment, experience, characteristic variables are all identically defined. In terms of candidates of instrument variables, we similarly select two dummy indicators for education reformation in the UK, i.e., the 1988 "Baker's Act" and 1998 "Education Act", which is similar to those in the previous chapter yet happened at a different period of time. Also, the cohorts are defined identically so to compare the result between two countries. For discussion concerning the variables, please refer to section 4.2.2.

Be that as it may, there are still some limitations that prevent us from making the comparisons identical. To start with, real estate investment in the UK data set is not identically defined due to limited accessibility of the data of industrial

real estate investment in the UK. More details such as the definition of our alternative variable and the reasoning thereof, is available in section 4.2.3. In the hope to further assist the aforesaid variable to more closely capture the arbitrage investment in the housing market, we introduce a new index to identify the industrial investment in technology and the level of employee empowerment thereof into the Mincerian structure. To our belief, introducing these two novel variables into the Mincerian wage structure would be our contribution to the Empirical literature in the UK context. Nevertheless, we would have to admit that, the coefficient of real estate investment is not identically defined in both chapters, hence we would not be able to compare the magnitude thereof directly between countries. As the said variable is as similarly defined as possible, the directions thereof is still referential and meaningful and thus we might be able to conclude there are some factors that function differently in each country (e.g., taxation, property regulation) that cause such differences. Another difference is the period of time we choose to study in the UK context. For closer discussion on the period chosen, or the time chosen for break point analysis, please refer to section 4.2.1 and 4.2.7 respectively.

4.1. Theoretical Framework

In this chapter, we continue to follow the wage determining structure established by Mincer (1974) while adding the industrial real estate investment so to discuss how different relevant policies implemented might be influential to wage via different wage determining factors, e.g., education or corporative real estate investment.

4.1.1. Mincerian Equation

In the following human capital function:

$$h(s,x) = h(\cdot)e^(\beta_1 S + \beta_2 X + \beta_3 X^2) \tag{4.1}$$

which follows the Mincerian human capital structure, where $h(\cdot)$ is a function of individual's characteristics regardless the accumulation of education and working experience, i.e., age, gender and so on. The empirical effect of these characteristics remain undetermined ex ante i.e.,

$$\begin{aligned} \tfrac{\partial h}{\partial age} &= h_{age} \lessgtr 0; \\ \tfrac{\partial h}{\partial gender} &= h_{gender} \lessgtr 0 \end{aligned} \tag{4.2}$$

The primary structure of the above human capital function, and that of the following empirical regression adapts the standard Mincerian Equation from Mincer's Accounting-identity model, which is summarized as follows(Mincer 1974):
Let P_t be the potential earnings of an individual at age t, with s years of education,

and k the ratio of costs of training investment:

$$\begin{aligned} P_t &= \prod_{j=0}^{t-1}(1+\rho_j k_j)P_0 \\ \ln P_t = \ln P_0 \ + \ s\ln(1+\delta_1) &+ \sum_{j=s}^{t-1}\ln(1+\rho_l k_j) \\ &\approx \ln P_0 + S\delta_1 + \rho_l \sum_{j=s}^{t-1} k_j \end{aligned} \tag{4.3}$$

Given a constant rate of return to schooling δ_1 for j=1...s, and a constant rate of return to training investment ρ_l

By following Mincer's linear assumption of declining rate of post=schooling investment $k_{s+x} = k(1-\frac{x}{T})$, x=T-s, with T being the length of work life and x the amount of work experience after schooling, then

$$\begin{aligned} \ln Y(s,x) \approx \ln P_{x+s} - k(1-\frac{x}{T}) = \\ [\ln P_0 - k] + s\delta_1 + \rho_l \sum_{j=s}^{t-1} k_j + \frac{kx}{T} \Rightarrow \\ \ln Y(s,x) = [\ln P_0 - k] + s\delta_1 + (\rho_l k + \frac{\rho_l k}{2T} + \frac{k}{T})x - \frac{\rho_l k}{2T}x^2 \end{aligned} \tag{4.4}$$

By expressing in terms that do not change along with s and x, i.e., $\ln P_0 - k$ with the human capital function, we could derive a common structure of Mincerian wage equation as follows:

$$\begin{aligned} \ln W = &\beta_0 + \beta_1 education + \beta_2 experience + \beta_3 experience^2 + \beta_4 gender + \beta_5 age + \\ &+ \epsilon \end{aligned} \tag{4.5}$$

4.1.2. Education Returns, and the Demand and Supply in the Labour Market

As done in the previous chapter, in chapter 4 we also attempt to apply sub-period analysis via examining the changes in education return as ex-post evidence to the change in the demand and supply of labour market, and whether it is in accordance with policies implemented that may have influence on the domestic labour supply and demand. With this approach we might be able to evaluate the net effect of these policies. The principles connecting labour demand and supply with education return is elaborated as follows. In Mincer's theoretical wage model in 1976, he proposes that labour interflow between the sectors would occur due to the wage differences, which would in turn change the wage premium between sectors (Mincer 1976).

Let's Assume the wage level in equilibrium in a labour market of high school graduate is w_H, while that in the first degree graduate is w_F , as shown in the in Figure 4.1.

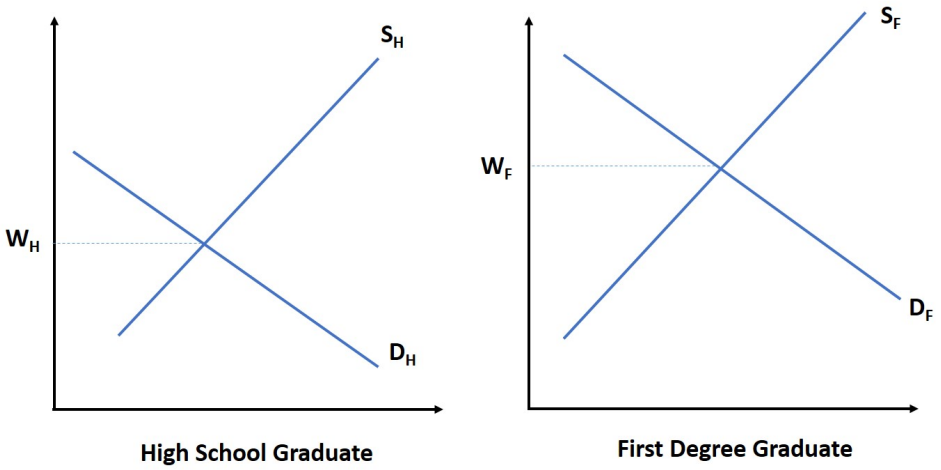


Figure 4.1: Labour Demand and Supply of High School Graduates only and First Degree Graduates Sector(Chiu 2004)

Let us follow Chiu's application of Mincer's work (2004)further assume $w_F > w_H$, and define the education return $R_s = \frac{W_F - W_H}{W_H}$ is the proportional premium a labour could earn, should she decide to complete a first degree and thereby join the first degree graduate labour market. Also, let us define the relative labour supply as the ratio between current labour supply in the first degree market, to that in the high school graduate market, and define the relative labour demand as the same ratio, but in terms of labour demand(Chiu 2004).

Ceteris paribus, education return (R) could be improved via two routes: 1) decrease in relative labour supply (rightward movement of labour supply curve in the high school graduate market S_H or leftward movement of labour supply curve in the first degree market S_F), or 2) increase in relative labour demand (leftward movement of labour demand curve in the high school graduate market D_H or rightward movement of labour demand curve in the first degree market D_F). Similarly, education return would experience a decrease if relative labour demand decreases, or relative labour supply increases. Be that as it may, the change in education return would be ambiguous if the relative labour supply and relative labour demand move in the same direction. To wit, given the presence of increasing educated labour supply due to an education expansion policy, if the following empirical results show the education return decreases albeit an increase in relative demand of educated workers, it might mean the relative demand changes by a smaller amount than relative supply does. Likewise, if increasing education returns is to be observed, albeit the presence of increasingly educated worker, it means the relative demand changes by a larger amount than relative supply.

4.1.3. Novel Wage Determining Factor: Corporative Real Estate Investment

In this chapter we also follow the process in chapter 3, by expanding the existing Mincerian wage determining structure with a novel variable, i.e., industrial real estate investment. Such attempt is made to discuss whether a similar negative impact could be influential on wage from industrial real estate investment. Assume the wage $\hat{w}$ is determined by the production function of firms that are as many as to achieve competitive equilibrium in an economy:

The production function in per capita term is:

$$y = k^{\alpha}[hL]^{1-\alpha} \tag{4.6}$$

A representative firm in this economy has two ways to gain profit: 1) sell its production at price P, and 2) using the remaining capital, i.e., the amount of capital that is not used in the production function $K_F = \bar{K} - K_y$ to invest in the real estate market. The production function follows the form as Cobb-Douglas Function with labour input (L), whereas the profit from the real estate investment is uncertain, due to the nature of the market. The profit is thus expressed in expectation, $\theta \in [0, 1]$ is the probability of better yields in the real estate market ($r_{F,H}$) and 1- θ is the probability of low yields, i.e.,($r_{F,L}$).

$$\max_{x} \qquad \pi = PY - wL - r_y K_y + [\theta(1 + r_{F,H})K_F + (1 - \theta)(1 + r_{F,L})K_F] - K_F$$

$$\text{subject to} \quad y = K_y^{\alpha}[hL]^{1-\alpha};\ K_y + K_F = \bar{K};$$

So, in this partial static competitive factor market equilibrium, by F.O.C, $\frac{\partial \pi}{\partial L} = 0$ it implies the real wage equals to marginal Productivity of Labour:

$$\frac{w}{p} = MPL = h(1 - \alpha)L^{-\alpha}(\bar{K} - K_F)^{\alpha} \tag{4.7}$$

and since $\frac{\partial}{\partial K_F}\frac{w}{P} < 0$ it implies if more capital is used to invest in the real estate market, it would reduce the real wage in equilibrium.

Also, by F.O.C, $\frac{\partial \pi}{\partial K_F} = 0$, the optimal level of Capital is:

$$K_F = \bar{K} - [\frac{r_y + \theta(r_{F,H} - r_{F,L})}{P\alpha}]^{\frac{1}{\alpha - 1}} \tag{4.8}$$

so it is discernible that if the probability of high yields (e.g., real estate bubble) increases, the higher the interest premium ($r_{F,H} - r_{F,L}$) is, or the higher the marginal cost of capital employment in the production r_y is, K_F would increase, i.e., more

capital would be shifted to the more profitable investment target.

Ergo, we expand the existing Mincerian structure by adding the extra factor, i.e., the industrial real estate investment, in the following manner:

$$\begin{aligned}\ln W =& \beta_0 + \beta_1 education + \beta_2 experience + \beta_3 experience^2 + \beta_4 gender + \beta_5 age + \\ & \beta_6 realestateinvestment + \epsilon\end{aligned} \tag{4.9}$$

4.2. Data

4.2.1. Primary Data

The data is collected from the British Household Panel Survey (BHPS), which was conducted by the Institute for Social and Economic Research (ISER) at the University of Essex from 1991-2009 (18 waves in total)[1].

Accordingly, the BHPS was designed as an annual survey of each adult (16+) member of a nationally representative sample of more than 5,000 households, making a total of approximately 10,000 individual interviews.

The same individuals were re-interviewed in successive waves and, if they split-off from their original households, all adult members of their new households were also interviewed. Children were interviewed once they reached the age of 16; there is also a special survey of 11-15 year old household members from Wave 4 (1994) onwards. Thus the sample remained broadly representative of the population of Britain as it changed through the 1990s. Wave 9 includes extra samples from Wales and Scotland with an emphasis on the Welsh language and feelings of nationality. Wave 11 includes an additional sample from Northern Ireland, which formed the Northern Ireland Household Panel Survey (NIHPS), and was added to increase the representivity of the whole of the United Kingdom.(University-Of-Essex 2010). In terms for the response rate, according to Buck et al, it fluctuated between 89.6% to 96.3% (Buck et al. 2006)[2]. The refusal rate, which in many cases might be an equivalent metric for attrition rate, fluctuated around 8 percent instead.

[1]After wave 19, it is latter merged with the United Kingdom Household Longitudinal Study (UKHLS), which was also carried out by ISER.

[2]Due to the fact that the Cohorts in our analysis are just divided according to what has been done in the previous chapter, the response rate cannot otherwise be calculated by the cohorts since it is not calculated by the cohorts in Buck et al's works.

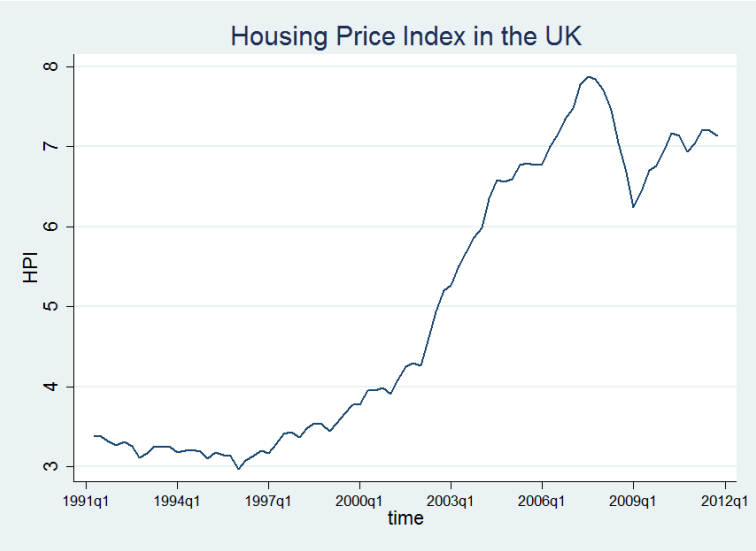


Figure 4.2: Quarterly UK Housing Price Index 1991∼2013(Nationwide 2014, National-Archive 2014)

For this chapter, the 18 waves are covered up to April 2009, which includes the periods of time that are of analytical interest to this chapter. From Figure 4.2, we could see the housing price-income ratio in the UK start to soar in 2003, This data set serves as the source for the following variables, e.g., education attainment years, working experiences, and characteristic variables (University-Of-Essex 2010). During our selection of time (1991∼ early 2009), it does not only include the boom of the UK housing market starting from 2003 and ending by the financial crisis in 2008, but also the two EU enlargements happening in 1995 and 2005 respectively. These two incidents (the 4th and 5th enlargements of the European Union) might purportedly affect the change in relative demand and supply of the UK labour market. Similar changes within the context of EU is less observable after 2005. With that being said, we would focus our discussion within the said period, albeit there is a similar upsurge in the UK housing market, if not higher in the period post 2009.

4.2.2. Variables

4.2.2.1. Education Attainment Years

To increase comparability between the UK's empirical results with those of Taiwan, the measurement of education attainment years follows what has been done in Chapter 3, i.e., the education attainment years of each interviewee are approximated by the average year of each level of education attainment[3].

[3]It should be acknowledged that, such an approach might inevitably overlook the part of variation contributed by those who attain education irregularly, e.g., dropouts, home-schooled, suspensions or extensions. Be that as it may, such an approach still has its advantage in terms of empirical application. Especially in the BHPS data set, some interviewees fail to provide precise dates of each education attainment, so such approximation is thus a viable way to supplement the

4.2.2.2. Working Experience

In empirical literatures of Mincerian analysis, experience is commonly included and assumed to have a non-linear relationship with earnings. Here in chapter 4, we follow the method in the previous chapter, taking actual experience for measurement of working experience. In the BHPS dat set, the start / end date of employment spell is recorded in detail for each job the interviewee has in her employment history. The employment spell would latter be summed and measured in years before inclusion into the regression.

4.2.2.3. Characteristic Variables

Following the approach in the last chapter, characteristics such as gender and age are included as well. Age is the physical age of the interviewee when she took the survey, and gender is a dummy indicator, being 0 if the interviewee is female, and 1 being male.

4.2.3. Industrial Real Property Investment

As the anonymity of BHPS data set prohibits researchers to have direct observation on the real estate investment of the corporation where the interviewees work, an industrial average investment is thus applied as a proxy. However, due to the limit of accessibility to the industrial investment on real estate property, such proxy requires further calculation. In the following paragraph, the gross capital stock of United Kingdom is captured from the STAN database of the OECD library, with which the annual amount of investment would be measured according to the following formula (OECD 2014) :

$$I_t = K_{t+1} - (1 - \delta_t)K_t \tag{4.10}$$

The gross capital stock (K_t) of each time t is inserted into the equation above, while δ_t is the depreciation rate of each year[4].

missing data, and maximize the information available.

[4]The depreciation rate applies the annual data listed as "the Consumption of Fixed Capital" (CFC), available in the Annual macroeconomic database released by the European Comission (European Comission 2014)

After measuring the annual investment on an industrial basis, in the following Mincerian regression, the property investment is measured in natural logarithms, before an estimator of the log industrial investment in the real estate market would be derived using the House Price Index as instrument, and latter applied into the 2sls Mincerian equation.

Nonetheless, since the real estate investment variable is not identically defined as that in Chapter 3, albeit as closely defined as we could with the help of Technology and Empowerment Industry Index (TEII, to be discussed in the following subsection), we should not directly compare the marginal impact of arbitrage real estate investment in Taiwan and that in the UK by the size of coefficients thereof. Be that as it may, since this valuable is not identically defined, yet similarly describing the real estate investment that is related with the housing market price fluctuations, we still could tell whether the arbitrage real estate investment is benign as a wage determining factor or not, by examining the direction of the coefficient.

4.2.4. Technology and Empowerment Industry Index

The industrial real property investment included in the Mincerian regression, as elaborated above, is not necessarily the most direct counterpart to Taiwanese industrial indebtedness for real property in the last chapter. The estimated part of investment that is related with the Housing Price Index, could more than likely include the non-speculative investment e.g., investments on factories, branches, and equipment that can actually be positively related to the corporation operation per se, and the human capital of their employees. Hence it is attempted here to include an extra explanatory variable, i.e., Technology and Empowerment Industry Index (TEII), as to account for the corporate investment on employees' human capital. From the Skill and Employment Survey, which is a series of surveys investigating the employed workforce in the United Kingdom, produced by Felstead et al., 9 questions are chosen from the 2006 survey[5](Felstead et al. 2012).

To utilize the information that could be retrieved in a integrated method, Multiple Correspondence Analysis (MCA) is implemented. MCA is a extended version of correspondence analysis, capable of analyzing multiple categorical variables (Hair et al. 2010). By axis-rotating, it explores and exploits the relation between the categorical variables by representing data as points mapping onto a low-dimensional Euclidean space. The dimensions derived from the MCA,can be thus regarded as a

[5]Due to the varieties among questions asked of different years, many of the variables selected are not available in years such as early as 1992, 1997,and 2001. Be that as it may, since the 2006 survey includes all 9 of the selected variables, a rather strong assumption is required, i.e., the difference among industries is fixed for the time being. Such simplicity comes with a certain level of concession, that might not seem realistic adjusting for the difference occurring intra-industrially, but similar to including an industry Fixed-Effect into regression.

form of index that is loaded with information integrated from the categorical variables. Inertia, on the other hand, is the singular value squared, and equivalent to the Eigenvalues of the covariance matrix in factor analysis. The sum of inertia of each dimension represents the volume of information contained thereof, and from which the contribution of each dimension, i.e., the ratio between the sum of inertia of the dimension and the total inertia. The measure of contribution allows readers to see how much information is contained in each dimension.

Following the approach of MCA, these 9 variables (8 of them are dummy variables and 1 categorical variable) would be redacted onto a lower dimensional spaces. The variables and their corresponding questions are available in Table 4.2. From Table 4.1, we see the contribution of the inertia that dimension 1 (a1) made is 65.81%, implying 65.81% of the total inertia can be accounted by dimension 1. Likewise, the contribution of inertia made by dimension 2 (a2) is 31.61% and together could cumulatively account for 97.43% of the total inertia. The implication of dimensions sometimes could be of assistance in interpreting the perceptual mapping. Often the dimensions are named after the variables that have the largest contribution to the said dimension (Hair et al. 2010). From Table 4.2, it is obvious that the "jothch3" (new communications technology introduced at his/her workplace 0=NO, 1=YES) is the largest contributor(0.152) among all in dimension 1, and "evmoney2" (whether interviewee can express views at meetings about: the financial position of the organisation he/she works for 0=NO, 1=YES) is the largest contributor (0.167) among all in dimension 2. Hence dimension 1 could be named as "communication technology" (or technology) and dimension 2as "liberty of expression on financial decision" (or empowerment).

A coordinate plot of how each variable makes a contribution is available in Figure 4.3, from which it is rather salient that along dimension 1, all the "YES"s locate at either quadrant II or quadrant III, and all the "No"s located at quadrant I and IV. To derive an inclusive index that is increasing in both technology spending on labours, it is required that dimension 1 to be rotated by 180°. Hence, for each interviewee in the survey, he or she has two scores for dimension 1 and dimension 2. To harmonize between the skill survey and the BHPS data set, the result of MCA is latter collapsed by industries (2 digit UKSIC92 code).

Also, after dimension 1 is re-scaled (rotated by 180°) a diagram of perceptual mapping is derived, by summing up over each industry among all the interviewees in 2006[6]. In Fig 4.4 it provides a closer overview of how each industry scores in either dimension. Lastly, to further simplify things while retaining the derived re-

[6]The industries are classified by the 2 digit UK Standard Industrial Classification 1992.

sults, the scores in the two dimensions would be further redacted into a weighted mean for each industry, and re-scaled into a TEII ranging in [0,100]. A bar chart summarizeing all the TEIIs for each industry is available in Figure 4.5[7].

Table 4.1: Multiple Correspondence Analysis

Multiple/Joint correspondence analysis — Number of obs = 2904
Total inertia = .0519875

Method: Joint (JCA) — Number of axes = 2

Dimension	principal inertia	percent	cumul percent
dimension 1	0.0342155	65.81	65.81
dimension 2	0.0164338	31.61	97.43
Total	0.0519875	100	

Table 4.2: Dimensional Contribution of Variables

Categories	Description	overall			dimension 1			dimension 2		
		mass	quality	%inert	coord	sqcorr	contrib	coord	sqcorr	contrib
hightr	*More than Two Year's Training, 0=NO, 1=YES*									
NO		0.071	0.67	0.008	0.332	0.669	0.008	-0.023	0.001	0
YES		0.04	0.67	0.014	-0.592	0.669	0.014	0.04	0.001	0
jothch2	*new computerised/automated eq'ment introduced at workplace 0=NO, 1=YES*									
NO		0.04	0.994	0.129	1.946	0.768	0.15	-1.525	0.226	0.092
YES		0.072	0.994	0.071	-1.078	0.768	0.083	0.845	0.226	0.051
jothch3	*new communications technology introduced at workplace 0=NO, 1=YES*									
NO		0.047	0.999	0.125	1.803	0.802	0.152	-1.289	0.197	0.077
YES		0.064	0.999	0.09	-1.305	0.802	0.11	0.932	0.197	0.056
jothch4	*other new equipment introduced 0=NO, 1=YES*									
NO		0.055	0.997	0.051	1.056	0.796	0.061	-0.767	0.202	0.032
YES		0.056	0.997	0.05	-1.034	0.796	0.06	0.751	0.202	0.032
evmoney2	*whether can express views at meetings about: financial position of organisation 0=NO, 1=YES*									
NO		0.053	0.995	0.099	1.142	0.462	0.069	1.77	0.533	0.167
YES		0.058	0.995	0.091	-1.052	0.462	0.064	-1.629	0.533	0.154
evinvest	*whether can express views at meetings about: investment plans of organisation 0=NO, 1=YES*									
NO		0.068	0.994	0.071	0.856	0.465	0.05	1.317	0.529	0.118
YES		0.043	0.994	0.112	-1.357	0.465	0.079	-2.088	0.529	0.187
evtrain2	*whether can express views on about training plans 0=NO, 1=YES*									
NO		0.019	0.888	0.033	1.39	0.728	0.036	0.943	0.161	0.017
YES		0.092	0.888	0.007	-0.284	0.728	0.007	-0.193	0.161	0.003
esuggest	*whether made any suggestions over last year about: improving efficiency 0=NO, 1=ONCE, 2= MORE THAN ONCE*									
NO		0.021	0.893	0.024	1.217	0.861	0.031	0.334	0.031	0.002
YES ONCE		0.01	0.683	0.005	0.564	0.425	0.003	0.636	0.259	0.004
MORE THAN ONCE		0.08	0.867	0.01	-0.384	0.797	0.012	-0.164	0.07	0.002
trainfinanced	*where the company finance the most recent training 0=NO, 1=YES*									
NO		0.097	0.612	0.002	0.116	0.501	0.001	0.079	0.111	0.001
YES		0.014	0.612	0.012	-0.792	0.501	0.009	-0.538	0.111	0.004

[7]Readers should notice that the TEII here is a relative measurement, that should only be compared in ordinal terms, but does not possess proportional implications. With that being said, for instance, an industry with TEII equivalent to 80 is of a higher focus in terms of human capital of employees than that with TEII equal to 40. But it does not imply that the former industry possesses twice as much human capital as the latter industry.

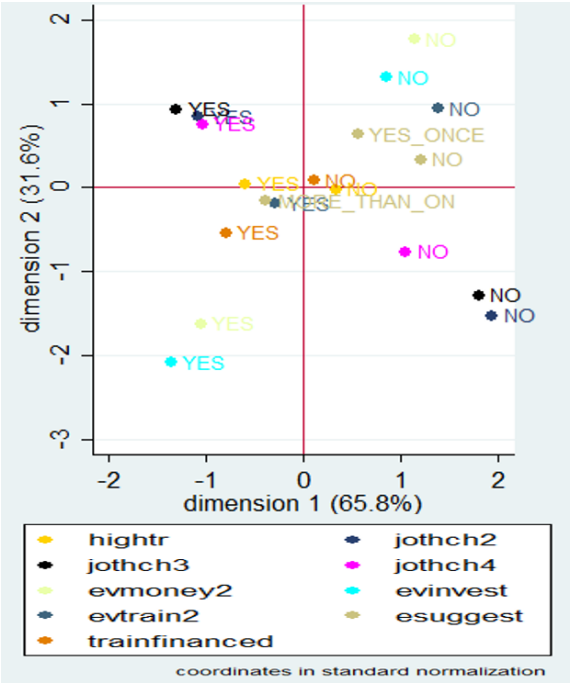


Figure 4.3: MCA Coordinate Plot

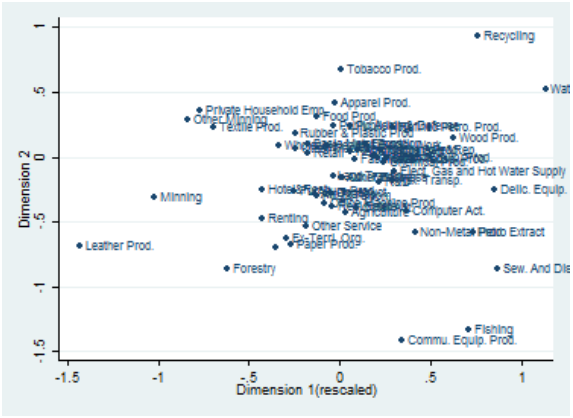


Figure 4.4: Perceptual Mapping by Standard Industrial Classification 1992

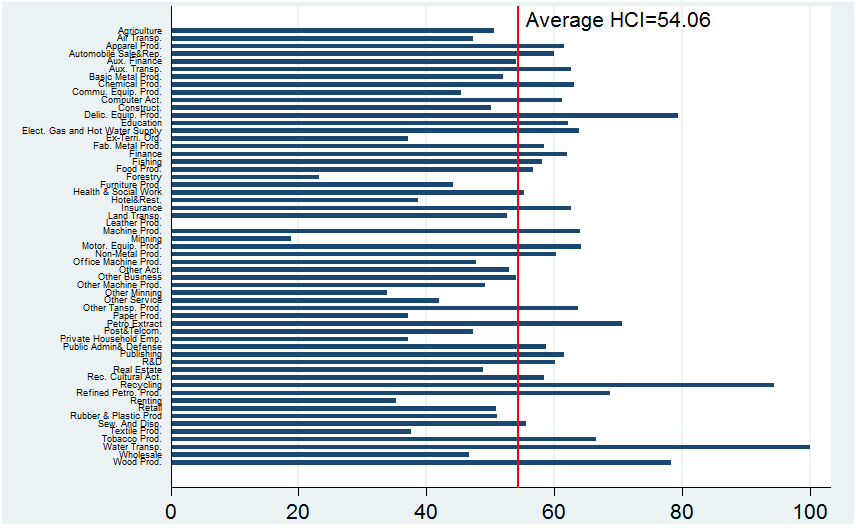


Figure 4.5: Technology and Empowerment Industry Index by UK Standard Industry Classification

4.2.5. Possible Candidates of Instrument Variables

4.2.5.1. IV: Dummy Indicator for Education Reformation

For the UK data set, let the dummy variable R1988=1 if the interviewee went to school between 1988 and 1998, and 0 otherwise, whereas dummy variable R1998=1 if the interviewee went to school after 1998, and 0 otherwise. In 1988, the Education Reform Act, sometimes referred to as "The Baker Act" was enacted, and considered as the most important education act since 1944, changed a public service into a market (Powell & Edwards 2005). It gave greater power back to schools over important decisions such as budget, staff employment which might have impact on the availability of education and thus might change an individual's decision of enrollment from one school to another[8]. Similarly in 1998, two related Acts are announced in succession: "Education (Student Loan) Act 1998" and Teaching and Higher Education Act 1998," which transferred student loans to the private sector, and have new rules applied to student loans ever since. Such change might likewise affect decisions of educational attainment.

4.2.5.2. IV: Housing Price Index

As for the Housing Price Index (HPI) in the UK, following the approach applied in the previous chapter, the ratio between the local average housing price and the median household income, sometimes also known as the housing price-income ratio, is harmonized with the BHPS data set by the date of interview (on a monthly basis) and regional code. The regional house price is captured from the database of the Nationwide Building Society, whereas the median household income is captured from the National Archive (Nationwide 2014, National-Archive 2014).

Be that as it may, another plausible metric to assess a housing bubble that is akin to our HPI is the housing price-to-rent ratio. Such a metric measures the ratio between purchasing price and rental price of a property in average at a specific time and in a specific place, intended to reflect the relative cost of owning versus renting (Himmelberg et al. 2005). Such data, in the form of time series, has been well recorded by different government agent or institutes in the UK, e.g., Land Registry, Nationwide, and the Halifax, on either a monthly or quarterly level. Nevertheless, such data is not equivalently available in Taiwan [9]. Such absence ff data explains why Taiwanese

[8]Moreover, it introduces other forms of education, e.g., City Technology Colleges (CTC) and Grant-maintained school (GMS) that are also free from the control of local authority but might have an impact on the educational decision for individuals to receive education.

[9]In the database constructed by the Taiwanese Ministry of Domestic Affairs, the average rental price is not available in the form of time series, but only recorded on an annual basis, national-wise (no county / municipal level data), for only a decade. Other private databases have similar issues.

empirical scholars would utilize alternative such as the HPI defined previously instead, which has been available for decades, or derive sampling statistics from their own research questionnaire. That said, due to the limit of data accessibility, this chapter would continue in using the HPI that is identically defined in both chapters, to achieve consistency.

4.2.5.3. IV: Regional Code

The original BHPS data set is classified into 19 regions, and further simplified into 12 regions so as to remain consistent with the data collected from Nationwide Building Society. A similar approach has been applied in the Taiwanese data set.

4.2.6. Inverse Mills Ratio

Another issue that has often been been raised in the analysis of Mincerian education returns is selection bias. To address that, this chapter follows the approach applied by Heckman's two stage correction model, adding a modification term, e.g., Inverse Mills ratio, derived by a first-stage probit model to estimate the labour participation rate (Heckman 1979):

$$z_i^* = \omega_i \gamma + u_i \tag{4.11}$$

and

$$z_i = \begin{cases} 1, & if z_i^* > 0 \\ 0, & if z_i^* \leq 0 \end{cases} \tag{4.12}$$

where ω_i is the individuals's characteristic, e.g., gender (=1 for male, and 0 for female), age, years of education attainment, dummy indicator of having children or not (=1 if having any child, and 0 otherwise), dummy indicator of residence (=1 if living in an urban area, and 0 if living in a rural area)[10]. The inverse Mills ratio would be included in cross-sectional estimates, and Quantile Regression estimates and is denoted as Λ.

4.2.7. Data Segmentation

Similarly, to compare coefficients across Cohorts, the BHPS dataset would be further segmented into 3 Cohorts. Following the arrangement in the previous chapter, the first Cohort is those who were born between 1953 and 1964 (Cohort I), second between 1965 and 1976 (Cohort II), and last from 1977 to 1983 (Cohort III).

[10]For BHPS data set, the definition of rural and urban residential indicator follows the one introduced in 2004 as a joint project between a number of government departments and delivered by the Rural Evidence Research Centre (RERC) at Birkbeck College. Accordingly, an area with a residential population more than 10,000 would be classified as an urban area, and those lower than 10,000 would be classified as a rural area(Office-For-National-Statisics 2014).

Such arrangement also allows a more direct comparison between the results of the UK and those of Taiwan. Furthermore, a similar attempt to see how coefficients change (or do not change) at certain break points is considered. In Chapter 3, the break points were selected at the time when the context in terms of the Foreign Trade Agreement (FTA) of Taiwan changes. In the UK's scenario, two break points are selected to simulate the change of FTA: 1995 when the 4th enlargement of the European Union was carried out, during which Austria, Sweden, and Finland, relatively wealthier countries, joined the EU, and 2005, when the 5th enlargement of the European Union became effective, as the A10 countries joined[11]. As explained previously, such a change within the context of EU members might have different impacts on the relative labour supply or demand respectively. Other candidates such as 1992 is arguably a good break point, when UK polytechnics became fully fledged universities under the Further and Higher Education Act of 1992 started to award their own degree (Panchamia 2012). Be that as it may, since our 2nd choice of break point at 1995 might as well include the variation brought by the first year students recruited by the "new" universities starting to participate into the labour force while also identifying the change in the UK labour market caused by the 4th enlargement. Given the fact that it would be pointless to a great extent including two break points too close with one another, and equivalently so if including a break point at 1992 that is too close to the starting year, i.e., 1991, in which case the sizes of sub samples would be extremely uneven. That said, we would have the two break points at 1995 and 2005 so to implement break point analysis.

4.3. Descriptive Statistics

The following section summarize some statistics for the BHPS data set. In Table 4.3, the mean of the variables of three Cohorts and those of the whole sample (Total) are presented. Once again (as with Taiwan in Chapter 3), the real wage measured in USD decreases over Cohorts. This is consistent with common assumptions held against the labour market, i.e., wage increases in education and experience in a linear/non-linear pattern, which is accumulated as age increases. Also, if compared with Taiwanese results in the previous chapter, the real wage in the UK is essentially higher for every Cohort than that in Taiwan. Education attainment year (Eduyear in the Table) increases from Cohort I to younger cohorts, yet slightly decreasing from Cohort II to III. The difference between Cohort I and younger cohorts (II and III) is somewhat similar with the Taiwanese case, yet at a slower pace (Cohort II: 10.885 and Cohort III: 10.808 in the UK, while Cohort II:13.03 and Cohort III:14.47

[11]The A10 countries are: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia.

in Taiwan). It may actually imply a more moderate education policy in the UK. Experience of each Cohorts, is as anticipated, increasing in age, and thus decreasing in Cohorts. As for the industrial investment in real property (Realpropinv in the Table), the difference between Cohorts seems to be moderate (largest difference between Cohort I and Cohort III is roughly 680 million USD), and it is essentially lower for all Cohorts in the UK than in Taiwan. Such might be evidence showing Taiwanese industries' stronger preference for real property investment. As for the HPI, it is less obviously but surely increasing in Cohorts. This result is similar in the Taiwanese finding, only the HPIs are larger in Taiwan for all Cohorts, implying the real property in Taiwan is less affordable than in the UK, with respect to average income. In terms of TEII, the value ranges around 55 for the three Cohorts, this might be understandable as interviewees of each Cohort is distributed in a similar, random pattern across all industries. Lastly, from the education composition ratios, it might be concluded that education attainment improves as the Cohorts become younger (illiteracy decreases from Cohort I to II and III), however, the portion of higher education (First degree + Higher degree) experience a smaller increase in Cohorts as opposed to that of Taiwanese result. This can also be regarded as evidence that the UK's education policy has followed a relatively balanced approach rather than biased toward higher education, as in the Taiwanese context.

Cohort	I:1953∼1964	II:1965∼1976	III:1977∼1983	Total
RealwageUSD	2788.068	2535.675	2212.628	2602.957
Eduyear	9.523	10.885	10.808	10.310
Exp	31.79	21.35	13.87	24.418
Realpropinv	64892.93	64321.09	63210.72	64373.488
HPI	4.539	4.579	4.977	4.629
TEII	55.711	55.594	54.809	55.509
Illiteracy or N/A	0.260	0.155	0.155	0.198
CSE	0.071	0.084	0.078	0.078
Olevel	0.267	0.286	0.286	0.278
Alevel	0.183	0.236	0.280	0.222
Dip. and Cert.	0.069	0.077	0.051	0.069
First degree	0.118	0.134	0.130	0.127
Higher	0.032	0.029	0.019	0.028
N	51650	52563	20829	125042

Table 4.3: Mean of BHPS variables: by Cohorts

In Table 4.4, wage obviously increases over time. Experience increases from 20 to 32 years, which is intuitively true as experience would monotonically increase along with age. Real property investment increases as HPI increases over time as

well. TEII still fluctuates around 55. As for the Education Composition ratio, it is obvious that education prevails over time, the illiteracy rate, ratio of CSE and that of O level decrease, while those of A level, First degree and Higher education increase.

Period	Before 1995	1996∼2005	After 2005	Total:
RealwageUSD	2077.444	2500.023	3375.914	2602.957
Eduyear	9.999	10.392	10.336	10.310
Exp	20.608	23.199	32.137	24.418
Realpropinv	49814.021	64050.025	85329.777	64373.488
HPI	3.265	4.336	6.903	4.629
TEII	56.981	55.342	55.171	55.509
Illiteracy or N/A	.200	.193	.214	.198
CSE	.101	.075	.062	.078
Olevel	.316	.276	.248	.278
Alevel	.220	.227	.206	.222
Dip. And Cert.	.052	.072	.074	.069
First degree	.097	.128	.153	.127
Higher	.014	.029	.042	.028
N	22732	78673	23637	125042

Table 4.4: Mean of BHPS variables: by Periods

From Table 4.5 to 4.7, variables are further summarized at different education levels for different Cohorts. Following the same measurement of wage premium in the descriptive statistics of the last chapter, as listed in Table 4.8, we could see the premium is lower for Cohort II, and become highest for the youngest Cohort, while the premium in the UK(in both percentage terms and in real USD) seems to be larger than that in Taiwan. [12]

[12]Readers should be aware of the difference between the education premium and the education return emphasized in the empirical result. The education premium here is a statistic that roughly measures the difference between the average wage of the educated (first degree and above) and that of the uneducated (those achieving an education level below first degree). The education return in the following empirical result is the marginal effect that one additional year of education attainment has upon wages, measured in percentage terms, ceteris paribus.

	Cohort I: 1953∼1964						
Education	CSE&below	O Level	A Level	Dip. and Cert.	First Degree	Higher	Total
RealwageUSD	1955.62	2318.69	2860.83	3283.70	4230.91	5090.59	2788.07
Eduyear	11.00	11.00	13.00	14.50	16.00	17.00	9.52
Exp	31.84	31.66	32.08	31.91	31.39	32.05	31.79
Realpropinv	64795.26	64687.14	64853.86	64756.93	65386.82	66331.93	64892.93
HPI	4.473	4.48	4.52	4.49	4.78	5.07	4.54
TEII	55.60	55.63	55.86	55.47	55.87	56.38	55.71
N	17134	13791	9451	3550	6077	1647	51650

Table 4.5: Mean of BHPS variables:by Education Level, Cohort I

	Cohort II: 1965∼1976						
Education	CSE &below	O Level	A Level	Dip. and Cert.	First Degree	Higher	Total
RealwageUSD	923.44	1574.52	1871.20	2504.16	2981.10	3397.64	1802.16
Eduyear	11	11	13	14.5	16	17	10.885452
Exp	21.20	21.65	20.75	22.00	21.46	22.33	21.35
Realpropinv	64148.79	63877.54	63584.30	64962.64	65817.40	67546.44	64321.09
HPI	4.51	4.49	4.45	4.70	4.9292599	5.16	4.58
TEII	55.51	55.02	55.62	56.35	55.850821	57.21	55.59
N	12517	15025	12423	4022	7069	1507	52563

Table 4.6: Mean of BHPS variables:by Education Level, Cohort II

	Cohort III: 1977-1983						
Education	CSE&below	O Level	A Level	Dip. and Cert.	First Degree	Higher	Total
RealwageUSD	1789.53	1872.27	2124.75	2399.95	2950.12	3678.33	2212.63
Eduyear	11.00	11.00	13.00	14.50	16.00	17.00	10.81
Exp	13.11	13.44	14.10	14.67	15.15	15.03	13.87
Realpropinv	62577.19	60463.11	61427.70	63342.86	72095.02	77193.57	63210.72
HPI	4.90	4.65	4.80	4.90	5.99	6.60	4.98
TEII	53.98	54.65	54.44	54.84	56.20	57.49	54.81
N	4839	5965	5833	1068	2718	406	20829

Table 4.7: Mean of BHPS variables:by Education Level, Cohort III

	Uneducated	Educated	Premium %
Cohort I	1819.75	3924.93	116%
Cohort II	1605.40	3057.16	90%
Cohort III	1075.60	2544.09	137%

Table 4.8: Education Premium by Cohorts Measured in USD

From Table 4.9 to 4.11, variables are otherwise summarized at different education levels for different periods. The education premium between uneducated and educated decreases over time.

	Before 1995						
Education	CSE&below	O Level	A Level	Dip. and Cert.	First Degree	Higher	Total
RealwageUSD	1647.43	1782.92	2135.12	2545.20	3041.83	4077.97	2077.44
Eduyear	11.00	11.00	13.00	14.50	16.00	17.00	7.34
Exp	22.05	20.10	19.29	21.35	20.18	22.38	20.61
Realpropinv	49778.23	49801.07	49614.01	49634.07	50477.27	50103.97	49814.02
HPI	3.24	3.25	3.26	3.27	3.38	3.36	3.27
TEII	59.01	57.23	57.00	55.16	52.58	49.11	56.98
N	6830	7175	5011	1193	2204	319	22732

Table 4.9: Mean of BHPS variables:by Education Level, Before 1995

	1996∼2005						
Education	CSE&below	O Level	A Level	Dip. and Cert.	First Degree	Higher	Total
RealwageUSD	1856.33	2094.45	2484.17	2874.39	3507.26	4241.48	2500.02
Eduyear	11.00	11.00	13.00	14.50	16.00	17.00	8.19
Exp	24.19	23.25	22.01	23.68	22.68	23.90	23.20
Realpropinv	64095.48	63963.27	63907.10	64036.83	64293.80	64539.51	64050.02
HPI	4.26	4.27	4.28	4.27	4.69	4.730	4.34
TEII	54.95	55.09	55.34	55.73	55.84	56.87	55.34
N	21126	21735	17830	5690	10033	2259	78673

Table 4.10: Mean of BHPS variables:by Education Level, 1996∼2005

	After 2005						
Education	CSE&below	O Level	A Level	Dip. and Cert.	First Degree	Higher	Total
RealwageUSD	2508.14	2777.43	3252.97	3807.76	4524.60	5140.67	3375.91
Eduyear	11.00	11.00	13.00	14.50	16.00	17.00	8.63
Exp	32.56	32.81	31.65	32.59	30.76	32.01	32.14
Realpropinv	84640.87	85677.82	85313.62	84742.98	86098.60	86120.06	85329.78
HPI	6.84	6.92	6.85	6.73	7.08	7.16	6.90
TEII	54.08	54.14	54.96	56.27	57.11	58.18	55.17
N	6534	5871	4866	1757	3627	982	23637

Table 4.11: Mean of BHPS variables:by Education Level, After 2005

	Uneducated	Educated	Premium %
Before 1995	1215.82	2608.48	115%
1996∼2005	1573.40	3156.84	101%
After 2005	2126.01	4146.74	95%

Table 4.12: Education Premium by Periods Measured in USD

4.4. Empirical Result

The following structure follows the standard Mincerian Equation adapted from both of Mincer's results,

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \\ &\beta_6 Real\ Esate\ Investment + \beta_7 \Lambda + \epsilon\end{aligned} \tag{4.13}$$

the Left Hand Side (LHS) is the natural logarithm of monthly wages, measured in USD, adjusted for the price level . The Right hand side (RHS) includes the education attainment years of each interviewee, her working experience years, the quadratic term of that, variables of characteristics such as age, and gender. Both education attainment years and industrial property investments are estimated with IVs . They nonetheless vary from one estimator to another, the choices as well as the reasons for those choices would be elaborated in each subsection of the estimator.[13]

4.4.1. Cross-Sectional Estimates

Before adapting the "amended version" of the Mincerian structure, let's start with the basic Mincerian structure, and add variables step-by-step to see if such inclusion significantly changes the direction of coefficients of existing variables. In Table 4.13, the first regression possesses the basic Mincerian structure, and is shown as follows:

$$\ln W = \beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \epsilon \tag{4.14}$$

The second equation adds two extra variables into the original Mincerian structure, i.e., industrial real property investment and inverse Mills ratio :

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \\ &\beta_6 Real\ Esate\ Investment + \beta_7 \Lambda + \epsilon\end{aligned} \tag{4.15}$$

[13]Reader should be aware of the fact that we have utilized the 2sls standard error for both the Cross-sectional model and the Quantile Regression model, for it is a built-in choice in the Stata software.

The third equation includes instrument variables, e.g., dummy indicators (R1988 and R1998) for education attainment years and Housing Price Index for industrial real estate investment. The regression is as follows:

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \\ &\beta_6 Real\ Esate\ Investment + \beta_7 \Lambda + \epsilon\end{aligned} \tag{4.16}$$

$$education\ year = \gamma_0 + \gamma_1 R1988 + \gamma_2 R1998 + u_1$$

$$Real\ Esate\ Investment = \omega_0 + \omega_1 HPI + u_2$$

The fourth equation retains the aforementioned variables in the Mincerian Equation, while adding the scores of dimension 1 (a1) and dimension 2 (a2) mapped onto the BHPS interviewees according to his/her industry code:

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \\ &\beta_6 Real\ Esate\ Investment + \beta_7 \Lambda + \beta_8 a1 + \beta_9 a2 + \epsilon\end{aligned} \tag{4.17}$$

$$education\ year = \gamma_0 + \gamma_1 R1988 + \gamma_2 R1998 + u_1$$

$$Real\ Esate\ Investment = \omega_0 + \omega_1 HPI + u_2$$

Instead of the scores of dimension 1 and 2, the fifth and last equation in Table 4.13 replaces them with the Technology and Empowerment Industry Index (TEII), as elaborated in the previous section:

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 + \beta_4 Age + \beta_5 gender + \\ &\beta_6 Real\ Esate\ Investment + \beta_7 \Lambda + \beta_8 TEII + \epsilon\end{aligned} \tag{4.18}$$

$$education\ year = \gamma_0 + \gamma_1 R1988 + \gamma_2 R1998 + u_1$$

$$Real\ Esate\ Investment = \omega_0 + \omega_1 HPI + u_2$$

From Table 4.13, it is noticeable that the only coefficients that change their directions are the age of interviewee when interviewed (labeled as "Age" in the Tables) and the industrial real estate investment (labeled as "lnrpropinv" in the Tables). All the coefficients appear to be significant in the last equation, the structure of which

is thus chosen for the subsequent empirical analysis. The inclusion of TEII (before or after re-scale) appears to be effectively shrinking the coefficient of real property investment (from 0.7% to 0.5% in (4) and 0.53% in (5)). This could be regarded as separating the part of variation originally explained by real property investment in (3), and thus leaving the real property investment closer to the definition of real property investment in the previous chapter, i.e., the investment on real property that is not for the purpose of production operation, but for arbitrage profit in the real estate market. B examining equation (1), (2), and (4), Readers will notice that almost all other variables remain in the same directions (except for age) and with a similar magnitude and at a significant level with or without real estate investment, hence to a greater extent the robustness of such inclusion is achieved. Also, even though the direction of the coefficient of real estate investment is different with or without HPI as its first stage IV, we still could observe the direction remains similarly positive after the inclusion of HPI as IV, in equation (3), (4), (5), while the magnitudes thereof remain close with one another. This could also be regarded as evidence of robustness.[14]

[14]A simple comparison between our choice of IV for education attainment, and the alternative ones such as ROSLA and precise timing of birth is included in App ..8 so to test the robustness of such choice.Also, a validity check of all the IVs are available in Section 4.4.1.1.

Table 4.13: Cross Sectional Estimator

	(1)	(2)	(3)	(4)	(5)
	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD
eduyear	0.0512***	0.0627***	0.0683***	0.0353***	0.0358***
	(0.000623)	(0.000617)	(0.00667)	(0.00685)	(0.00697)
exp	0.0521***	0.0184***	0.0229***	0.0260***	0.0263***
	(0.00112)	(0.00107)	(0.00157)	(0.00166)	(0.00170)
exp2	-0.00154***	-0.000677***	-0.000672***	-0.000783***	-0.000781***
	(0.0000364)	(0.0000345)	(0.0000531)	(0.0000603)	(0.0000614)
Age	0.00672***	-0.00408***	-0.00966***	-0.00880***	-0.00901***
	(0.000286)	(0.000310)	(0.000649)	(0.000552)	(0.000569)
gender	0.531***	0.613***	0.966***	0.804***	0.809***
	(0.00651)	(0.00635)	(0.0208)	(0.0120)	(0.0124)
lnrpropinv		-0.0198***	0.700***	0.502***	0.538***
		(0.00237)	(0.0419)	(0.0246)	(0.0267)
Λ		0.664***	0.798***	0.645***	0.648***
		(0.00785)	(0.0225)	(0.0229)	(0.0233)
a1				0.502***	
				(0.0209)	
a2				0.423***	
				(0.0191)	
TEII					0.0195***
					(0.000736)
_cons	6.119***	6.435***	-1.152**	1.477***	-0.00599
	(0.0140)	(0.0274)	(0.388)	(0.195)	(0.248)
eduyear					
R1998			0.195***	0.250***	0.250***
			(0.0569)	(0.0596)	(0.0596)
R1988			3.427***	3.366***	3.366***
			(0.0379)	(0.0417)	(0.0417)
_cons			9.459***	9.460***	9.460***
			(0.0167)	(0.0188)	(0.0188)
1^{st}stage F statistic			5986.74	5023.71	5023.71
lnrpropinv					
HPI			0.0707***	0.128***	0.128***
			(0.00201)	(0.00215)	(0.00215)
_cons			10.06***	9.637***	9.637***
			(0.0100)	(0.0113)	(0.0113)
1^{st}stage F statistic			1233.13	3511.28	3511.28
H-S statistic			22139.609	18810.858	18164.339
N	137832	133890	133172	106904	106904
="* p<0.05	** p<0.01	*** p<0.001"			

In Table 4.14, the Mincerian results are executed by different sub groups, i.e., by different Cohorts and different sub periods as explained in the previous paragraphs. To start with, in the general equation that includes all Cohorts, the education return is 3.58% for one additional year of education. The experience seems to be positive and nonlinear, increasing by 2.63% for one additional year of experiences. The nonlinearity thereof is consistent with the result by Mincer (1974), and it appears that experience is of slightly less impact on wages than education. Also, if compared with the counterpart result in Taiwan, both education and experience seems to be of less impact on wage in the UK than in Taiwan (education: 10.1% and experience: 15.4%). Age is of negative impact to wage, while there appears to be a gender gap that is unfriendly for females, while the reason for the coefficient seems to be unreasonably large, might be due to the fact that there are some omitted variable biases[15]. Real property investment is still positive (0.538%) after including TEII, while TEII also has a positive impact on wage.

For the Mincerian results of the three Cohorts, see Table 4.14. A coefficient plot for each variable, and aligned by Cohorts, is included as Figure 17. For education attainment years, it appears to be decreasing in Cohorts (from Cohort I: 18.8%, Cohort II: 4.72% to Cohort III: 0.8%), while experience appears to be less significant (only significant for Cohort III: 2.99%). From the significant coefficients of age, it might be concluded that the impact of age on wage differs by age per se, i.e., experience accumulated as age increases for younger generations, hence age has a positive impact on the wage of the younger generation (4.46% for one additional year), while physical strength diminishes with age, hence explaining why age would have a negative impact on Cohort I(-0.779% for one additional year). A gender gap still significantly exists for all Cohorts, yet it seems to be decreasing in Cohorts (Cohort I: 113.1%, Cohort II: 81.9% and Cohort III: 48.5%). Real Property investment remain positive and increasing in Cohorts(Cohort I: 0.310%, Cohort II: 0.706% and Cohort III:0.729% for an extra 1% of the investment in real property). Such result once again contradicts the counterpart in the Taiwanese result: it appears in the UK that such investment has significantly positive correlation with wage, even after including TEII, and could be regarded as evidence that in the UK, such investment in real property is not necessarily for arbitrage purposes, but rather, spent for the purpose of increasing profit via expanding production activities. Lastly yet unsurprisingly, the TEII seems to have positive correlation with wage (Cohort I: 1.54%, Cohort II: 2.13% and Cohort III: 1.69% for an additional point increase in TEII), implying the more cultivation an industry has on its technology and labour

[15]Variables such as matrimonial status, number of children, number of working hours could all be hidden in the dummy gender indicator, which would only be acknowledged to be omitted yet not to be discussed as the focus of these two chapters is on education return and the novel variable introduced.

empowerment, the higher wage a worker could obtain. Also, it looks like TEII is of higher marginal importance for the younger Cohorts (II and III). This is similar with the coefficients of Real Property Investment. It might be concluded that younger Cohorts have benefited more from industrial investment, be it spent on fixed cost of real property, or technology and labour empowerment supporting employee activities, as opposed to older Cohorts, who might have established enough ability so that further capital might be less helpful.

As for differences in each sub-period, the impact of education seems to be decreasing in periods (55.2% before 1995, 4.39% between 1996 and 2005, and insignificant afterward), while experience becomes of higher marginal impact on wage for more recent periods (2.18% before 1995, 2.23% between 1996 and 2005, and 3.67% after 2005), and remaining as a nonlinear, increasing pattern for the significant terms (after 1996). Age, however, shows different marginal impact in different periods: before 1995, age appears to be of positive impact on wage (2.05%), whereas it becomes of increasingly negative impact afterward (-0.947% between 1996 and 2005, and -1.07% after 2005). Such change could be the result of average age increases within the sample, hence the aforementioned effect of diminishing physical strength might dominate over the positive impact of age. As for the gender gap, it is similarly observable in each sub-period (72.6% before 1995, 88.0% between 1996 and 2005, and 55.1% after 2005). Real property investment, nonetheless, demonstrates less significant results (only significant between 1996 and 2005: 0.743%). Such insignificancy though could not support to the statement that industrial real property investment has a positive impact on wage in the UK data set. Still, it is likewise insignificant to assume that corporations in the UK have a similar inclination as those in Taiwan, obtaining arbitrage profit in real property market so that labour suffers wage loss. Lastly, TEII still retain its positive correlation with wage (Cohort I: 2.62%, Cohort II: 2.26% and Cohort III: 3.45% for an additional point increasing in TEII). A summarizing coefficient plot for subperiod comparison is available in Figure 18.

Lastly, the IVs appears to be significant in each cohort and sub-period, except for education dummy indicators in Cohort I. These education dummies would make more sense if the sample (or sub-samples) is mixed-age. Due to the range of age Cohort II and III cover respectively (Cohort II: 1965∼1976 and Cohort III: 1977∼1983), some of the interviewees would be exposed to the change of education caused by education reform, while some do not. These two indicators would work very well by identifying the variations within these two cohorts incurred by education reform at the said time points. That said, it does not work so well in Cohort I, as both of them are dropped in the regression, due to the fact that most of the interviewees

outgrow the age they normally receive education when these two education reforms occurred.

Table 4.14: Cross Sectional Estimator by Different Cohorts and Periods

	general	Cohort I	Cohort II	Cohort III	Before1995	1996∼2005	After 2005
	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD
eduyear	0.0358***	0.188***	0.0472***	0.00866*	0.552***	0.0439***	-0.0132
	(0.00697)	(0.0255)	(0.00649)	(0.00385)	(0.0889)	(0.00894)	(0.0107)
exp	0.0263***	-0.00204	0.00927	0.0299**	0.0218**	0.0223***	0.0367***
	(0.00170)	(0.00402)	(0.00523)	(0.0104)	(0.00704)	(0.00252)	(0.00426)
exp2	-0.000781***	0.000240	-0.0000598	-0.000834	0.000384	-0.000613***	-0.00126***
	(0.0000614)	(0.000161)	(0.000321)	(0.000892)	(0.000267)	(0.0000908)	(0.000140)
Age	-0.00901***	-0.00779**	0.00465	0.0446***	0.0205**	-0.00947***	-0.0107***
	(0.000569)	(0.00261)	(0.00303)	(0.00519)	(0.00652)	(0.000939)	(0.00102)
gender	0.809***	1.131***	0.819***	0.485***	0.726***	0.880***	0.551***
	(0.0124)	(0.0405)	(0.0280)	(0.0269)	(0.113)	(0.0290)	(0.0335)
lnrpropinv	0.538***	0.310***	0.706***	0.729***	0.181	0.743***	0.107
	(0.0267)	(0.0331)	(0.0671)	(0.0576)	(0.225)	(0.0709)	(0.0833)
TEII	0.0195***	0.0154***	0.0213***	0.0169***	0.0262***	0.0226***	0.0345***
	(0.000736)	(0.00108)	(0.00154)	(0.00138)	(0.00393)	(0.00156)	(0.00262)
Λ	0.648***	2.341***	0.482***	0.546***	2.699***	0.680***	0.410***
	(0.0233)	(0.333)	(0.0273)	(0.0203)	(0.338)	(0.0283)	(0.0365)
_cons	-0.00599	0	-2.235***	-2.655***	-3.741*	-2.400**	4.594***
	(0.248)	(.)	(0.639)	(0.541)	(1.839)	(0.739)	(0.947)
eduyear							
R1998	0.250***	0	3.230***	2.068***	1.983	0.0939	0.418***
	(0.0596)	(.)	(0.430)	(0.0302)	(5.726)	(0.0763)	(0.0957)
R1988	3.366***	0	3.223***	11.88***	3.781***	3.401***	2.707***
	(0.0417)	(.)	(0.0425)	(0.0603)	(0.136)	(0.0518)	(0.0796)
_cons	9.460***	10.56***	10.55***	2.84e-14	8.736***	9.494***	10.07***
	(0.0188)	(0.0309)	(0.0279)	(0.0561)	(0.0475)	(0.0238)	(0.0393)
lnrpropinv							
hpi	0.128***	0.106***	0.140***	0.145***	0.288***	0.0710***	0.0695***
	(0.00215)	(0.00417)	(0.00408)	(0.00551)	(0.0252)	(0.00317)	(0.00606)
_cons	9.637***	9.718***	9.541***	9.548***	8.864***	9.921***	10.14***
	(0.0113)	(0.0216)	(0.0214)	(0.0311)	(0.0828)	(0.0153)	(0.0428)
N	73995	30609	30853	12533	9498	47061	17436
="* p<0.05	** p<0.01	*** p<0.001"					

4.4.1.1. Validity Test for Instrument Variables

Similar with the previous Chapter, a couple of tests would be included so as to examine the validity of the chosen instruments, and thus to determine the choice of IV in in the Quantile Regression Estimator. For the correlation test, the first stage F statistics would be of reference, whereas the over-identifying restrictions test would be applied to examine if including all instrument variables would violate the over-identification restriction. From Table 4.13, the first stage F statistics are all large enough to reject the null hypothesis H_0: both the coefficients of instrument variables for education attainment years equal 0, and the coefficient of the instrument variable (HPI) for property investment equals 0. Aside from the significance level of all the IVs in the 1st stage, the F statistics would also serve as supporting evidence for correlation.

As for the over-identification Hansen-Sargan statistic (noted as H-S statistic in Table 4.13), the result shows the H-S statistic is large enough to reject the null hypothesis H_0: the over-identification is valid. Hence we should admit that, our choice of instrument variable might not be exogenous at the same time all are included. Even though the statistical significance of the cross sectional estimate seems to be meaningful and economically explainable, and the first stage statistics supports the correlation between instrument and endogenous variables, the over-identification H-S statistic would not support such inclusion of all instruments.

If not all instruments should be included at once, which one should we give up in the following estimator? Education reformation dummy indicators (R1988 R1998), albeit significant in the first stage for almost all cohorts and subperiods, appear to drop in the first Cohort, simply due to the fact that the people in this Cohort tend to be too old to face such change when receiving education. That said, even though these two indicators helps us to address the endogeneity issue hidden in the education attainment years, we would not utilize these two IVS in the following estimator, in order to improve the consistency across different cohorts.

In the following section, ipso facto, the Quantile Regression Estimator would be applied with the HPI as the only instrument for a similar reason as in chapter 3: it allows us to capture the industrial investment made for arbitrage profit in the housing market.

4.4.2. Quantile Regression Estimates

Following the approach in the previous chapter, the Quantile Regression (QR) Estimator is applied to measure the marginal impact of the aforementioned variables upon the dependent variable, i.e., wage, at any designated quantile (Koenker & Bassett 1978). The theoretical model is available in Chapter 3.

To include the estimator of property investment/ loan that functions as of capital, the QR estimator is amended with the endogenous variable, i.e., property investment /loan, applying House Price Index and regional code as IVs. The QR estimators are presented for the subperiods and Cohorts previously assigned in the following pages.

Hence, following the methods outlined in Section 3.4.2, the QR coefficients at each quantile can be estimated in the following Mincerian equation:

$$\ln W_{it} = \beta_0 + \beta_1 education\ year_{it} + \beta_2 experience_{it} + \beta_3 experience_{it}^2 + \beta_4 age_{it} + \beta_5 gender_{it} + \beta_6 Real\ Esate\ Investment_{it} + \beta_7 \Lambda_{it} + \sum_{t=n}^{N} \gamma_t D_t + \epsilon_{it} \tag{4.19}$$

$$education\ year_{it} = \gamma_0 + \sum_{t=n}^{N} \gamma_t D_t + \sum_{t=n}^{N} \psi_t region\ code_{ti} + u_1$$

$$Real\ Esate\ Investment_{it} = \omega_0 + \sum_{t=n}^{N} \omega_t D_t + \delta_1 HPI_{it} + \sum_{t=n}^{N} \sigma_t region\ code_{it} + u_2$$

The variables, dummy indicator of time and region, and the choices of instruments are similarly arranged as in the previous case. According to the efficiency hypothesis proposed by Stiglitz, labour productivity should be positively correlated with wage level (Stiglitz 1976). In the following result, the coefficients of variables are estimated at each quantile, from the 10th to the 90th quantile. Also, the following result is first estimated as a whole, then separately estimated and compared by Cohorts, and sub-periods, just as in the previous Chapter.

To start with, let's take a look at the general result including all Cohorts and sub-periods. The education return seems to be significantly decreasing in each quantile (from 10th: 6.2% down to 90th: 4.2%). Such a decreasing pattern among quantiles is consistent with the findings discovered by Denny and O'Sullivan (Denny & O'Sullivan 2007). The estimated values here in general are larger than that estimated with the previous estimator (Cross-Sectional: 3.58%) . The experience return, also decreases by quantile (from 10th:5.3% down to 90th:0.5%), while remaining nonlinear for all quantiles (squared term being negative). The estimated values here are larger than those estimated with previous estimator (Cross-Sectional: 2.63%) . Also, experience appears to be of less impact than education on wage return for all quantile, which is similarly observed in previous estimates. Age, unlike education and experience, appears to be significantly negative for the majority of quantiles, but the impact becomes smaller as the quantile progresses, i.e., it increases in quantile (from 10th: -1.6% to 90th: 00.9%). This might be interpreted as: age might have a negative marginal impact on lower wage levels, which is relatively yet more likely to involve work with low technological levels, and a higher degree of manual skill. Whereas age becomes of significantly positive marginal impact for higher quantiles (70th and above), possibly implying jobs at higher wage quantiles might involve higher technological levels, requiring less manual skill, and abilities that cannot be accounted by experience, which

maybe accumulated with age. The gender gap, still significantly survives throughout all quantiles, yet is decreasing as the quantile increases (from 10th: 96.2% to 90th: 58.6%). This can be explained in a similar manner as age: by and large, females might be inherently limited in terms of physical strength, that is more likely relevant at lower wage quantiles, while at higher wage quantiles, females are as capable as males, if not more capable, in terms of abilities other than physical strength, such as intelligence, hence the gap shrinks.

Real property investment appears to be signficantly around 0.3% for each quantile. Such an estimate is smaller than that estimated in the Cross-Sectional result.

Lastly, TEII ranges from 10th: 1.6% to 90th:1.2%, which are smaller than that previously estimated(Cross-Sectional:1.95%), yet still demonstrating positive correlation between TEII and wage. The coefficient plot of the variables against quantiles is available in Appendix .19.

Table 4.15: Quantile Regression Estimator

lnrwageUSD	UK General								
	10	20	30	40	50	60	70	80	90
eduyear	0.0620011	0.059809	0.0582457	0.0570497	0.0554979	0.0542062	0.0518231	0.048308	0.0420195
lower	0.0595731	0.0566891	0.0564767	0.0554245	0.0538822	0.0527059	0.0506251	0.047263	0.0406154
upper	0.0647749	0.0617117	0.059511	0.0578453	0.0566384	0.0552491	0.0530806	0.0497024	0.0435715
exp	0.0538163	0.0386189	0.0307281	0.0241027	0.0186482	0.0147797	0.0112962	0.0088671	0.0051067
lower	0.0486913	0.0356185	0.0284142	0.0207539	0.0158953	0.0123161	0.0088317	0.0070825	0.0033843
upper	0.0565324	0.0416698	0.0335992	0.026985	0.0205918	0.0166602	0.012578	0.0107442	0.006489
exp2	-0.0015249	-0.0010515	-0.0007982	-0.0006264	-0.0004903	-0.0003995	-0.0003242	-0.0002662	-0.0001737
lower	-0.0016171	-0.0011622	-0.0009071	-0.0007303	-0.0005603	-0.0004545	-0.000368	-0.000323	-0.0002173
upper	-0.0012567	-0.0009382	-0.0007233	-0.0005433	-0.0004167	-0.0003295	-0.0002579	-0.0001883	-0.0001118
Age	-0.0157837	-0.0090553	-0.0061361	-0.0036377	-0.0017123	0.0005954	0.0029048	0.0051887	0.0088205
lower	-0.0164448	-0.0099463	-0.0066995	-0.0041555	-0.0024549	-0.0001434	0.002145	0.004422	0.0081794
upper	-0.0148998	-0.008683	-0.0057236	-0.002931	-0.0011266	0.001349	0.003607	0.0058739	0.0095263
gender	0.9626356	0.940513	0.8507693	0.7699098	0.7188053	0.6789967	0.6471811	0.6141869	0.5856024
lower	0.9078248	0.9199845	0.8347571	0.7628232	0.7030633	0.6644639	0.6305978	0.6010758	0.5718998
upper	0.9855147	0.9495487	0.8631631	0.7876875	0.7282786	0.6908917	0.6557993	0.6261908	0.5979522
lnrpropinv	0.3514215	0.3482556	0.3283278	0.3130111	0.3106069	0.3102876	0.3216008	0.3243283	0.336306
lower	0.3039182	0.3201596	0.3134099	0.3036438	0.2978154	0.2948834	0.3109034	0.3141365	0.3247398
upper	0.4048811	0.3789341	0.3579682	0.3398448	0.3317861	0.3333449	0.3492873	0.3428034	0.3537023
TEII	0.0165393	0.0140566	0.0124759	0.0112668	0.0109309	0.010767	0.010788	0.0111036	0.0119665
lower	0.0152363	0.0131493	0.0118742	0.0107103	0.010541	0.0100512	0.0100872	0.0103426	0.0109013
upper	0.0176811	0.014929	0.0138901	0.0127946	0.0119737	0.0114749	0.0116088	0.0116917	0.0129121
lambda	0.8790593	0.839496	0.8088665	0.7704273	0.7290336	0.6793416	0.6041319	0.5016159	0.3448297
lower	0.8678953	0.8304901	0.7858358	0.7456593	0.7114968	0.6606351	0.5892731	0.4866788	0.3323004
upper	0.8965051	0.8496543	0.8236558	0.7846271	0.7454026	0.6939306	0.6227646	0.5215344	0.3646228
_cons	0.9124674	1.328651	1.856033	2.269904	2.48101	2.626185	2.663728	2.811482	2.906252
lower	0.2940889	0.9512389	1.491435	1.919855	2.240342	2.367271	2.353213	2.618497	2.68912
upper	1.475852	1.623902	2.006988	2.389326	2.618624	2.787677	2.831007	2.951049	3.086194
ehat	-0.4909397	-0.4788243	-0.4432501	-0.4117545	-0.3988342	-0.3909297	-0.3966857	-0.395212	-0.3950439
lower	-0.5532799	-0.5162413	-0.4840817	-0.4474046	-0.425572	-0.4210877	-0.4322445	-0.4205582	-0.419912
upper	-0.4211605	-0.4403287	-0.4252936	-0.3997131	-0.3831424	-0.3732866	-0.3844544	-0.378283	-0.3746575
N	10490	10489	10489	10489	10490	10492	10486	10489	10489

As for the Cohort Analysis, to start with, education returns retain their decreasing pattern in quantiles for all three Cohorts (for Cohort I, it ranges from 10th: 6.4% to90th: 4.3%, for Cohort II, it ranges from 10th: 7.0% to90th: 3.2%, and for Cohort III, it ranges from 10th:5.3% to 90th:1.1%). Such result is somewhat close to that estimated by Denny and O'sullivan in 2007, who studied a different group of data (1991 British National Child Development Survey: Male ,born in 1958). Such group is equivalent to Cohort I in our analysis, while the estimates thereof range from 5% to almost 0 across the 10th to 90th quantile.(Denny & O'Sullivan 2007).

Though the differences are less obvious between Cohort I and Cohort II, we still might be able to conclude that the youngest generation (Cohort III) suffers from lower education returns at each quantile as opposed to their senior counterparts. Such difference is also observed in the Cross-Sectional estimate. Also, compared with the Cohort education return estimated in the Taiwanese dataset, the education return is lower

in UK than that in Taiwan for all Cohorts. Such difference is consistent with the Cross-sectional result. Also, the range of education return across quantiles in each cohort seems to be slightly smaller in the UK (measuring the difference between the quantiles of the highest and lowest value: Cohort I: 2.2%, Cohort II: 3.7% Cohort III: 4.3%) than in Taiwan (Cohort I: 2.2%, Cohort II: 5.1% Cohort III: 7.9%) , which will be discussed in the concluding section.

For experience, the decreasing pattern is still observed for all Cohorts, though insignificant at some quantiles(for Cohort I, it ranges from 10th: 2.3% to 90th: 0.04%, for Cohort II, it ranges from 10th: 4.0% to 90th: -0.4%, and for Cohort III, it ranges from 10th: 7.0% to 90th: -1.3%). It appears to increase as the Cohorts get younger.. However, the decreasing pattern in each quantile is not as obviously observed in the Taiwanese results for all Cohorts.

Age appears to significantly increase, and positive for all Cohorts, and increasing as Cohorts being (for Cohort I, it ranges from 10th: 1.8% to 90th: 2.4%, for Cohort II, it ranges from 10th: 2.40% to 90th: 3.9%, and for Cohort III, it ranges from 10th: 7.1% to 90th: 10.2%). Once again, it might confirm with the previous counterparts, which are at a lower level of significance. Though the marginal impact of Cohort I in Taiwan from the previous Chapter is insignificant, the impact of age is still observed to be similarly stronger for the younger Cohort, while such impact is smaller in the UK results. Gender Gap appears to be significantly decreasing in quantile for all 3 Cohorts (for Cohort I, it ranges from 10th: 113.6% to 90th: 51.5%, for Cohort II, it ranges from 10th: 99.9% to90th: 47.7%, and for Cohort III, it ranges from 10th: 55.8% to 90th: 30.6%). This decreasing pattern in quantile once again is consistent with the general result, while the shrinking gap in Cohorts is also observed in the Cross sectional estimator. It may be concluded as the issue of gender inequality in the UK has been addressed, and thereby improved for the time being. However, neither a similar decreasing pattern across quantile, nor that across Cohorts is observed in the Taiwanese result.

Real property investment remains positive, however, it does not demonstrate an obvious pattern across quantiles, yet seems to increase in Cohorts (for Cohort I, it ranges from 10th: 0.056% to 90th:0.127%, for Cohort II, it ranges from 10th: 0.149% to 90th:0.256%, and for Cohort III, it ranges from 10th:0.116% to 90th:0.221%), which is similarly observed in the Cross-sectional estimate. As stressed in the previous chapter,

the counterpart in Taiwan is negative for the younger Cohorts (partly for Cohort II, and all quantiles for Cohort III). Such asymmetry is similarly observed in previous estimates.

Lastly, the marginal impact of TEII on wage appears to demonstrates decreasing pattern in quantile for all three Cohorts (for Cohort I, it ranges from 10th: 1.2% to 90th:0.6%, for Cohort II, it ranges from 10th: 1.1% to 90th: 0.8%, and for Cohort III, it ranges from 10th:1.3% to 90th:0.7%), which is consistent with the general result, while such impact appears to be slightly stronger for younger Cohorts, which is likewise observed in the previous estimate.

The coefficients, the lower and the upper bounds of variables at each quantile are recorded in detail in Tables 20, 21, and 22. The coefficient plots over quantiles of each variables are available in Appendix .20, .21 and .22.

Table 4.16: Quantile Regression Estimator Cohort I

lnrwageUSD	UK Cohort I								
	10	20	30	40	50	60	70	80	90
eduyear	0.0646327	0.0584768	0.0547743	0.0534934	0.0501692	0.0494873	0.0469801	0.0459859	0.0425919
lower	0.058671	0.054354	0.0519432	0.051105	0.0480831	0.047407	0.0453462	0.0442204	0.0403887
upper	0.0711868	0.0622615	0.0598552	0.0592447	0.0534307	0.0529948	0.0505312	0.0487177	0.0442705
exp	0.0233705	0.0225637	0.0149829	0.0109273	0.006673	0.0035318	0.0027304	0.0013581	0.000049
lower	0.01743	0.0165953	0.0089685	0.0050689	0.001145	0.0004564	-0.0011514	-0.0026139	-0.0063638
upper	0.0280845	0.02651	0.0186061	0.0133134	0.0084712	0.0058232	0.0036429	0.004124	0.0038696
exp2	-0.000604	-0.0006775	-0.0004436	-0.00036	-0.0002599	-0.0001615	-0.0001329	-0.0001218	-0.000146
lower	-0.0008182	-0.0008523	-0.0006095	-0.0004772	-0.0003625	-0.0002889	-0.0001896	-0.000248	-0.0002581
upper	-0.000392	-0.0004625	-0.0002175	-0.000156	-0.000085	-0.0000587	-9.22E-06	0.0000381	0.0000701
Age	0.0176746	0.016991	0.0181036	0.0176131	0.0180591	0.0182609	0.0199136	0.0221799	0.0239482
lower	0.0131623	0.0156389	0.0171633	0.0168321	0.017022	0.017471	0.0182774	0.0214623	0.0226113
upper	0.0210417	0.0190216	0.020577	0.0207061	0.0209494	0.0207288	0.0228757	0.0246723	0.0258824
gender	1.136294	1.023787	0.8961411	0.8064097	0.7236394	0.6518934	0.5841925	0.5293438	0.5148683
lower	1.11565	1.006961	0.870225	0.7780917	0.6970751	0.6274817	0.5574478	0.4996992	0.4826638
upper	1.217353	1.047508	0.9265313	0.8317555	0.7522486	0.6727854	0.6089703	0.5418116	0.540821
lnrpropinv	0.055763	0.1051704	0.1260973	0.1203381	0.1265948	0.1191413	0.1264731	0.1097872	0.1271785
lower	-0.008553	0.0766599	0.0996931	0.0814829	0.0932596	0.0932342	0.0885622	0.0822368	0.0808503
upper	0.1546883	0.1398832	0.1470093	0.1376466	0.1390137	0.1347229	0.1428591	0.1363423	0.1545678
TEII	0.0118154	0.0101647	0.0087938	0.0077606	0.0073993	0.0068979	0.0066195	0.006445	0.0068137
lower	0.0102596	0.0095046	0.007425	0.0058343	0.0062103	0.0054882	0.0052491	0.005057	0.004623
upper	0.0143263	0.0122243	0.010081	0.0090862	0.0082393	0.0078997	0.0079429	0.0074552	0.0079481
lambda	0.8819524	0.7548265	0.5686432	0.5121484	0.4057778	0.3455361	0.2418083	0.1653395	0.1018019
lower	0.7641218	0.6169993	0.5188274	0.3842697	0.3346146	0.2805605	0.1765809	0.1312545	0.0520712
upper	1.021993	0.8791657	0.6982776	0.6171392	0.4735827	0.3747429	0.3335195	0.2100237	0.161081
_cons	2.970849	3.146281	3.426006	3.849883	4.099945	4.427761	4.56999	4.903764	4.937436
lower	1.939718	2.752245	3.218858	3.599717	3.919594	4.202679	4.355399	4.577003	4.622251
upper	3.593226	3.335941	3.746877	4.204983	4.427691	4.747439	5.045905	5.331931	5.503417
ehat	-0.1303328	-0.1687602	-0.1773942	-0.1603162	-0.1624857	-0.1450551	-0.1481825	-0.1225055	-0.1262557
lower	-0.2487632	-0.2084209	-0.1993675	-0.1817675	-0.1745396	-0.1636805	-0.1663461	-0.1554486	-0.1629405
upper	-0.0525633	-0.1317617	-0.1410459	-0.1049876	-0.1217001	-0.1084538	-0.1044274	-0.0908487	-0.0729033
N	4415	4418	4410	4414	4415	4414	4414	4414	4414

Table 4.17: Quantile Regression Estimator Cohort II

lnrwageUSD	UK Cohort II								
	10	20	30	40	50	60	70	80	90
eduyear	0.0700119	0.0622699	0.0608324	0.0568459	0.0541145	0.0495511	0.0443749	0.0388185	0.0327531
lower	0.0621891	0.0589667	0.0580844	0.0533518	0.0510049	0.0469657	0.040402	0.0352427	0.0269839
upper	0.0742394	0.0683405	0.0673571	0.0598469	0.0569709	0.0531852	0.0481116	0.0413287	0.0346128
exp	0.0396336	0.0307297	0.0202505	0.0157552	0.0105807	0.0071859	0.0027506	0.0020068	-0.0035448
lower	0.0326253	0.0251253	0.015188	0.0119843	0.0060015	0.0028044	-0.0020265	-0.0030849	-0.0083416
upper	0.048298	0.0339307	0.0238641	0.0205131	0.0152718	0.012096	0.007669	0.0057306	0.0038495
exp2	-0.001427	-0.0013795	-0.0009067	-0.000801	-0.0006088	-0.0005231	-0.0003269	-0.0002972	-0.0000193
lower	-0.0021964	-0.00169	-0.0011448	-0.0012386	-0.0009863	-0.0008431	-0.0007681	-0.0006303	-0.0005329
upper	-0.0008857	-0.0009437	-0.0006323	-0.0005322	-0.0003425	-0.0001449	-0.0000427	0.0000445	0.0003253
Age	0.0241536	0.0252477	0.0261858	0.0281537	0.0307582	0.0324431	0.0344973	0.037244	0.0394027
lower	0.01939	0.021194	0.0233162	0.0254475	0.0288649	0.0305804	0.0328157	0.0353519	0.0357105
upper	0.026979	0.0285754	0.0299171	0.0296306	0.0323195	0.0343888	0.0369491	0.039298	0.0405527
gender	0.9988581	0.8811752	0.7422035	0.6318504	0.5727574	0.5430557	0.5113258	0.4641978	0.477262
lower	0.9633969	0.850821	0.7209133	0.6133391	0.5637735	0.5241634	0.4933134	0.4555029	0.4629773
upper	1.04469	0.9208853	0.770841	0.6566192	0.5992233	0.5670742	0.5329056	0.4880044	0.5114332
lnrpropinv	0.1489501	0.1846179	0.1664079	0.1445677	0.1519585	0.1856481	0.2169351	0.2178143	0.2560206
lower	0.0882027	0.1581092	0.1264635	0.1125374	0.1293107	0.1523616	0.1821862	0.1906658	0.2359138
upper	0.2057263	0.2318006	0.2152182	0.1995185	0.1814893	0.2130841	0.2471821	0.2522271	0.3158475
TEII	0.0106395	0.0092698	0.0081174	0.0073419	0.0067686	0.0070683	0.0067897	0.0060862	0.0076196
lower	0.0093916	0.0084778	0.0067877	0.0055994	0.0052786	0.0050119	0.0055042	0.0052921	0.0065772
upper	0.0114098	0.0105908	0.0088866	0.0084377	0.0078177	0.0078189	0.0072587	0.0070092	0.0084025
lambda	0.7443032	0.7036328	0.6842582	0.6327885	0.5637813	0.46829	0.3611448	0.2081994	0.1440818
lower	0.6766924	0.6582911	0.6264884	0.5922641	0.5400854	0.4290008	0.3211526	0.1818741	0.1324878
upper	0.779865	0.7645296	0.7151937	0.6719217	0.6014539	0.5238074	0.4112586	0.274615	0.1836189
_cons	2.133656	2.357159	2.925669	3.448558	3.573503	3.408397	3.310902	3.564111	3.326896
lower	1.630604	1.820913	2.492866	2.914339	3.268763	3.157773	3.061472	3.196893	2.874099
upper	2.793776	2.714547	3.268953	3.833371	3.822968	3.755689	3.639547	3.818236	3.529022
ehat	-0.2486999	-0.281026	-0.2484323	-0.2033549	-0.2000215	-0.2359212	-0.2720409	-0.2659889	-0.3012757
lower	-0.3207844	-0.3465461	-0.3145895	-0.2751025	-0.2402802	-0.2723746	-0.3146367	-0.3130906	-0.3731609
upper	-0.1742439	-0.2432482	-0.1974303	-0.1582512	-0.1747958	-0.1920375	-0.2332126	-0.2350124	-0.2753279
N	4426	4425	4427	4424	4437	4415	4425	4425	4425

Table 4.18: Quantile Regression Estimator Cohort III

lnrwageUSD	UK Cohort III								
	10	20	30	40	50	60	70	80	90
eduyear	0.0534547	0.0445439	0.0360776	0.0323514	0.0281963	0.0252994	0.0211165	0.0180785	0.0110062
lower	0.0395248	0.0323789	0.0303133	0.0283276	0.0231961	0.0225334	0.0199729	0.0147115	0.0087102
upper	0.0660767	0.0488988	0.0393858	0.034826	0.0329234	0.0279467	0.0254833	0.0218232	0.0148683
exp	0.0749304	0.0421799	0.0245885	0.0177963	0.0100322	0.0039683	0.0025946	-0.0001275	-0.0135076
lower	0.0364187	0.0160192	0.0024459	0.0005275	-0.002199	-0.0031001	-0.0053218	-0.0193503	-0.0265991
upper	0.1067836	0.0854435	0.0559207	0.0525409	0.0420011	0.0313757	0.0202081	0.013099	-4.79E-06
exp2	-0.0083019	-0.0035458	-0.0022104	-0.0016517	-0.000703	-0.0000396	-0.000103	0.0001976	0.001029
lower	-0.0120943	-0.0094496	-0.0059884	-0.0056278	-0.0044776	-0.0038968	-0.0024109	-0.0013656	-0.0003804
upper	-0.0016263	-0.0006528	0.000389	0.0003212	0.0006264	0.001336	0.0013077	0.0019442	0.0020689
Age	0.0722778	0.0764175	0.0769266	0.0798545	0.0821869	0.0855954	0.0896869	0.0936992	0.1022787
lower	0.0602268	0.0680386	0.0684961	0.0709774	0.0751601	0.0798938	0.0836266	0.0882675	0.0959378
upper	0.0814996	0.0852163	0.082802	0.0848766	0.0857739	0.0897472	0.0950281	0.1003999	0.1113951
gender	0.5577825	0.4505298	0.393891	0.3514496	0.3257496	0.3134944	0.2998623	0.291853	0.3064872
lower	0.5293304	0.4115884	0.3666553	0.3349426	0.3013598	0.2992067	0.2806743	0.2725173	0.273476
upper	0.6257311	0.4804567	0.4248356	0.3750223	0.3432306	0.3341093	0.322401	0.3221649	0.3411941
lnrpropinv	0.1160758	0.142105	0.181297	0.1815409	0.1976203	0.2076385	0.2204057	0.2055416	0.2209796
lower	0.0196755	0.0750255	0.1055197	0.1406706	0.1538511	0.1670735	0.1925401	0.1813024	0.1814563
upper	0.2440601	0.2093901	0.2506309	0.2322371	0.2538317	0.2386523	0.2586873	0.241699	0.2943534
TEII	0.0127193	0.0098774	0.0093653	0.0087546	0.0083753	0.0078124	0.0081049	0.0070385	0.0070652
lower	0.0103068	0.008445	0.0082279	0.0077454	0.007242	0.0069117	0.0069756	0.0063069	0.0056978
upper	0.0161219	0.0119491	0.010813	0.0105638	0.0099796	0.0091961	0.0094513	0.0080606	0.0091946
lambda	0.7121267	0.7278499	0.7056976	0.6543291	0.6119456	0.5622464	0.4957056	0.4153228	0.3050275
lower	0.6603685	0.693532	0.6588283	0.6113331	0.5693893	0.5241845	0.4534248	0.3769484	0.2689352
upper	0.7477567	0.7572429	0.7490019	0.6900926	0.6353975	0.5871631	0.5276797	0.4419762	0.3389003
_cons	1.948196	2.264352	2.214881	2.393201	2.390244	2.410687	2.353098	2.656902	2.596954
lower	0.5886328	1.568433	1.604811	1.936867	1.856128	2.138055	2.070172	2.354802	2.010955
upper	2.832133	2.75369	2.84524	2.755683	2.811544	2.766604	2.637182	2.849008	2.927912
ehat	-0.1527711	-0.1703863	-0.2068921	-0.2045624	-0.21885	-0.236094	-0.2537331	-0.2379209	-0.2538033
lower	-0.2931739	-0.2558155	-0.2953516	-0.2681088	-0.275151	-0.2750602	-0.2928991	-0.2778705	-0.3448515
upper	-0.0548117	-0.0817725	-0.1143457	-0.1555758	-0.1731616	-0.1938947	-0.2240251	-0.2110285	-0.2177146
N	1650	1651	1648	1651	1648	1650	1649	1650	1649

Now consider the comparison between sub-periods. Education returns, to start with, seem to be significantly decreasing in quantiles, (Before 1995 it ranges from 10th: 6.2% to 90th:4.9%, Between 1996 and 2005 it ranges from 10th: 6.5% to 90th:4.8%, and after 2005 it ranges from 10th: 5.9% to 90th:4.9%). **For most quantile, the decrease is significant at two break points respectively**.
Experience also demonstrates a decreasing pattern over quantile for all sub periods (Before 1995 it ranges from 10th: 5.7% to 90th:0.3%, Between 1996 and 2005 it ranges from 10th: 4.5% to 90th:0.1%, and after 2005 it ranges from 10th: 5.5% to 90th:0.4%). Also, the return of experience is consistently weaker than that of education for all subperiods, which is similarly observable for all subperiods (except for one insignificant result of Cross-Sectional estimates).

Being similar to the general result, Age still demonstrates an increasing pattern, from negative marginal impact at lower quantiles to positive at higher quantiles, for all three subperiods (before 1995 it ranges from 10th: -1.1% to 90th:1.1%, between 1996 and 2005 it ranges from 10th: -1.3% to 90th:1.0%, and after 2005 it ranges from 10th: -1.8% to 90th:0.8%). The marginal impact of experience does not go through significant changes.

In terms of the gender gap, it demonstrates a consistent, decreasing pattern as quantile increases for all subperiods (before 1995 it ranges from 10th: 106.3% to 90th:56.1%, between 1996 and 2005 it ranges from 10th: 89.5% to 90th:50.5%, and after 2005 it ranges from 10th: 64.9% to 90th:49.1%). Also, over subperiods, the gap seems to be shrinking, which is consistent with previous estimated results, implying the issue of gender payment gap has been improved gradually over time.

Real property investment, however, does not present a significant marginal impact for all subperiods (before 1995 it is insignificant, between 1996 and 2005 it ranges from 20th: 0.209% to 90th:0.154%, and after 2005 it ranges around 0.05% for the significant quantiles). Such an insignificant result is similarly observed in the Cross-Sectional estimate.

Last but not least, TEII is still significantly positive throughout all 3 subperiods, and decreasing by quantile, as similarly observed before (before 1995 it ranges from 10th: 0.4% to 30th:0.1%, and insignificant for the rest of the quantiles, between 1996 and 2005 it ranges from 10th: 1.3% to 90th:0.8%, and after 2005 it ranges from 10th:

2.6% to 90th:1.3%). The increasing pattern across subperiods seems to be similarly observed for the second break point, i.e., at 2005 when A10 countries are included in EU.

The coefficients, the lower and the upper bounds of variables at each quantile are recorded in detail in Tables 23, 24, and 25. The coefficient plots over quantiles of each variables are available in Figures 23, 24 and 25.

Table 4.19: Quantile Regression Estimator Before 1995

lnrwageUSD	UK Before 1995								
	10	20	30	40	50	60	70	80	90
eduyear	0.0615515	0.0655949	0.0666959	0.0677269	0.0673494	0.0638496	0.0625957	0.0576779	0.0490065
lower	0.0552495	0.0611716	0.0628953	0.0661646	0.0652764	0.061102	0.0590151	0.0549262	0.043981
upper	0.0698947	0.0709678	0.0706574	0.071093	0.0703624	0.0679593	0.0654466	0.0613857	0.0529052
exp	0.057487	0.0456306	0.036428	0.0265659	0.0194527	0.0164592	0.0122587	0.0098654	0.0034563
lower	0.0448877	0.0404717	0.0321045	0.0235019	0.0160301	0.0114871	0.0087908	0.0070484	0.0020811
upper	0.065463	0.051396	0.0423381	0.0339845	0.0269648	0.0229299	0.0166204	0.0141663	0.0110437
exp2	-0.0016318	-0.001316	-0.001103	-0.0007847	-0.0005478	-0.0005013	-0.0004193	-0.0004159	-0.0002177
lower	-0.0019864	-0.0015139	-0.0013601	-0.0010905	-0.0008504	-0.0006817	-0.000616	-0.0005914	-0.0005832
upper	-0.0012623	-0.0012012	-0.0009036	-0.0006478	-0.0004607	-0.0003953	-0.0003468	-0.0003299	-0.0001764
Age	-0.0106951	-0.0038975	-0.001984	-0.0000741	0.0005652	0.0020193	0.0040528	0.0068483	0.0105938
lower	-0.0128244	-0.0063392	-0.0033905	-0.0013673	-0.001234	0.0004329	0.0030175	0.0052671	0.0086729
upper	-0.0081801	-0.0010467	0.0004797	0.0017087	0.002242	0.0042373	0.0061953	0.0089764	0.0138909
gender	1.063328	1.064505	0.962478	0.842996	0.7676006	0.7132667	0.678575	0.6285797	0.5613719
lower	1.011493	1.005713	0.9183285	0.8173907	0.733162	0.6868716	0.6487967	0.5953928	0.4911799
upper	1.138536	1.101578	0.99268	0.8772744	0.8039796	0.7493269	0.7156968	0.6593033	0.5974305
lnrpropinv	0.0318473	0.0120462	-0.0000529	-0.0212252	-0.0038302	0.0132421	0.0373282	0.0498306	0.038012
lower	-0.0604037	-0.029064	-0.0431907	-0.0518037	-0.0426172	-0.0363648	-0.0157431	0.0003814	-0.014006
upper	0.0895615	0.0320004	0.0335967	0.0177547	0.0157143	0.0340219	0.0726074	0.0694226	0.0723228
TEII	0.0048139	0.0024872	0.001245	0.0001203	0.0001324	-0.0003187	-0.0001558	0.0003173	0.0010995
lower	0.0013077	0.0007155	0.0000728	-0.0009661	-0.001002	-0.001155	-0.0010539	-0.0005329	-0.0002237
upper	0.0067604	0.0042584	0.0019285	0.0007502	0.0006567	0.0004719	0.0008984	0.0013345	0.0022408
lambda	0.8884415	0.8891366	0.8896732	0.8901766	0.8877888	0.8439991	0.8082017	0.6869859	0.4620742
lower	0.8404317	0.8209128	0.8569298	0.8640652	0.848165	0.8181458	0.7612528	0.6180789	0.3631493
upper	0.9598144	0.940452	0.9230437	0.9313251	0.9087015	0.87873	0.8510473	0.7487119	0.5353436
_cons	4.366799	4.828414	5.279183	5.768372	5.801369	5.853048	5.748441	5.809635	6.217983
lower	3.928689	4.494653	4.976829	5.369937	5.615642	5.601786	5.367308	5.591832	5.90207
upper	5.438373	5.358683	5.788312	6.128658	6.199358	6.287554	6.197062	6.293462	6.799564
ehat	-0.0744007	-0.0149201	0.0125836	0.0478122	0.0345954	0.0134402	-0.0141927	-0.0315892	-0.0129709
lower	-0.164321	-0.0420429	-0.0396227	-0.0040629	0.0049417	-0.0159377	-0.0645857	-0.0653214	-0.0581399
upper	0.0478656	0.0342363	0.0728092	0.0936101	0.0931051	0.0792187	0.0560142	0.0318663	0.0494485
N	1827	1821	1824	1824	1823	1824	1824	1824	1823

Table 4.20: Quantile Regression Estimator 1996∼2005

lnrwageUSD	UK 1996∼2005								
	10	20	30	40	50	60	70	80	90
eduyear	0.0650664	0.0621356	0.0600655	0.0595452	0.0584086	0.0576921	0.055912	0.0521699	0.047497
lower	0.0611152	0.059554	0.057049	0.0578562	0.0570074	0.0558762	0.0545369	0.0509736	0.0461467
upper	0.0695211	0.0654859	0.0627478	0.0615284	0.0601933	0.0592688	0.0580959	0.0543014	0.0497964
exp	0.0453966	0.0327371	0.0253017	0.0186132	0.0144927	0.0101558	0.0059494	0.0038218	0.0006668
lower	0.038753	0.0281793	0.0219073	0.0158127	0.0121335	0.006706	0.0038533	0.0004765	-0.0030226
upper	0.0502832	0.0361391	0.0275105	0.0205963	0.016704	0.0126701	0.0081756	0.0074083	0.0028693
exp2	-0.0013191	-0.0008916	-0.0006465	-0.0004538	-0.0003592	-0.0002578	-0.0001575	-0.0001077	-0.0000354
lower	-0.001618	-0.0010766	-0.0007437	-0.0005465	-0.0004486	-0.0003585	-0.0002628	-0.0002513	-0.0001094
upper	-0.0010188	-0.0007143	-0.0005246	-0.0003562	-0.0002444	-0.0001144	-0.0000854	2.90E-06	0.0000724
Age	-0.0134107	-0.0074038	-0.0047417	-0.0022247	-0.0000921	0.0022794	0.0044558	0.0068268	0.0101163
lower	-0.0152076	-0.0083544	-0.0056281	-0.0030768	-0.0011364	0.0013139	0.0038266	0.0061842	0.0091428
upper	-0.0113743	-0.0063706	-0.0037615	-0.0016647	0.0004376	0.0030432	0.0050449	0.0076033	0.0111362
gender	0.8951385	0.8640541	0.7789809	0.7057086	0.6524007	0.6125392	0.584663	0.5479875	0.5054755
lower	0.8488571	0.8366932	0.7580059	0.6859351	0.6393955	0.5920401	0.5621046	0.5312182	0.4879757
upper	0.9232817	0.8889959	0.8042432	0.7315055	0.6743939	0.6262314	0.5967264	0.5626438	0.5244191
lnrpropinv	0.1916268	0.2092715	0.1987701	0.1775225	0.1656777	0.1603644	0.1698301	0.1623121	0.1536445
lower	0.0932241	0.149784	0.167	0.1354719	0.1236999	0.128722	0.132131	0.1174811	0.1182852
upper	0.2365227	0.2381182	0.246519	0.2097165	0.2026524	0.1942517	0.1967236	0.1899432	0.1863404
TEII	0.0134393	0.0115205	0.0097861	0.0085047	0.0078976	0.0077328	0.0076927	0.0078815	0.0084686
lower	0.0118607	0.0098333	0.0085125	0.0068161	0.0064275	0.0064307	0.0065126	0.006441	0.0065422
upper	0.0154166	0.0125929	0.0105338	0.0094129	0.008686	0.0083691	0.0084064	0.0090167	0.009405
lambda	0.8372396	0.7986655	0.7763066	0.7461024	0.7043788	0.6545486	0.6004401	0.4857843	0.3411077
lower	0.803973	0.7688347	0.7431269	0.7258	0.6856762	0.6347016	0.5732923	0.4625463	0.3135454
upper	0.8760983	0.8278829	0.8055705	0.7645882	0.7210429	0.6668492	0.6157842	0.4983086	0.3634172
_cons	2.690938	2.878561	3.321225	3.778473	4.084207	4.267683	4.31358	4.578434	4.893672
lower	2.206811	2.574383	2.796547	3.407664	3.660738	3.901768	4.015213	4.238103	4.517899
upper	3.718483	3.480077	3.636211	4.289506	4.560752	4.647027	4.736735	5.092824	5.335634
ehat	-0.3214861	-0.3255022	-0.2964701	-0.253454	-0.2272708	-0.2127161	-0.2161357	-0.2019505	-0.1799121
lower	-0.3908656	-0.3616719	-0.3522095	-0.2893331	-0.2702575	-0.2527757	-0.2469956	-0.2375542	-0.2178129
upper	-0.1888914	-0.2423752	-0.2560406	-0.2001462	-0.173883	-0.1730805	-0.1694365	-0.1465755	-0.1347277
N	6688	6685	6684	6686	6689	6688	6685	6680	6685

Table 4.21: Quantile Regression Estimator After 2005

lnrwageUSD	UK After 2005								
	10	20	30	40	50	60	70	80	90
eduyear	0.0587415	0.0583202	0.0568544	0.0559733	0.0554276	0.0548883	0.0538696	0.0533567	0.0492648
lower	0.0481829	0.0507184	0.0493893	0.0519743	0.0525736	0.0504222	0.0505	0.0500782	0.0447588
upper	0.0643972	0.0616675	0.0607664	0.0597795	0.0584204	0.0582213	0.0558731	0.0547864	0.0530428
exp	0.0547877	0.0387157	0.0284355	0.0231614	0.0182093	0.013558	0.010034	0.0068607	0.0039526
lower	0.0383551	0.0318998	0.0228601	0.017171	0.0135613	0.0100859	0.0056895	0.0026602	0.0013854
upper	0.0748889	0.0455668	0.0326949	0.0282687	0.0224313	0.0193126	0.0165554	0.0123703	0.0080636
exp2	-0.0016759	-0.0011049	-0.0007668	-0.0006569	-0.0005323	-0.000435	-0.0003388	-0.0002608	-0.000217
lower	-0.0024807	-0.0013949	-0.000931	-0.0008298	-0.000706	-0.0006239	-0.0005625	-0.0004667	-0.000396
upper	-0.0010368	-0.0008784	-0.0006218	-0.0004526	-0.0003943	-0.0003187	-0.0002131	-0.0001534	-0.000092
Age	-0.0180423	-0.0107775	-0.0076128	-0.0053396	-0.0026892	-0.0005335	0.0023754	0.0052602	0.0080547
lower	-0.020843	-0.0126543	-0.008828	-0.0058349	-0.0035152	-0.0013247	0.0016533	0.0044026	0.006694
upper	-0.015841	-0.0092535	-0.0059789	-0.0034144	-0.0012755	0.0009681	0.0036616	0.0067572	0.0092504
gender	0.6493434	0.695492	0.6562453	0.6168718	0.5773666	0.5452033	0.5196666	0.4953356	0.4913454
lower	0.6010948	0.651506	0.6327971	0.5862172	0.556906	0.5211255	0.4871235	0.4703089	0.4608833
upper	0.7002043	0.7252856	0.6832575	0.636251	0.6067266	0.5722725	0.5362548	0.5208154	0.5191733
lnrpropinv	0.0075147	0.027293	0.0623626	0.0684749	0.0515989	0.0432953	0.0438476	0.0478011	0.0627589
lower	-0.0965122	-0.0221268	0.0154078	0.0355162	0.0296799	0.0133209	0.0049633	0.0197637	0.0196349
upper	0.094791	0.0846297	0.1182708	0.1016825	0.1019043	0.0964723	0.1004956	0.1049248	0.1447938
TEII	0.0256666	0.0217368	0.0200924	0.0194251	0.0176265	0.016106	0.0160295	0.0161302	0.0134202
lower	0.0237393	0.0206572	0.0187999	0.0183696	0.0165558	0.0149602	0.0144653	0.0143869	0.0095904
upper	0.029538	0.0231492	0.0218471	0.0207711	0.0188761	0.0176372	0.0177087	0.0173252	0.016556
lambda	0.8132712	0.7664841	0.7544686	0.7184571	0.6694446	0.6228426	0.5483779	0.4579577	0.3186716
lower	0.7785521	0.7340326	0.719618	0.6821668	0.6391799	0.5680243	0.5245891	0.4115313	0.2678378
upper	0.9282592	0.8193759	0.7992004	0.7491123	0.6952097	0.6638331	0.5639212	0.5197789	0.3606335
_cons	4.4889	4.66235	4.570477	4.700778	5.096166	5.390779	5.505411	5.586088	5.820713
lower	3.365476	3.973763	3.966312	4.305141	4.546045	4.826609	4.900458	5.003039	4.81356
upper	5.653787	5.212983	5.100072	5.11256	5.383363	5.673888	5.903127	5.919683	6.450624
ehat	-0.0965056	-0.1054982	-0.1369012	-0.126434	-0.089242	-0.0700344	-0.0618236	-0.0557638	-0.0569559
lower	-0.195408	-0.1820465	-0.2010703	-0.1696179	-0.1593147	-0.1433615	-0.1354318	-0.1316198	-0.161367
upper	0.0179176	-0.048336	-0.0874195	-0.0960184	-0.0581892	-0.0321538	-0.0215713	-0.0308064	-0.0014391
N	1981	1979	1981	1979	1996	1964	1986	1981	1972

Several points could be drawn to briefly summarize the above: First of all, the Quantile Regression estimates in general are quite close to the values estimated by the Cross-Sectional estimator. Moreover, the inter-Cohort difference in terms of education return is similarly observed in the Taiwanese results robustly.

Also, educations returns decrease as wage quantile increases. This is consistently observed in all Cohorts, for all subperiods, and such pattern is observed in Taiwan as well, except for Cohort I. This is consistent with the results concluded by Denny and O'Sullivan, i.e., education could compensate for what innate ability falls short of, and the policies that improve the universal access to education is beneficial to the welfare of citizens (Denny & O'Sullivan 2007).

Since Taiwanese education returns only show a decreasing pattern for the younger Cohorts, it might be reasonable to deduce that, the education policy in UK that compensates for the innate abilities of citizens and shrink the wage differences among those with different abilities may have rewards for a longer term as opposed to its Taiwanese counterpart.

Furthermore, as in Table 4.22 which summarizes education return estimated with different estimators for both countries, it cannot be robustly determined whether the UK education return is lower or higher than the Taiwanese education return. Nonetheless, given the fact that the QR estimator retains the structure of the Cross-sectional (OLS) estimator, and free of the issue of instrument over-identification, it might be reasonable to regard the Qunatile Regression estimates as a modified version of Cross-Sectional estimates. Ipso facto, the education return in the UK is lower than that in Taiwan, i.e., education should not be the factor that single-handedly allows UK citizens to have higher marginal earnings than Taiwanese citizens, even though its education policy seems to have beneficial implication on the less capable ones even on the first Cohort, whereas in Taiwan, such a benefit is not as obvious on the first Cohort.

Table 4.22: Education Return by 3 estimators in the Uk and Taiwan

		I	II	III
CS	TW	0.193***	0.544***	0.00452
	UK	0.188***	0.0472***	0.00866*
QR	TW	0.106∼0.08***	0.127∼0.076***	0.101∼0.043***
	UK	0.064∼0.043***	0.070∼0.032***	0.053∼0.011***

UK	Before1995	1996∼2005	After 2005
CS	0.552***	0.0439***	-0.0132
QR	0.062∼0.049***	0.06∼0.048***	0.059∼0.049***

Table 4.23: UK Education Return Estimates Comparison

Also, at each break point, it appears that the education return does experience downward changes at both structural breaks in 1995 and 2005 respectively. Such downward change, as elaborated in the theoretical section, might be the result of change in the relative labour supply and relative demand. Education return decreases at the break points, as relative labour supply increases at a rate faster than relative labour demand. To put more specifically, the uneducated labour demand increase was caused by the wealthier 3 countries joining EU in the 4th EU expansion, while the educated labour supply increase was caused by the 5th EU expansion.

Lastly, the important and significant factor, i.e., industrial real property investment, seems to be positive for almost all cohort, which is similarly observed in Cross sectional results. Be that as it may, it dose not experience significant change over the break points. Possible explanations are discussed in the concluding section.

4.5. Conclusion

Though the magnitude of coefficients estimated by two different estimators are not conformably the same, for the education marginal return, the pattern among Cohorts is somewhat similar: it decreases as the Cohort gets younger (Comparing Cohort I, II

TW	Before 2002	2003∼2009	After 2009
CS	0.45	-0.210*	0.136***
QR	0.078∼0.167***	0.038∼0.097***	0.089∼0.100***

Table 4.24: Taiwanese Education Return Estimates Comparison

with that in III). This is similarly observed and concluded in the French data by Chauvel (2010), who describes such decreasing patterns over cohort as "inter-generational decline"(Chauvel 2010). If our result in Quantile Regression is to be more confidently stressed, then it is the youngest cohort receiving the lowest education return. As mentioned in the introduction section, higher education experiences expansion over time, and thus is asymmetric to the aforesaid pattern of marginal education return as cohort being. Such asymmetry between education attainment and the return thereof is somehow similar with "inflation scolaire" (diploma inflation) described as by Chauvel in his French experience, as well as similarly concluded in Taiwanese analysis in the previous chapter. On the other hand, as education returns have decreasing marginal impact on wage for younger Cohorts, other variables, e.g., experience and age, show an increasing pattern for younger Cohorts, implying: as education depreciates (experiences inflation as the marginal return decreases), experience and age become of more importance and thus have higher marginal influence on wage.

As previously concluded, the comparison in education returns between the UK and Taiwan could be consistently determined between both estimators.

For the Cross-Sectional and Quantile Regression estimators, the education return seems to be higher at all Cohorts in Taiwan than those in the UK.[16] Since the education return in the UK seems to be lower than that in Taiwan, one might argue there is of less importance in the UK education system that would shed light on Taiwanese education policy. However, the range between quantiles in education return in the UK seems to be smaller than that in Taiwan. One possible reasoning might be due to a much more comprehensive vocational education system, and a stronger labour demand for the "uneducated" (i.e., workers with a vocational degree, or diploma), driving the education premium downward but at the same time, shrinking the disparity of education return between different income levels.

Furthermore, the industrial investment on real property could be the de facto element that matters. As shown in the previous section, the marginal impact on wage from industrial investment on real property is almost significantly positive for all Cohorts, and this pattern is robustly observed for both estimators, which is different in

[16]Given the fact that the Quantile Regression estimator is free of the over-identification issue that lies in the Cross-Sectional estimator, the Quantile Regression estimator might be more trust-worthy.

Taiwan, especially for the Cohort III. Possible reasons could be: a) a more comprehensive taxation system in the UK might function as an "inhibitor" effectively preventing arbitrage investment in real property market. Such an inhibiting tax system should be deemed as the transaction cost mentioned by Connock (2002). A summarizing table compares the taxation systems in the UK and Taiwan is presented as follows: the

Table 4.25: Comparison between UK and Taiwan Taxation on Real Property(339-Citizen.com 2014, GOV.uk 2014)

	the UK	Taiwan
Council Tax	£900 3000 per year	N/A
Capital Gain Tax(CGT) on Rent Revenue	Income tax rate <20%: CGT rate =18%; o.w. CGT rate =28%	N/A
Property Tax	progressive rate	6% in average
Stamp Duty Land Tax	payable at progressive rate for property above £125000	announced price*0.01 %
Property Transaction tax	payable at different rate for: buy-to-let properties business premises land inherited property	6%∼40% of the transaction income, often circumvented
tax base evaluation	revaluated every 5 year by local committee	revaluated every 4 year by local committee e.g., construction and real estate companies

differences between taxation systems may largely originate from geographical factors, e.g., local custom , tradition, and practice varying from one context to another, and the complexity of the taxation systems often hinders comparison between countries. Suffice it to say, however, the lack of council tax, and capital gains tax in Taiwan, would function as incentives encouraging corporations to invest and achieve arbitrage in real estate property.

More importantly, the evaluation of the tax base is evaluated by local committee members, e.g., companies from real estate, construction and finance industries, who purportedly "understand the demand in housing market," yet their incentive is hardly compatible so to evaluate properties decently. Needless to say, a game is never fair when a player doubles as referee, hence the housing price is seriously underestimated for a understandable reason, i.e., self interest optimization of these corporations.

As to conclude from the structural break analysis, the result being more significantly observed in the UK than that in Taiwan could be due to the fact that, in Taiwan, the relative labour demand (for educated labour to uneducated ones) created by the FTAs at the break points (2002, and 2009 respectively) is relatively small in the short

run, as opposed to the increase in relative labour supply created by the long-growing education expansion. The education return would not be able to experience the benefit by the increased labour demand, which is easily offset by the also increasing labour supply. By contrast, the education return experiences significant decreases in the UK over the two break points. At the first break point (in 1995), as we tend to focus on one of the many driving factors: the relative labour demand might be dragged down by the increasing demand for uneducated workers from the three new member states (Austria, Sweden, and Finland), while almost occurring at the same time, the higher education in the UK has been redefined by including polytechnics as universities, the relative labour supply hence also increases.

Similarly, the education return decreases significantly by the second break point at 2005, which could be the result of the import of educated workers not only from A10 countries, but also from the western European Economic Area (EEA) countries, i.e., A15 countries such as France, Italy and Spain, and even from non-EEA countries, e.g., India, or China. Such increase in relative labour supply, in part, might decrease the education return, even though the relative demand for educated workers might experience an increase as the A10 countries become member states of the EU. From the significant results in the previous section, the positive change in relative supply should be larger than the change in relative demand. Such interpretation coincides with the conclusion made by Dustman and Frattini (2014), which states: the UK attracts the highest number of university-educated migrants of any country in the European Union, while the immigrants are in average more educated than the UK native....whereas such ability to attract highly skilled immigrants – even from within the EEA, where no restrictions can be imposed, is a strong and important feature of the UK economy [17] (Dustmann & Frattini 2014). Although the selection of structural break points is not able to measure a impact of a particular single event without including other effects caused by other stimuli, by comparing the change of coefficients before and afterward, the result is in accordance with the actual occurrences, and their impact on the economy proposed by the theoretical framework.

This chapter introduces novel variables into the Mincerian structure, such as TEII, and industrial real estate investment. The limitation upon the availability of data,

[17] the rate of university degree and above to the overall Diaspora, west EEA: 62%, east EEA: 25% and non-EEA: 48% is all higher than that in the UK: 25%(Guardian 2014).

e.g., corporative investment in real property of the company where interviewee works should be of more direct influence than that estimated. Such limitations might compromise the analytical result to a certain degree. Future research could improve the validity of analysis by directing corporate survey data among enterprises from different industries, so to acquire first-hand data on TEII, and real estate investment at the company level (which purportedly crowds out or reinforces the operative investment). One alternative data source that might fit into this description is the Workplace Employment Relations Study (WERS), collecting data from both employers and employee at the company level. Also, taxation is suggested by the literature and this chapter, as an important factor that prevents corporative arbitrage in real estate market. It might be of explanatory importance in the Mincerian structure, hence it would be viable to be included into the regression as to see whether companies facing higher taxation obstacles would be less likely to perform arbitrage in the housing market, if the survey data is acquired by corporations from different industries.

Chapter 5

Conclusion

This doctoral thesis contributes to the empirical labour literature by introducing novel variables into existing analytical structure, and derives significant results that are consistent with the empirical findings of Taiwanese empirical academe, and thereby provide innovative explanation to the current quandary of Taiwanese labour.

To start with, in Chapter 2 this thesis introduces cyclical export gap as a new variable into the Okun structure, in which the positive term is significant and robustly substantiates the theoretical prediction of Dutt et al. In other words, in the short run, cyclical unemployment gap might have significant positive correlation with export gap, due to the industrial restructuring between the capital intensive industry and the labour intensive industry. Even though it is not particularly robust between the two data sets, from the HP data set, the cyclical export gap exhibits significant structural changes at 1990 and 2002 respectively, which might be related with the growing trade dependence of Taiwan upon China.

Secondly, by applying the Mincerian wage structure in Chapter 3, this thesis attempts to examine some of the wage determining factors in the Mincerian Structure. Based on our QR estimates, it shows that, nonetheless, the education marginal return of the youngest cohort in Taiwanese sample is significantly lower than that of their senior counterparts. We argue such as a circumstantial evidence how expansionary education policy increases the labour market educated supply. Such a cumulated effect of "diploma inflation" is similar with what has been observed by Chauvel (2010) in France. Furthermore, a novel variable introduced into the Mincerian structure, i.e., the industrial investment in real property is negatively correlated with the wage of the youngest cohort, and the negative marginal impact brought by a 1% increase in the industrial investment in the real property is robustly and significantly negative for the youngest cohort in Taiwan. Lastly, the change in education return or the marginal influence of industrial investment in real property at the structural break points purportedly occurring at the time when the bilateral trade

between Taiwan and China is strengthened, is not significant enough to support the government argument that the FTAs should have a benign influence on labour's wage. This thesis does not argue that the FTAs between the two economies have no influence on the wage, as it seems the relative demand for educated workers is not necessarily growing as fast as the expansion of the educated labour supply incurred by the education expansion in Taiwan since early 1990s.

Thirdly, the thesis continues the Mincerian structure by analysing the BHPS dataset in the UK, and discovers the education return decreases for younger cohorts, which is similarly observed in Taiwan. For the Cross-Sectional and Quantile Regression estimators, the education return seems to be higher at all Cohorts in Taiwan than those in the UK, while the range between quantiles in education return in the UK seems to be smaller than that in Taiwan. One possible reasoning might be due to a much more comprehensive vocational education system, and a stronger labour demand for the "uneducated", shrinking the disparity of education return between different income levels. What also might be concluded is that the similar negative impact on the wage of the youngest Taiwanese cohort receives from industrial investment on real property is not observable in the UK counterpart. We extrapolate one of the reason being so is that, the more comprehensive tax system in the UK, especially that concerning capital gain tax and real estate arbitrage might be effectively preventing the industrial investment being harmful to the labour wage in the UK. The thesis argues this should be one of the factors causing the difference in wage determining factors between the two countries. Also, the decrease in the education returns at both the structural break points when the trade partners joining to the FTA seems to be consistent with the possible change in the UK labour market corresponding to the breaks.

Possible directions for future relevant research that could stem from the conclusions and findings of this thesis include: to extend the Okun structure onto Taiwanese data covering more recent entries, when factor intensity reversal between China and Taiwan occurs. Also, in terms of the wage determining equation in Taiwan, the impact of technical progress is absent and might be of interest for further research. Furthermore, as taxation is conjectured to be an important factor that influences the wage difference between the two countries, future Mincerian analysis is encouraged to keep tabs on harmonizing variables that capture the variation of the taxation system, e.g., by the differences of industries, regions, and date. Lastly, the nature of survey data might ameliorate the explanatory power of industrial investment, which serves as a proxy to the capital that has been crowded out due to arbitrage in housing market. It might be of potential interest for future research to study the Mincerian dynamics using individual level data collected from several companies

from different industries, so to study the companies' arbitrage investment, or the taxation obstacle each company encounters, and how these factors affect wages of their employees.

Appendix .1. Augmented Dickey–Fuller test for HP and HW datasets

.1.1. HP Filtered Cyclical Unemployment

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       120

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -3.970           -3.503            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0016
```

.1.2. HP Filtered Cyclical GDP Growth

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       120

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -6.283           -3.503            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

.1.3. HP Filtered Cyclical Export Growth

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       120

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -5.733           -3.503            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

.1.4. HW De-seasonal Cyclical GDP growth

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       120

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -6.066           -3.503            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

.1.5. HW De-seasonal Cyclical Export growth

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       120
```

```
                          ---------- Interpolated Dickey-Fuller ---------
               Test         1% Critical       5% Critical      10% Critical
             Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)           -6.094           -3.503            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Appendix .2. Test of Serial Correlation:Breush-Godfrey LM test

.2.1. Unfiltered ADL Model

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	0.934	1	0.3337
2	3.281	2	0.1939
3	4.094	3	0.2515
4	4.149	4	0.3862
5	5.614	5	0.3456
6	5.745	6	0.4523
7	9.175	7	0.2404
8	10.414	8	0.2372
9	11.038	9	0.2731
10	11.233	10	0.3397

.2.2. Unfiltered ADL Model with Export

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	0.099	1	0.7529
2	1.602	2	0.449
3	1.761	3	0.6234
4	1.893	4	0.7555
5	1.896	5	0.8634
6	2.128	6	0.9076
7	5.091	7	0.6489
8	10.5	8	0.2317
9	11.812	9	0.2241
10	11.893	10	0.2923

.2.3. HP ADL Model

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	4.876	1	0.0272
2	6.419	2	0.0404
3	6.989	3	0.0722
4	8.793	4	0.0665
5	10.417	5	0.0642
6	11.181	6	0.0829
7	11.253	7	0.1279
8	15.513	8	0.0499
9	15.552	9	0.0768
10	15.553	10	0.1132

.2.4. HP ADL Model with Export

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	0.344	1	0.5578
2	2.268	2	0.3217
3	2.278	3	0.5167
4	2.419	4	0.6591
5	7.556	5	0.1825
6	8.056	6	0.234
7	11.078	7	0.1352
8	13.998	8	0.0818
9	16.237	9	0.0621
10	16.243	10	0.0929

.2.5. HW ADL Model

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	3.207	1	0.0733
2	5.064	2	0.0795
3	5.143	3	0.1616
4	5.521	4	0.2379
5	6.602	5	0.2519
6	7.791	6	0.2538
7	7.962	7	0.336
8	11.851	8	0.158
9	12.292	9	0.1974
10	12.508	10	0.2525

.2.6. HW ADL Model with Export

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	1.08	1	0.2986
2	4.432	2	0.1091
3	4.568	3	0.2063
4	4.614	4	0.3293
5	4.614	5	0.4648
6	4.945	6	0.5509
7	5.215	7	0.6338
8	9.732	8	0.2843
9	9.865	9	0.3616
10	9.907	10	0.4487

.2.7. HP ADL Model Chow Test

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	0.053	1	0.8171
2	0.993	2	0.6087
3	1.009	3	0.7991
4	3.312	4	0.5071
5	4.615	5	0.4646
6	5.794	6	0.4467
7	5.82	7	0.5609
8	22.49	8	0.0041
9	25.205	9	0.0028
10	30.258	10	0.0008

.2.8. HP ADL Model Chow+Asymmetry

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	1.804	1	0.1792
2	2.789	2	0.248
3	3.197	3	0.3622
4	3.871	4	0.4237
5	22.391	5	0.0004
6	26.421	6	0.0002
7	31.519	7	0
8	54.002	8	0
9	55.749	9	0
10	57.252	10	0

.2.9. HW ADL Model Chow Test

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	8.941	1	0.0028
2	9.129	2	0.0104
3	11.923	3	0.0077
4	12.78	4	0.0124
5	18.302	5	0.0026
6	19.965	6	0.0028
7	22.807	7	0.0018
8	31.686	8	0.0001
9	32.539	9	0.0002
10	36.011	10	0.0001

.2.10. HP ADL Model:Break = 1986q1

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	0.011	1	0.9162
2	0.274	2	0.8718
3	0.293	3	0.9614
4	3.322	4	0.5055
5	6.993	5	0.2211
6	9.333	6	0.1557
7	12.236	7	0.0931
8	12.697	8	0.1227
9	14.712	9	0.0992
10	15.563	10	0.1128

.2.11. HW ADL model :Break= 1986q2

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	2.059	1	0.1513
2	2.078	2	0.3537
3	4.372	3	0.224
4	4.955	4	0.292
5	5.276	5	0.3831
6	6.491	6	0.3705
7	6.876	7	0.4419
8	6.876	8	0.55
9	7.792	9	0.5552
10	8.113	10	0.6178

Appendix .3. Decision of Lag Order

.3.1. Selection of Lag Order: Information Criteria of HP-filtered Data

Selection-order criteria

Sample: 1984q4 - 2012q2 Number of obs = 111

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	202.749				0.000095	-3.58107	-3.54146	-3.48343
1	258.656	111.81	4	0	0.000037	-4.51633	-4.43711	-4.32105
2	298.22	79.127	4	0	0.00002	-5.15712	-5.03829	-4.86419
3	310.324	24.209	4	0	0.000017	-5.30314	-5.1447	-4.91258
4	339.973	59.298	4	0	0.000011	-5.76528	-5.56723	-5.27708
5	393.411	106.88	4	0	4.4e-06*	-6.65605*	-6.41839*	-6.07021*
6	397.277	7.732	4	0.102	4.40E-06	-6.65364	-6.37637	-5.97015
7	399.263	3.9716	4	0.41	4.60E-06	-6.61734	-6.30047	-5.83622
8	402.789	7.052	4	0.133	4.60E-06	-6.6088	-6.25231	-5.73004
9	404.93	4.2837	4	0.369	4.80E-06	-6.57532	-6.17922	-5.59892
10	408.088	6.3152	4	0.177	4.90E-06	-6.56015	-6.12444	-5.4861
11	414.022	11.868*	4	0.018	4.80E-06	-6.59499	-6.11967	-5.4233
12	415.223	2.403	4	0.662	5.00E-06	-6.54457	-6.02964	-5.27524
13	419.861	9.2756	4	0.055	5.00E-06	-6.55606	-6.00152	-5.18909
14	421.157	2.5906	4	0.628	5.30E-06	-6.50732	-5.91318	-5.04271
15	423.278	4.2433	4	0.374	5.50E-06	-6.47348	-5.83972	-4.91123

Endogenous: HPunemp HPcGDPgth HPexportgth

Exogenous: cons

.3.2. Selection of Lag Order: Information Criteria of HW-filtered Data

Selection-order criteria
Sample: 1984q4 - 2012q2 Number of obs = 111

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	415.014				1.20E-07	-7.42368	-7.39397	-7.35045
1	500.251	170.47	9	0	3.00E-08	-8.79732	-8.67849	-8.5044
2	514.859	29.215	9	0.001	2.70E-08	-8.89835	-8.6904	-8.38574
3	517.448	5.1787	9	0.818	3.10E-08	-8.78285	-8.48577	-8.05054
4	532.829	30.762	9	0	2.80E-08	-8.89782	-8.51162	-7.94582
5	590.964	116.27	9	0	1.1e-08*	-9.78313*	-9.30781*	-8.61144*
6	595.255	8.5826	9	0.477	1.20E-08	-9.69829	-9.13384	-8.30691
7	599.849	9.1881	9	0.42	1.40E-08	-9.6189	-8.96533	-8.00783
8	603.784	7.8701	9	0.547	1.50E-08	-9.52764	-8.78495	-7.69688
9	611.266	14.965	9	0.092	1.60E-08	-9.50029	-8.66849	-7.44984
10	622.791	23.05	9	0.006	1.50E-08	-9.54579	-8.62486	-7.27564
11	629.761	13.94	9	0.124	1.60E-08	-9.50921	-8.49916	-7.01937
12	638.212	16.902	9	0.05	1.60E-08	-9.49932	-8.40015	-6.78979
13	650.035	23.646*	9	0.005	1.60E-08	-9.55018	-8.36189	-6.62096
14	652.53	4.9898	9	0.835	1.80E-08	-9.43298	-8.15555	-6.28406
15	657.094	9.1273	9	0.426	2.00E-08	-9.35304	-7.9865	-5.98444

Endogenous: HPunemp HWrGDPgth HWexportgth
Exogenous: cons

Appendix .4. Quandt Likelihood Ratio (QLR) test: for an unknown break date

From the Chow test, the structural change incurred by trade liberalization is observed at the assumed break date at 1990q1 and 2002q1. Nonetheless, is it possible that breaks in fact occurs multiple times, in accordance with any other unexpected shock in the history of Taiwan?

To discover the candidates of the unknown break date, the Quandt Likelihood Ratio (QLR) test, also known as the sup Wald test, can thus be applied to detect whether the Chow statistics surpass the critical value at any given unknown dates within the sample set (Quandt 1960):

The QLR statistic = the maximal of Chow statistics within the assigned interval.

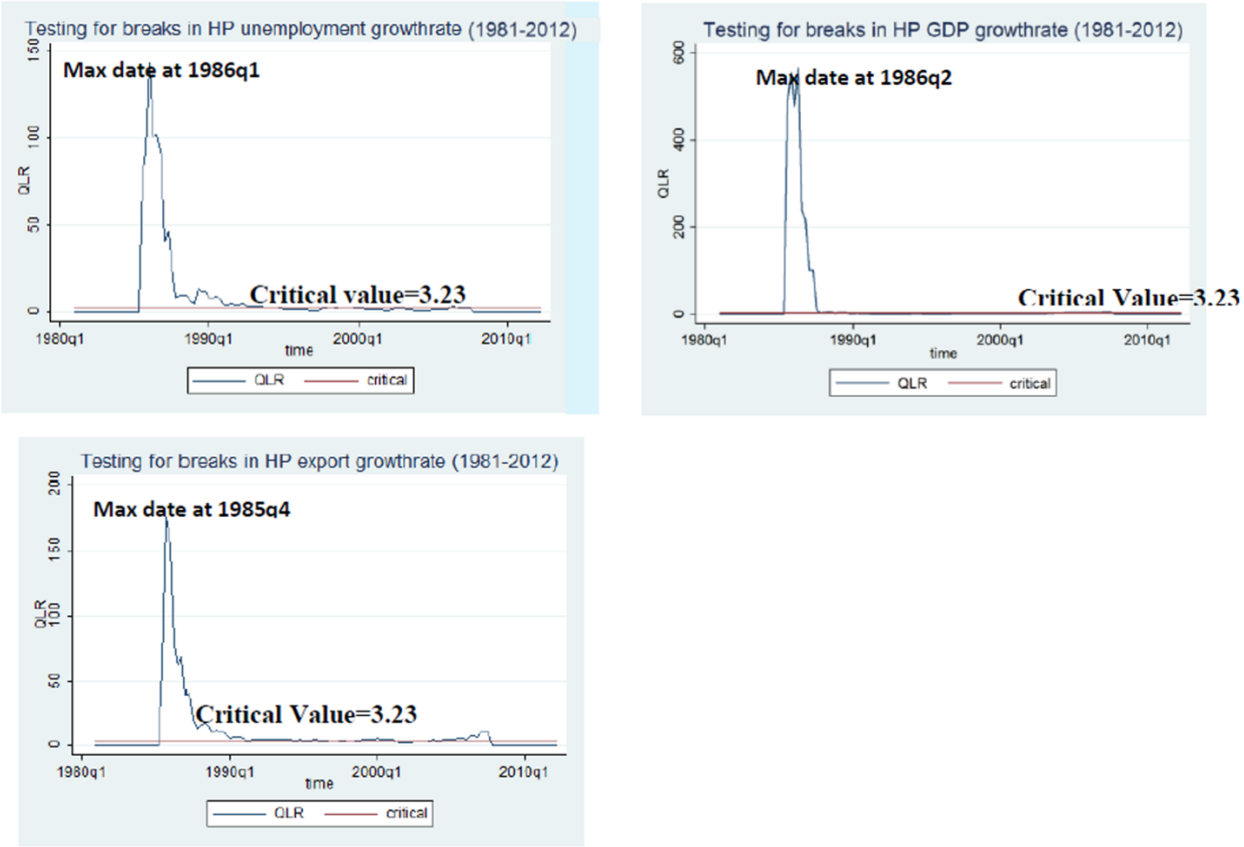
Let $F(\tau)$ = the Chow test statistic testing the hypothesis of no break at date τ. The QLR test statistic is the maximum of all the Chow F-statistics, over a range of τ, $\tau_0 \leq \tau \leq \tau_k$: QLR = $\max[F(\tau_0), F(\tau_{0+1}), \ldots, F(\tau_{k-1}), F(\tau_k)]$. A conventional choice for τ_0 and τ_1 are the inner 70% of the sample (exclude the first and last 15%.)

In large samples, QLR has the following distribution:

$$\max_{a \leq s \leq 1-a} \left(\frac{1}{q} \sum_{i=1}^{q} \frac{B_i(s)^2}{s(1-s)}\right) \tag{1}$$

where B_i, i =1,. . . ,n, are independent continuous-time "Brownian Bridges" on $0 \leq s \leq 1$ (a Brownian Bridge is a Brownian motion deviated from its mean), and where a = 0.15 (exclude first and last 15% of the sample). Readers should be informed that, as a modified Chow test,the QLR statistic identifies the date within the 75% of sample time, it simply locate the most possible break date, while not denying there is not any other date when structural date could happen, as long as the Chow statistics surpass the critical value, at any given date. Hence the breaks at our previously identified dates, i.e., 1990q1, 2002q1 are still valid in the sense that the Chow statistics thereof surpass the critical level. For graphical evidence, please refer to Figure 1 and 2.

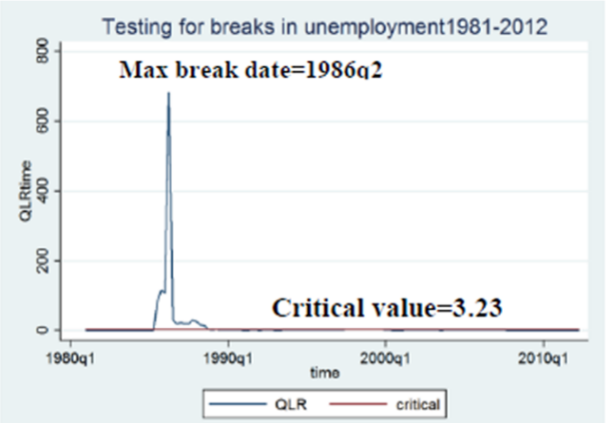
Figure 1: HP dataset Quandt Likelihood Statistics

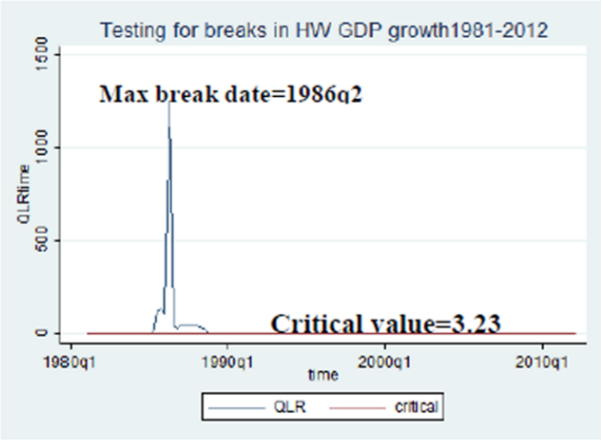


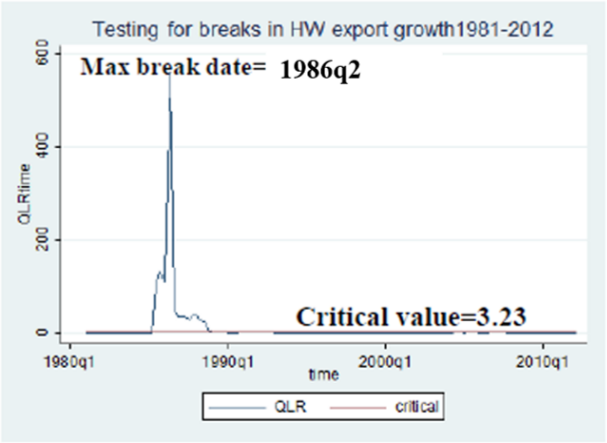
In the afore-presented models, three variables are included (the autocorrelated terms of unemployment rate, real GDP growth rate, real export gap) with 5 lags. In other words, the number of restriction is above 10, hence the critical value at 10%, 5%, and 1% are 2.48, 2.71. and 3.23 respectively[1]. Similar to the Chow test, we could measure the F statistics for each variables (i.e., cyclical unemployment rate, cyclical GDP growth rate, cyclical export gap rate) within the given range of 70%. Nonetheless, the QLR statistics for all three variables fall fairly close to one

[1]The list of Critical Values is available in Stock and Watson (Stock & Watson 2006)

Figure 2: HW dataset Quandt Likelihood Statistics







another, 1986q1, a simple average of the three candidates, is thus selected. Likewise, from the QLR statistics of three different variables in the HW dataset, the assumed break date is at 1986q2, which is one quarter next to the estimated break in the HP dataset.

Hence the following passage will include another ADL model with the dummy variable "Z_t", which equals to 1 if the time is after 1986q1 for the HP dataset and 1986q2 for the HW dataset respectively, together with its interactions terms:

$$\begin{aligned} u_t^* =& \gamma_1 + \sum_{i=1}^{p} \alpha_{1,i} u_{t-i}^* + \sum_{i=1}^{p} \beta_{1,i} y_{t-i}^* + \sum_{i=1}^{p} \delta_{1,i} export_{t-i}^* + \gamma_2 Z_t + \\ & \sum_{i=1}^{p} \alpha_{2,i} Z_{t-i+1} u_{t-i}^* + \sum_{i=1}^{p} \beta_{2,i} Z_{t-i+1} y_{t-i}^* + \sum_{i=1}^{p} \delta_{2,i} Z_{t-i+1} export_{t-i}^* + \epsilon \end{aligned} \tag{2}$$

Table 1: ADL model (break date = 1986q1 for HP and 1986q2 for HW)

	HP ADL Model	Before 1986q1 Z=0	After 1986q1 Z=1	De-seasonal ADL model	Before 1986q2 Z=0	After 1986q2 Z=1
Unemployment			HPunemp			
L1.	0.924***	0.087***	1.019***	0.822***	-0.502***	0.811***
	(0.0912)	(0.0006)		(0.0716)	(0.1460)	
L2.	-0.137	0.040***	-0.1	-0.0516	0.0682	0.046
	(0.0950)	(0.0002)		(0.0883)	(0.0652)	
L3.	-0.153*	-0.655***	-0.227***	-0.0843	-0.786***	-0.082***
	(0.0835)	(0.0008)		(0.0800)	(0.0695)	
L4.	0.688***	0.372***	0.695***	0.760***	0.381***	0.646**
	(0.1070)	(0.0003)		(0.1150)	(0.0819)	
L5.	-0.501***	0.104***	-0.537***	-0.713***	0.228**	-0.667**
	(0.0756)	(0.0002)		(0.0956)	(0.1080)	
GDP		HPcGDPgth			HWsrGDPth	
L1.	-2.296*	14.81***	-2.800***	-3.705***	67.10***	-4.080***
	(1.3530)	(0.0014)		(1.1540)	(11.5300)	
L2.	-1.241	-37.450***	-1.260***	-3.394***	19.00*	-2.400*
	(1.1030)	(0.0001)		(1.2530)	(10.3500)	
L3.	1.823	-7.019***	1.001***	-1.575	10.61	-1.86
	(1.1140)	(0.0042)		(1.0930)	(6.4560)	
L4.	-1.909*	6.860***	-1.059***	-2.348*	50.22***	-2.570***
	(1.1340)	(0.0003)		(1.2410)	(10.6800)	
L5.	4.807***	-18.61***	5.190***	-0.624	-6.632**	-1.018*
	(1.5780)	(0.0011)		(1.3040)	(3.1160)	
Export		HPexportgth			HWsexportgth	
L1.	-0.563	-7.736***	-0.391***	-0.885*	-14.33***	-1.090***
	(0.5970)	(0.0001)		(0.4700)	(2.8060)	
L2.	0.39	7.752***	0.640***	0.028	-19.72***	-0.130***
	(0.6510)	(0.0030)		(0.5420)	(4.7340)	
L3.	-0.027	-1.471***	0.815***	-0.148	-9.036***	0.558***
	(0.6370)	(0.0051)		(0.5610)	(3.1350)	
L4.	1.854***	4.308***	1.310***	1.608***	-18.96***	1.620***
	(0.5530)	(0.0012)		(0.4880)	(2.8840)	
L5.	-1.084*	3.151***	-1.721***	0.934**	-6.457***	0.853***
	(0.6000)	(0.0075)		(0.3760)	(1.9280)	
Adjusted R2	0.858	0.914		0.85	0.906	
legend: * p<0.05 ** p<0.01 *** p<0.001						

Table 2: Chow Statistics of HP and HW datasets at QLR Breaks

	HP dataset	HW dataset
Chow Statistics	Z=0	Z=0
Unemployment	$F_{(6,89)}$=101.65	$F_{(6,89)}$=28.67
	Prob=0.0000	Prob=0.0000
GDP	$F_{(6,89)}$=566.32	$F_{(6,89)}$=44.97
	robP=0.0000	Prob=0.0000
Export	$F_{(6,89)}$=78.01	$F_{(6,89)}$=59.11
	Prob=0.0000	Prob=0.0000

For HW dataset,$\bar{R}^2$ is 0.906, larger than 0.85, which is$\bar{R}^2$ for the de-seasonal ADL model, but it is smaller than 0.914, which is $\bar{R}^2$ in the HP counterpart.

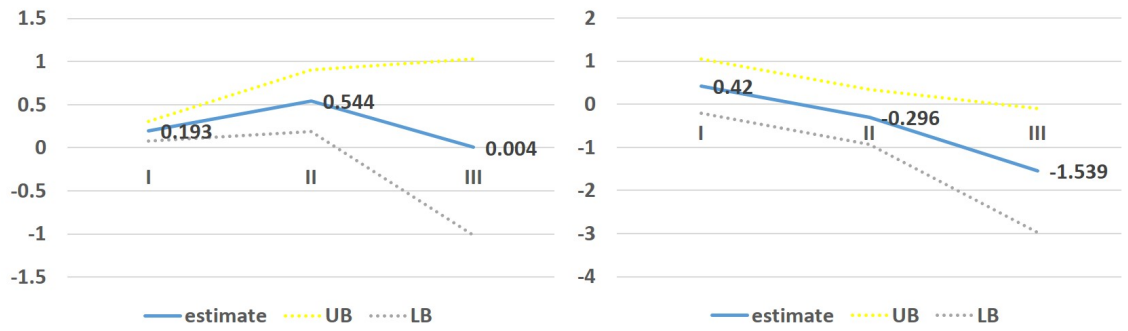
Nonetheless, the results of the two datasets are in general similar with one another in terms of sign for the significant terms, only the HW result is in general more obvious with more significant terms, and greater in terms of absolute value, but it is unanimously smaller after the break for both datasets: in HP dataset, the GDP coefficients range from -37.45 to -7.02 for negative terms and from 6.86 to 14.81 for positive terms before break date (Z=0), as opposed to ranging from -2.80 to -1.06 for negative terms and from 1.00 to 5.19 for positive terms. In HW dataset, the GDP coefficients take negative value as -6.63 and ranging positively from 19.00 to 6.71 before the break date (Z=0) and significantly all negative ranging from -4.08 to .1.01.

For export coefficients: in HP dataset, the coefficients range from -7.74 to -1.47 for negative terms and 3.15 to 7.75 for positive terms before break date (Z=0), and ranging from -1.72 to -0.39 for negative terms and 0.64 to 1.31 for positive terms afterward. As for HW dataset, the export coefficients range from -19.75 to -6.45 before the break date, and range from -1.09 to -0.13 for negative terms, and from 0.56 to 1.62 for positive terms afterward.

How could we justify that the break occurs at this date? It could be a result of multiple, intertwined shocks, both external or internal, that happened at the given date. One possible reason to start with could be the initiation of the bubble economy in Japan. It might have boosted up the purchasing power of Japanese domestic market, and therefore increasing relative demand on labour intensive commodities from the export processing zones of Taiwan. This is consistent with the H-O prediction proposed by Dutt et al., while Taiwan has switched its role as a labour-abundant country exporting labour intensive components,e.g., integrated circuit (IC) or Vacuum Fluorescent Display (VFD),required for the production of electronic goods that are made by Japanese enterprises. In such case, the unemployment rate is negatively correlated with export gap in both sub periods.

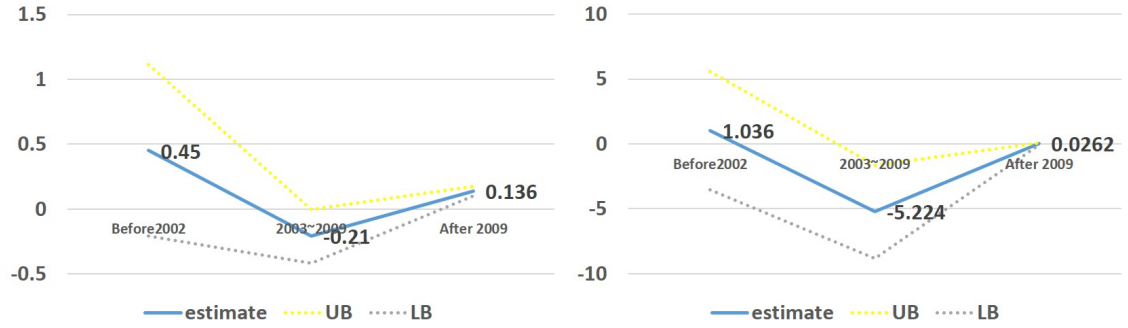
Such dynamics might be strengthened by the fact that the international raw material prices linked with the prices of manufactured goods and services hit their lowest levels in recorded history at early 1986. The price level in general was as low as at the depths of the Great Depression, and in some cases (e.g., lead and copper) it is lower than their 1932 levels (Drucker 1986). Being so, the inter-industrial movement of labour and capital might occur, flowing into labour –intensive sectors, therefore the overall job matching rate is increasing, implying a negative relation between unemployment and export gap and of course, a negative relation between

unemployment and GDP growth, given the production level is also increased due to decreased production cost(Bau et al. 1992). Lastly, the year 1986 was at the very end of the 38 year Taiwanese martial law, that had been abolished ever since 1949. This was the same year when the Democratic Progressive Party, the first opposition party ever in Taiwanese history, was illegally established in September of that year. Even though the break date is at 1986q1 which is at least a half year earlier, still, the disturbance of social atmosphere as well as the expectation of true democracy might actually have some impact on the confidence of local labour, employers and investors, which might affect the production function endogenously.



(a) Education Return by Different Cohorts **(b)** Prop. Invest. Coef. by Different Cohorts

Figure 3: Cross-Sectional Mincerian Estimates by Different Cohorts



(a) Education Return by Different Periods **(b)** Prop. Invest. Coef. by Different Periods

Figure 4: Cross-Sectional Mincerian Estimates of Education Return by Different Periods

Appendix .5. Coefficient Estimates of Taiwan and UK

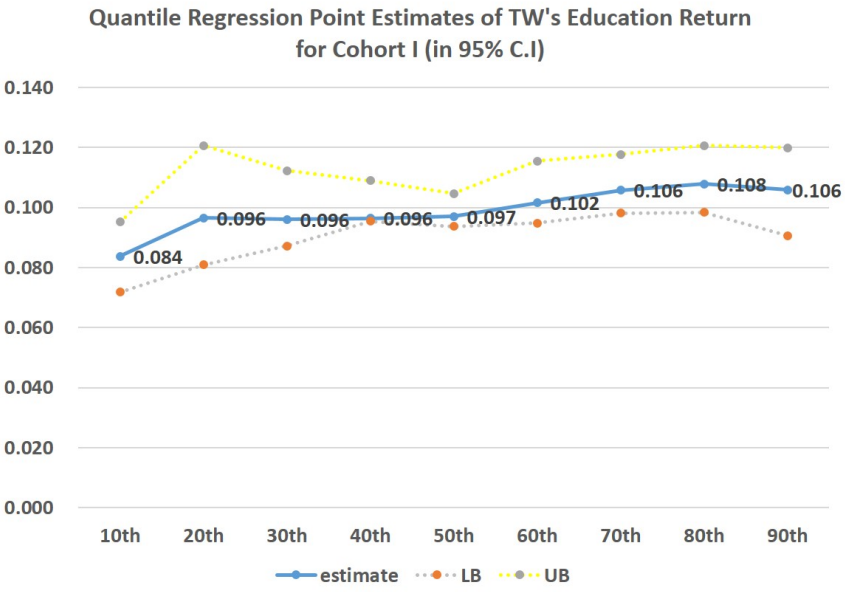


Figure 5: QR Estimates of TW's Education Return: Cohort I

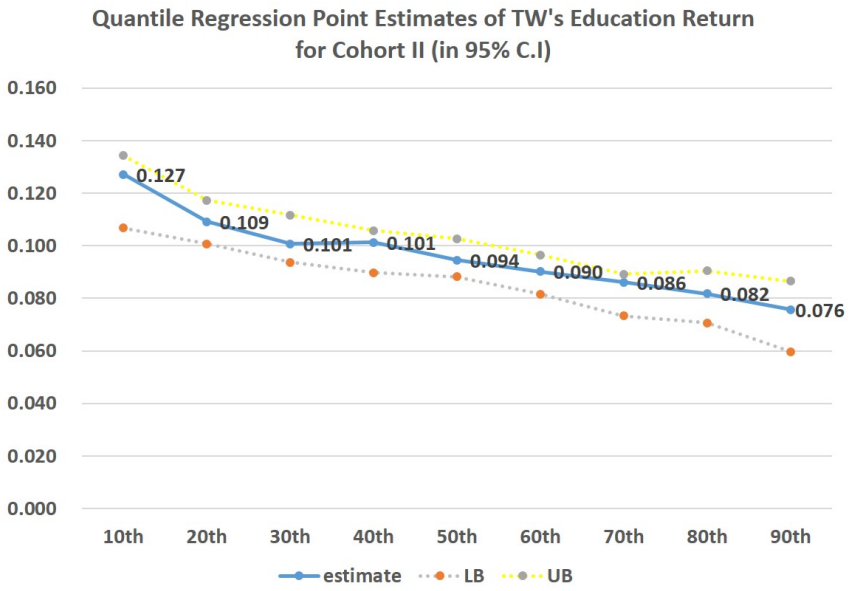


Figure 6: QR Estimates of TW's Education Return: Cohort II

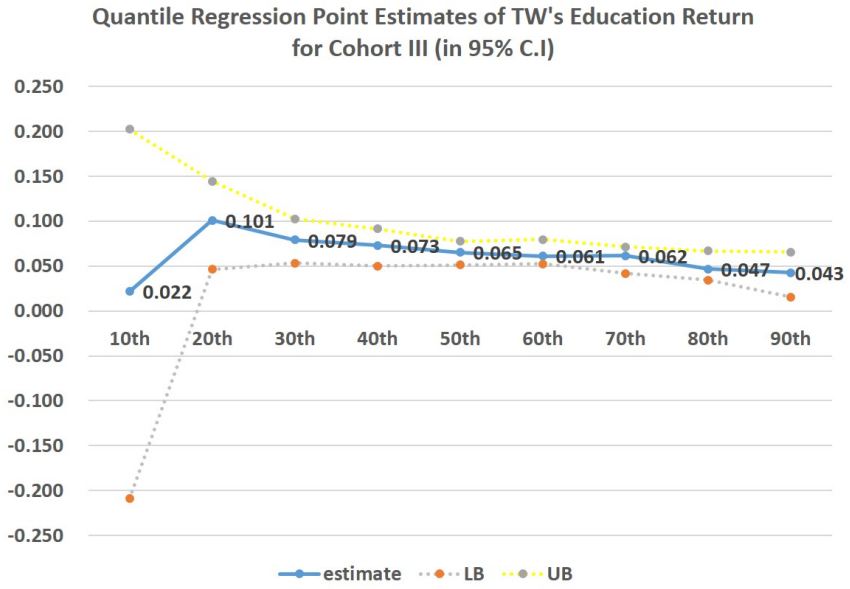


Figure 7: QR Estimates of TW's Education Return: Cohort III

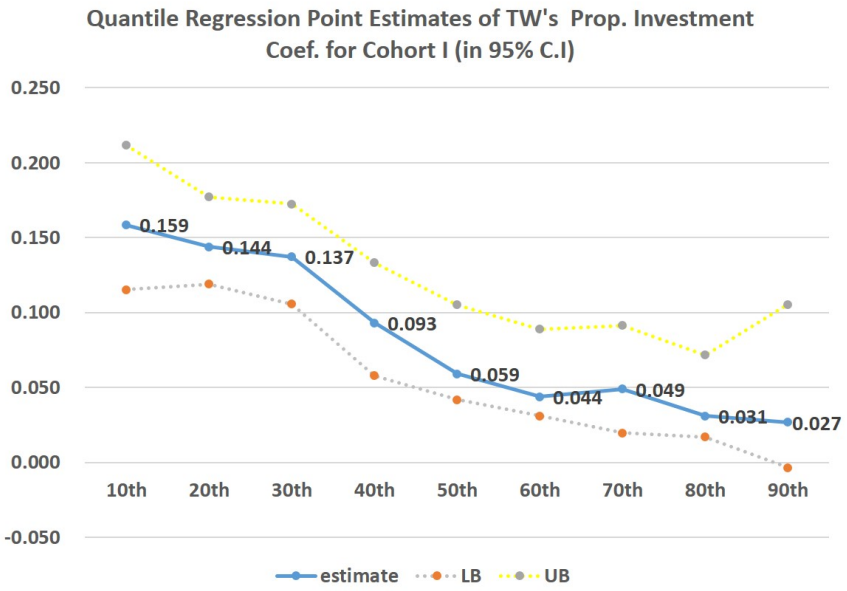


Figure 8: QR Estimates of TW's Prop. Investment Coefficient: Cohort I

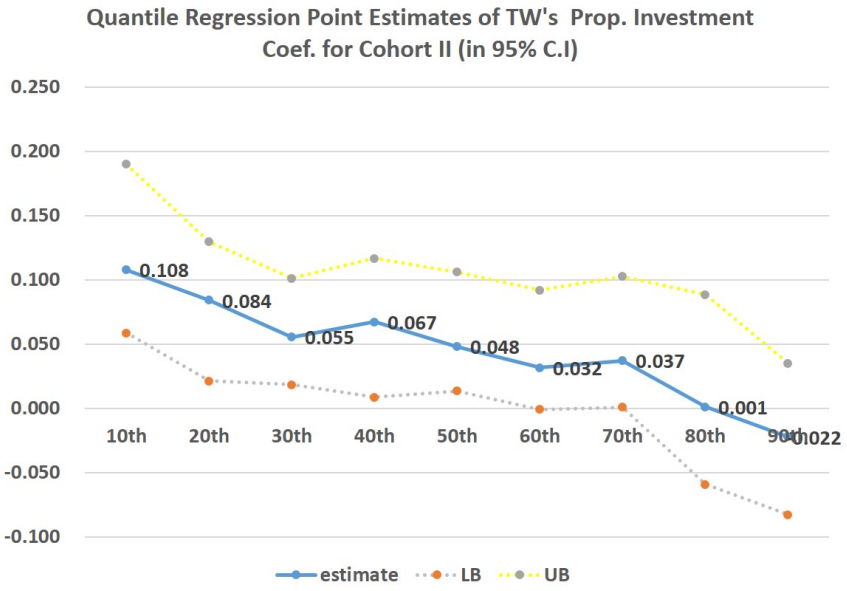


Figure 9: QR Estimates of TW's Prop. Investment Coefficient: Cohort II

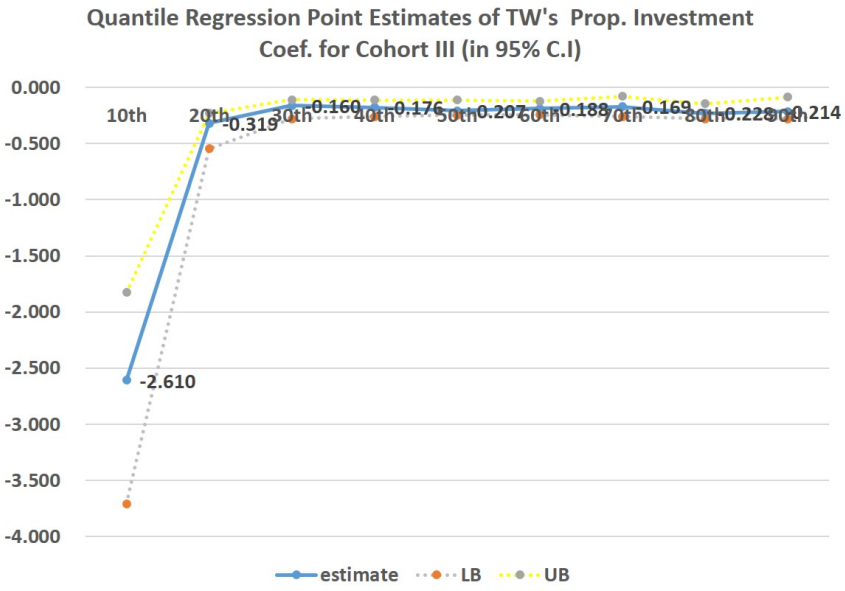


Figure 10: QR Estimates of TW's Prop. Investment Coefficient: Cohort III

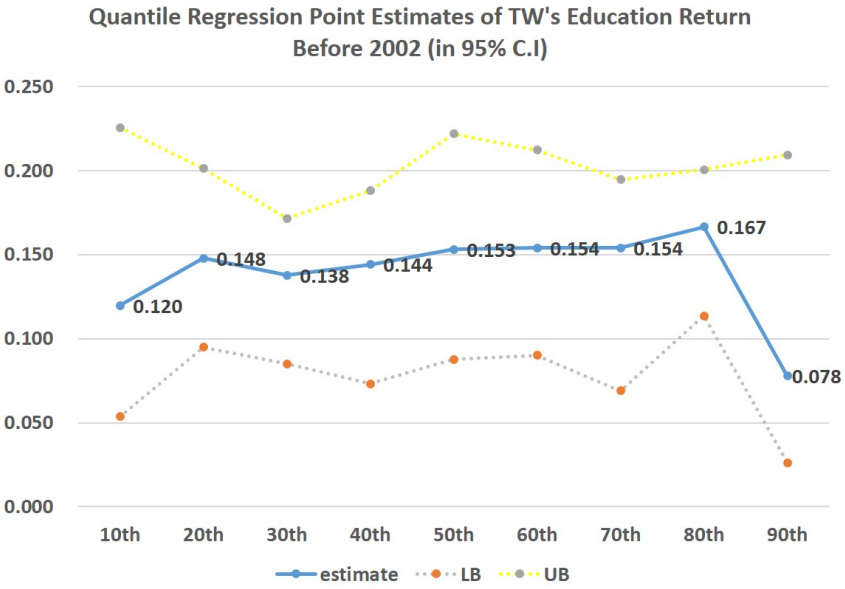


Figure 11: QR Estimates of Education Return: Before 2002

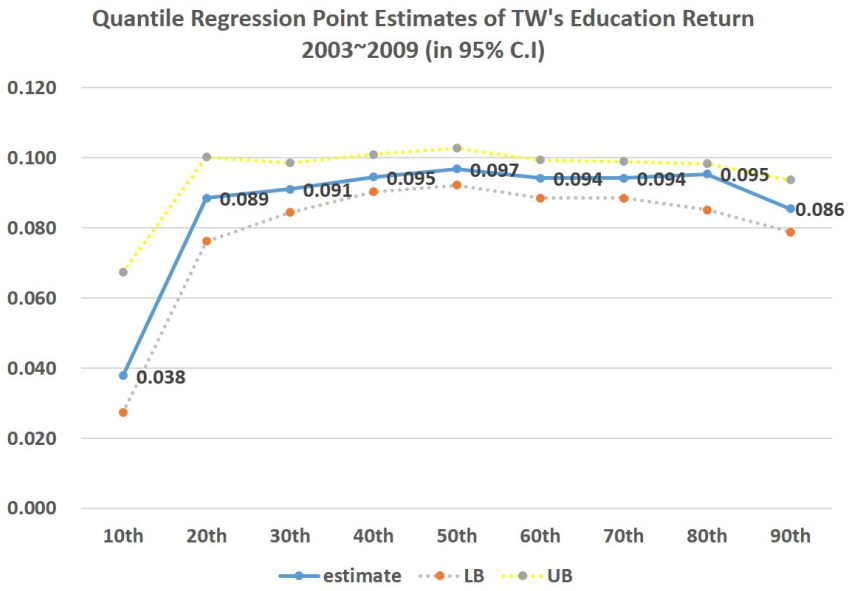


Figure 12: QR Estimates of Education Return: 2003∼2009

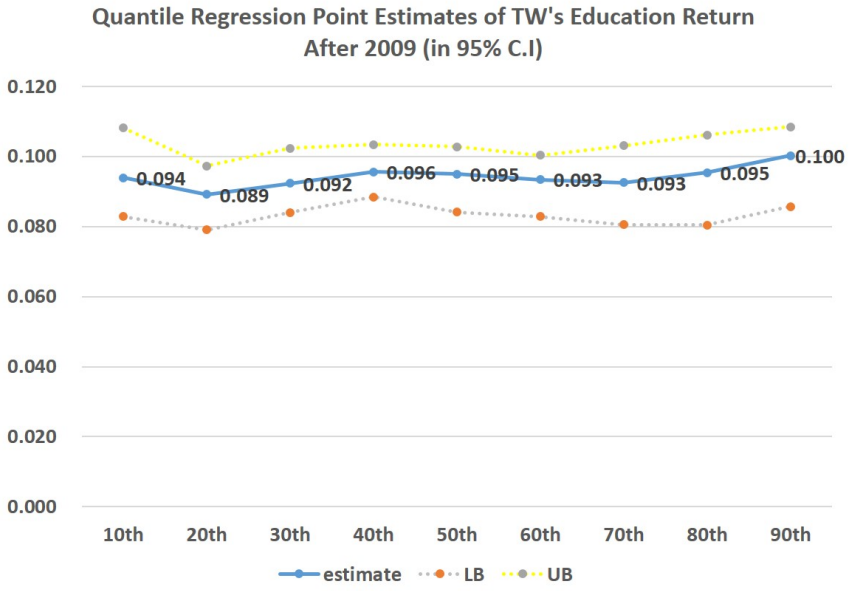


Figure 13: QR Estimates of Education Return: After 2009

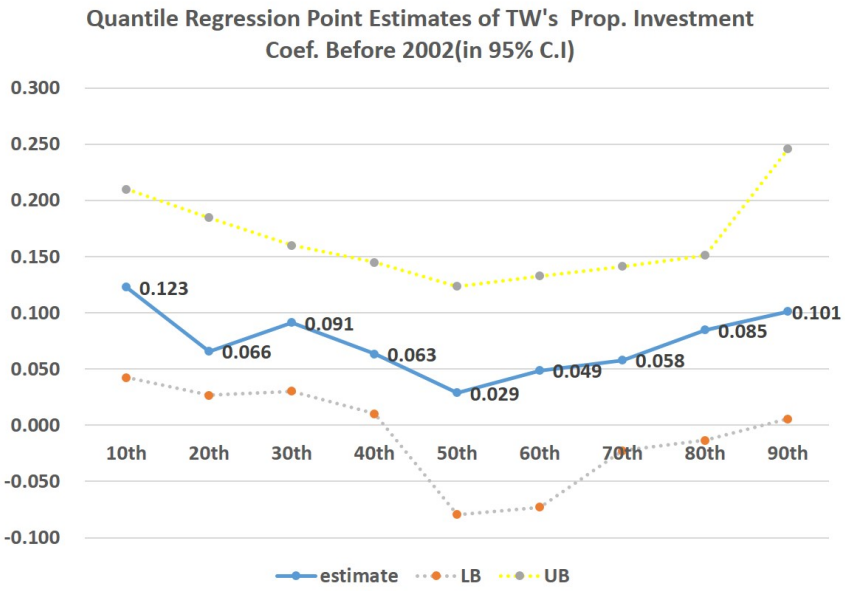


Figure 14: QR Estimates of Prop. Investment Coefficient: Before 2002

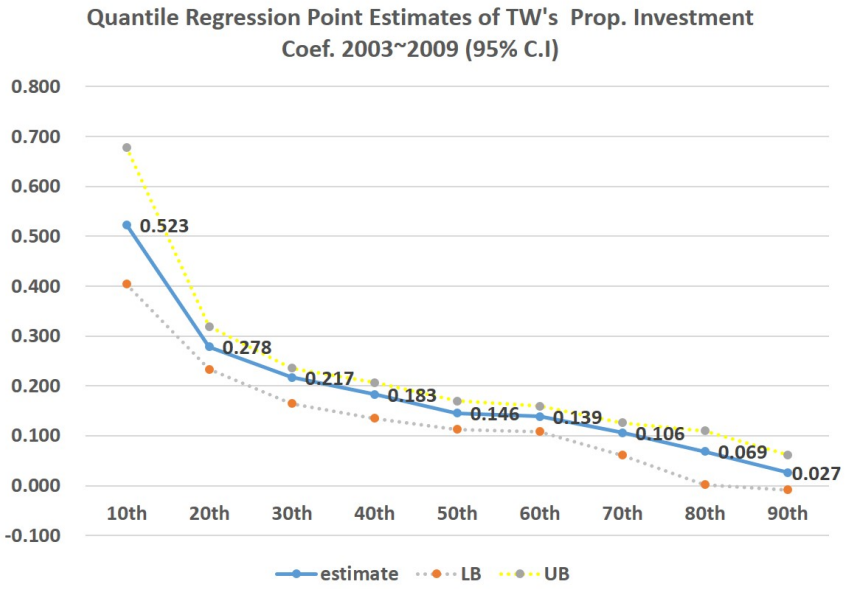


Figure 15: QR Estimates of Prop. Investment Coefficient: 2003∼2009

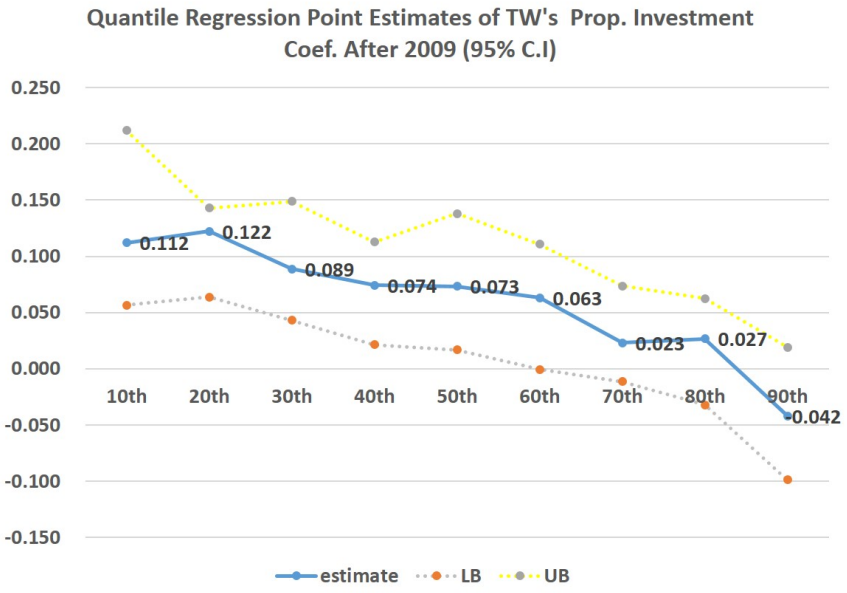


Figure 16: QR Estimates of Prop. Investment Coefficient: After 2009

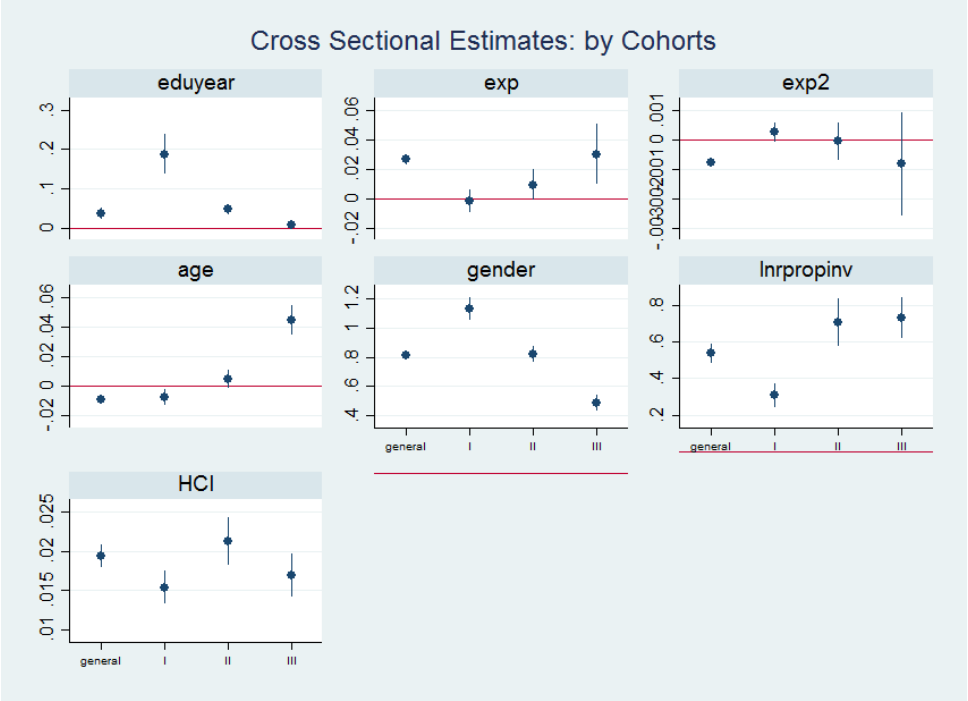


Figure 17: Coefficient Plots of Cross-Sectional Estimates: by Cohorts

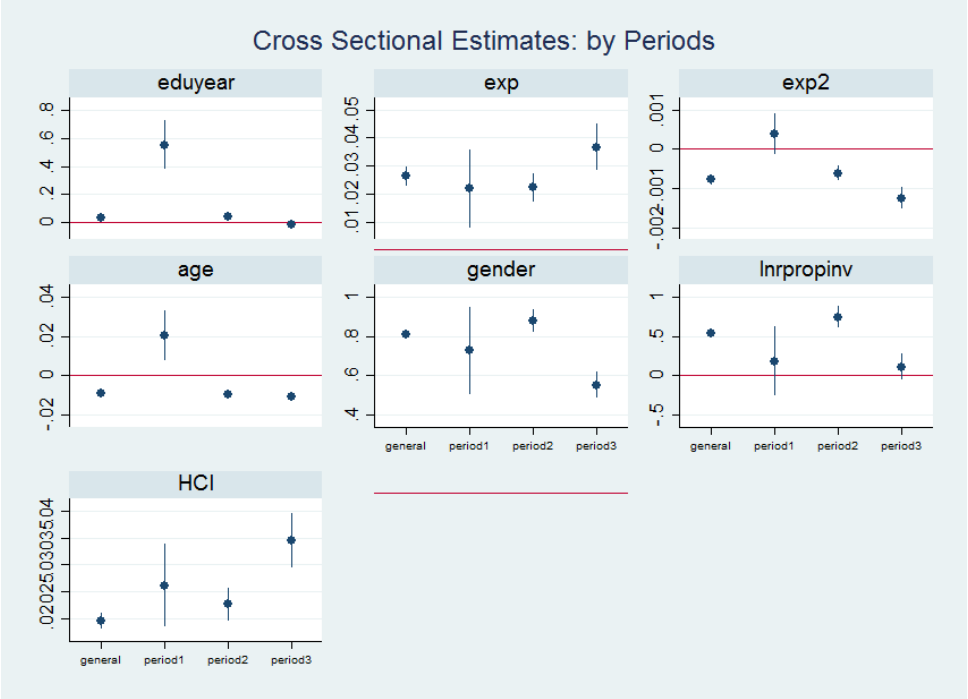


Figure 18: Coefficient Plots of Cross-Sectional Estimates: by Periods

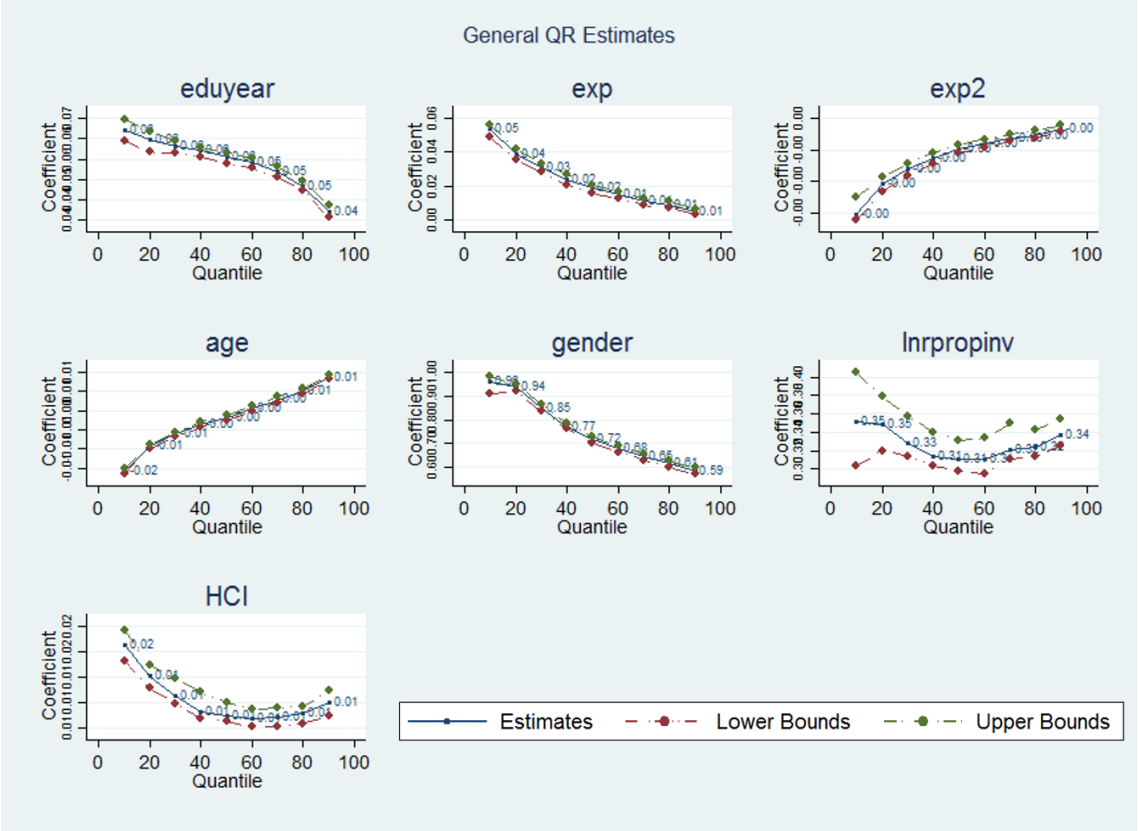


Figure 19: Quantile Regression Estimates: All Cohorts

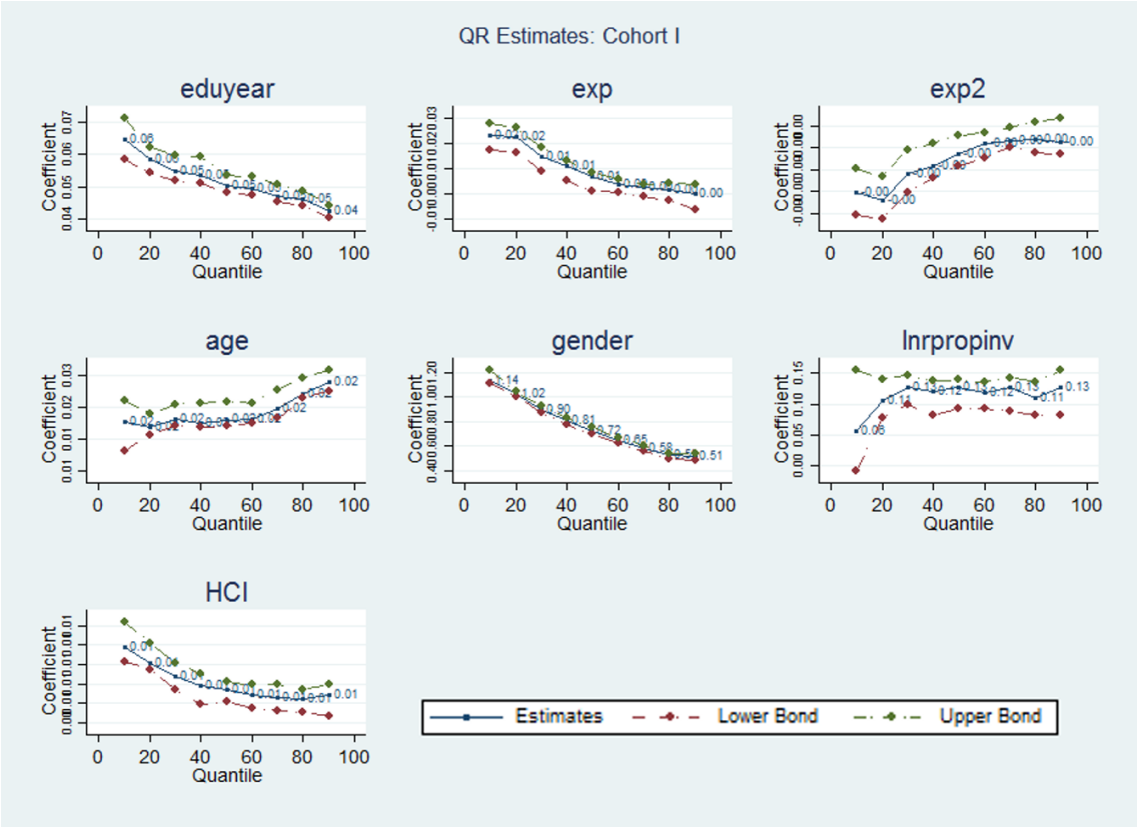


Figure 20: Quantile Regression Estimates: Cohorts I

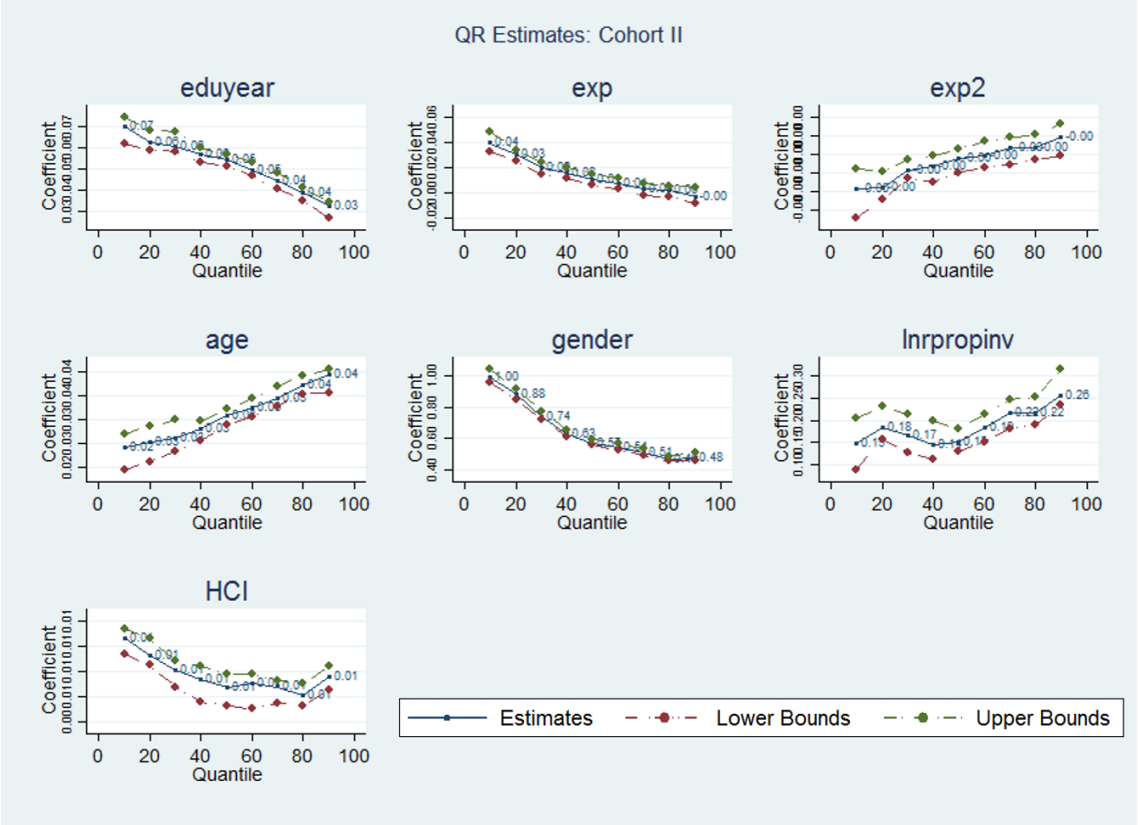


Figure 21: Quantile Regression Estimates: Cohorts II

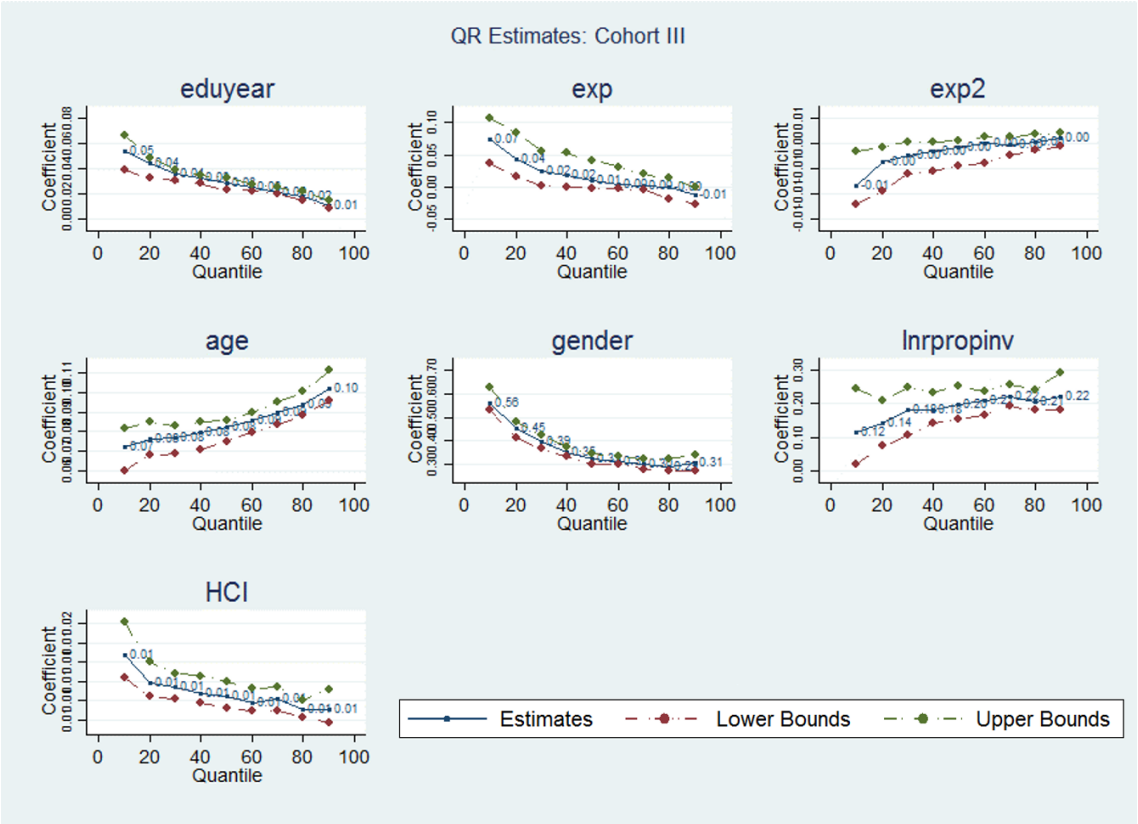


Figure 22: Quantile Regression Estimates: Cohorts III

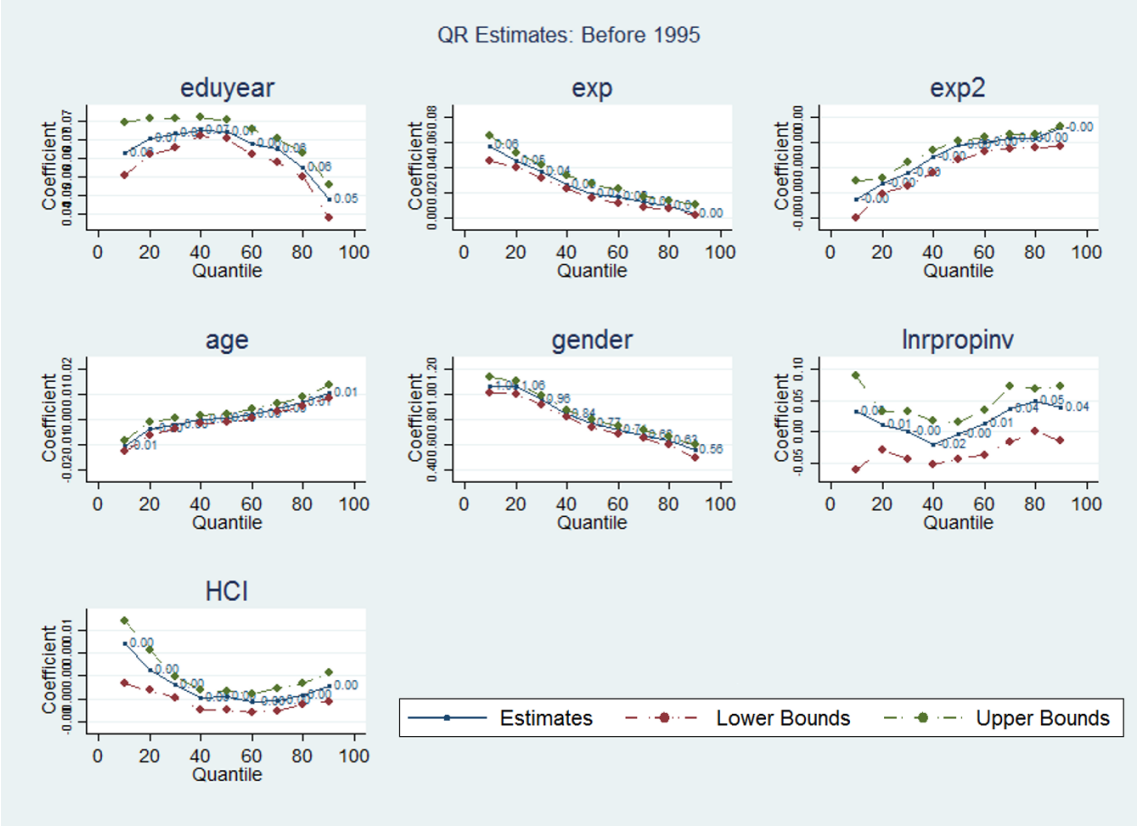


Figure 23: Quantile Regression Estimates:Before 1995

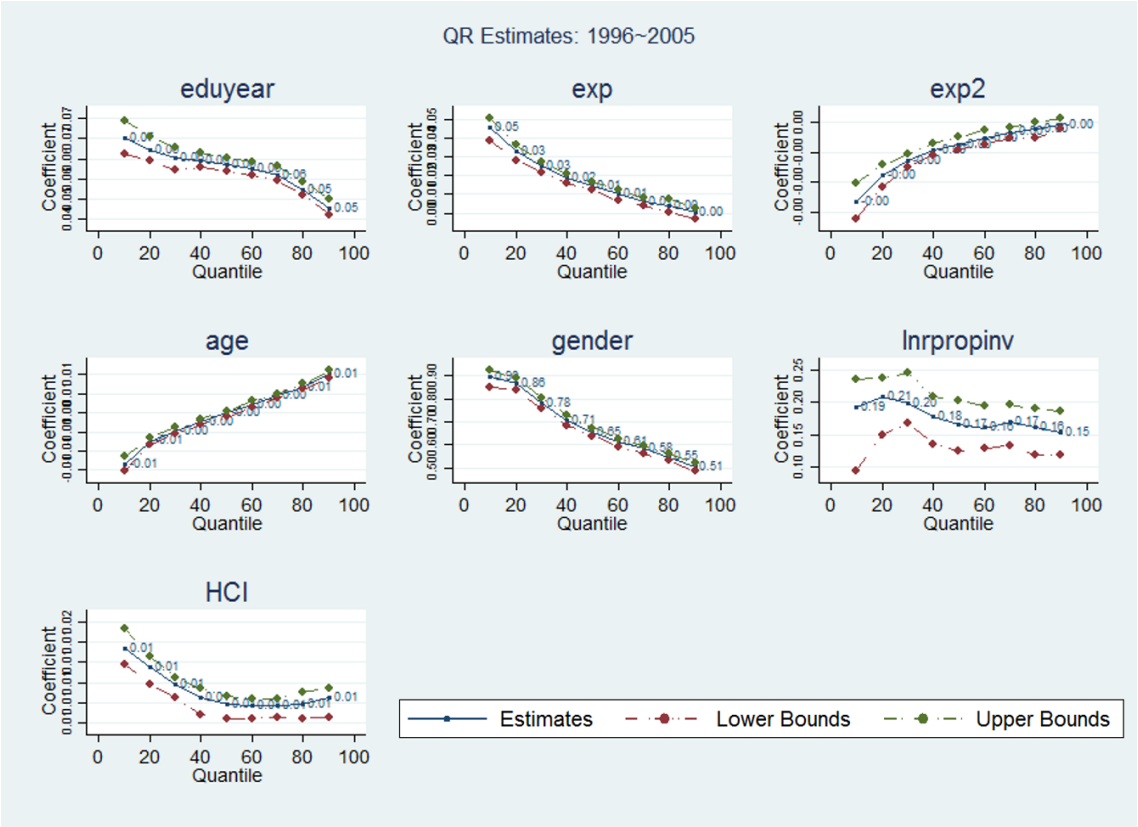


Figure 24: Quantile Regression Estimates:1995∼2005

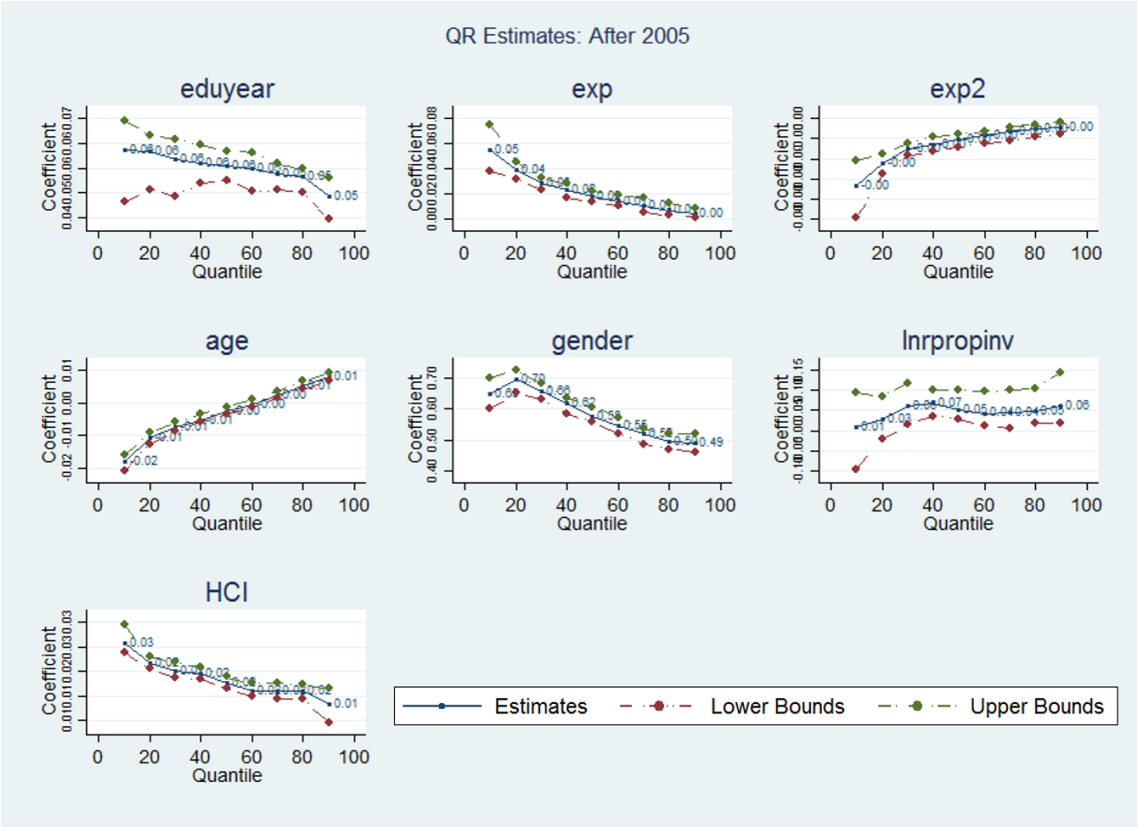


Figure 25: Quantile Regression Estimates: After 2005

Appendix .6. Taiwanese Time Fixed Effect Mincerian Estimates

Given the longitudinal nature of the Taiwanese PSFD dataset, the result could only be statistically meaningful under the strong assumption of i.i.d.[2]The following estimator applies the fixed time effect model with instrument variables, which are different for cohort analysis and period segmentation.[3] The estimates directly focus on cohort and time-segmented analysis, and are elaborated as follows.

The fixed time Mincerian wage estimator is presented in the following equation,

$$\ln W_{it} = \beta_0 + \beta_1 education\ year_{it} + \beta_2 experience_{it} + \beta_3 experience_{it}^2 + \beta_4 Age_{it} + \beta_5 gender_{it} + \beta_6 Property\ Investment_{it} + \beta_7 \Lambda_{it} + \sum_{t=n}^{N} \gamma_t D_t + \sum_{t=n}^{N} \psi_t Z_t + \epsilon_{it} \tag{3}$$

the education attainment is similarly estimated as in the Cross-Sectional estimator, i.e., dummy indicators R1987 and R1999 for the general result, while they are removed as to avoid multicollinearity in the Cohort analysis.

Industrial property investment is estimated with House Price Index of the region where the interviewee resides at the time when she receives her most recent monthly wage, and the year dummies as to estimate the arbitrage investment in the real estate market of each industry:

$$Property\ Investment_{it} = \omega_0 + \omega_1 HPI_{it} + \sum_{t=n}^{N} \gamma_t D_t + u_2$$

where D_t is the year dummies in which n ranges from 1999 to 2011, and Z_t is the dummy indicator of 15 industries.

The following table focuses on the coefficients of the variables, hence that of the dummy indicators of time, or industries are not listed.

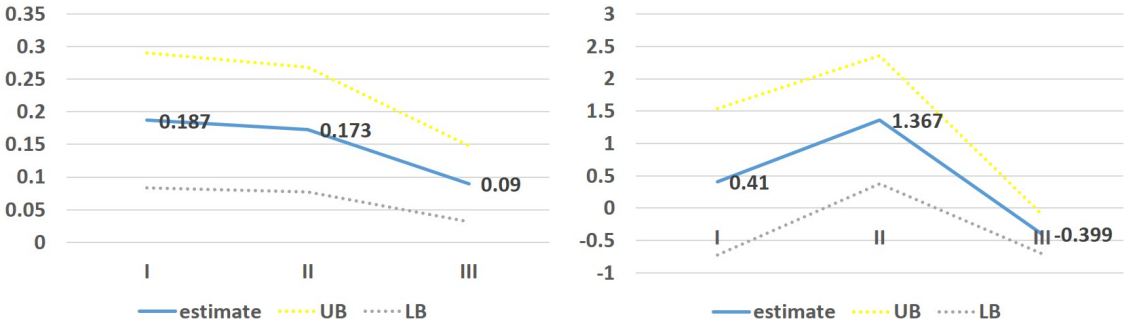
[2]Cross sectional estimator $Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_k X_{ki} + u_i, i = 1, ..., n$ is an Ordinary Least Square (OLS) estimator which requires the Gauss-Markov Assumptions, i.e., 1. conditional mean of residual $E(u \mid X_1 = x_1, ..., X_k = x_k)$ is zero. 2.i.i.d. observations: (x_i, y_i) is independent from, and has the same distribution as, $(x_{1j}, ..., x_{kj}, y_j)\ \forall i \neq j$; 3. finite 4th moment: $E(X_{1i}^4) < \infty, ..., E(X_{ki}^4) < \infty, E(Y_i^4) < \infty$. and 4. no perfect multicollinearity

[3]To minimize Omitted Variable Bias (OVB), the application of fixed time estimate is an attempt to capture the unmeasurable/non-recordable factors that is changing over time, but constant cross individuals, e.g., legal regulation, content of knowledge taught while receiving education, elasticity, structure, hiring preference, job finding rate, job separation rate within labour market at the given time.

Table 3: Fixed Time Mincerian Regression

	general lnrwageUSD	CohortI lnrwageUSD	CohortII lnrwageUSD	CohortIII lnrwageUSD	Before2002 lnrwageUSD	2003~2009 lnrwageUSD	After 2009 lnrwageUSD
lnrwageUSD							
eduyear	0.177***	0.187***	0.173***	0.0908***	0.106	0.0969	0.238***
	(0.0347)	(0.0314)	(0.0290)	(0.0176)	(0.0819)	(0.0671)	(0.0355)
exp	0.144***	0.0407***	0.0761***	−0.00215	0.0227	0.185***	0.102***
	(0.0171)	(0.00872)	(0.0189)	(0.0189)	(0.0225)	(0.0428)	(0.0182)
exp2	−0.00272***	−0.000578***	−0.00190***	0.000232	−0.000359	−0.00380***	−0.00151***
	(0.000265)	(0.000173)	(0.000372)	(0.000950)	(0.000613)	(0.000723)	(0.000244)
Age	0.0101	−0.0525***	−0.00326	0.0372**	−0.0200	0.0516	−0.0341**
	(0.0107)	(0.0150)	(0.0133)	(0.0115)	(0.0492)	(0.0264)	(0.0117)
gender	0.588***	1.039***	0.457***	0.304***	0.606	0.611**	0.526***
	(0.0919)	(0.177)	(0.0902)	(0.0830)	(0.463)	(0.222)	(0.0858)
lnavgproploan	−2.686***	0.410	1.367**	−0.399**	2.817	−5.784***	3.338
	(0.675)	(0.577)	(0.506)	(0.154)	(3.915)	(1.334)	(1.772)
invmills	1.094*	2.020***	0.757	0.132	0.727	0.487	1.470***
	(0.446)	(0.552)	(0.600)	(0.646)	(1.823)	(1.054)	(0.402)
_cons	10.52***	10.32***	10.79***	11.48***	0	10.58***	9.881***
	(0.106)	(0.180)	(0.183)	(0.117)	(.)	(0.193)	(0.752)
N	9885	3566	3924	1994	406	6153	3326

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$



(a) Education Return by Different Cohorts **(b)** Prop. Invest. Coef. by Different Cohorts

Figure 26: Fixed Time Mincerian Estimates by Different Cohorts

(a) Education Return by Different Periods **(b)** Prop. Invest. Coef. by Different Periods

Figure 27: Fixed Time Mincerian Estimates by Different Periods

The fixed time estimate of education return seems consistent with the previous result of cross-sectional estimates on cohorts, being significant for all three cohort (0.187% for Cohort I, 0.173% for Cohort II, and 0.09 for Cohort III). Likewise, a graphic comparison is presented in Fig 26a.

For Cohort I and II, the fixed time estimates of experience are still increasing and significantly non-linear, yet insignificant for Cohort III. The result is still consistent with Cross-Sectional estimates.

As for characteristic variables, the fixed time estimate of age are generally consistent with Cross-Sectional estimates for all three cohorts (-0.0525% for cohort I, insignificant -0.0326% for cohort II and 0.0372% for cohort III). The same estimate seems of less statistic significance in Taiwan, only for the youngest cohort (0.0317% for Cohort III), with which we might conclude, at least for the youngest cohort that age matters more in UK than in Taiwan. Consistency is also observable in gender, showing gender gap in wage for male workers.

The fixed time estimate of average arbitrage property investment appears to be generally consistent with cross sectional estimates, (insignificant 0.978% for Cohort I, 1.367% for Cohort II, and -0.399% for Cohort III). They appears to be the variable with the largest impact among all the variables. It once again support the statement that the younger cohort in Taiwan suffers from wage loss due to such arbitrage investment. Figure 26b presents the difference between cohorts.

For subperiods comparison, The fixed time estimate of education return seems not contradictory due to the insignificant level before 2009, but still significantly positive after 2009 (0.238%). The graphic comparison is presented in Figure 27a. Experience factor likewise seems consistently increasing and nonlinear between two estimates, also only significant after 2002 and similar to cross sectional estimates, it is of smaller impact after 2009. By and large, consistency can also be observed in characteristics such as age, albeit insignificantly as they are. and in gender, which once again support a gender gap in wage.
Lastly, in fixed time estimates, average arbitrage property investment is only significant and negative in the period between 2003 and 2009, also shows consistency between two estimates, and supportive the theoretical prediction (please check Figure 27b).

Appendix .7. UK Fixed-Effect Mincerian Estimates

Following the method applied in the previous chapter, in this section, Fixed-Effects of time and region code are included to account for the unmeasurable/non-recorded

factors. The regressions for both Cohort analysis and sub-period analysis have the same structure, and presented as follows:
The fixed time Mincerian wage estimator is presented in the following equation,

$$\begin{aligned}\ln W_{it} &= \beta_0 + \beta_1 education\ year_{it} + \beta_2 experience_{it} + \beta_3 experience_{it}^2 + \beta_4 Age_{it} \\ &+\beta_5 gender_{it} + \beta_6 Real\ Esate\ Investment_{it} + \beta_7 HCI_{it} + \beta_8 \Lambda + \sum_{t=n}^{N} \gamma_t D_t + \epsilon_{it} \\ education\ year_{it} &= \gamma_0 + \sum_{t=n}^{N} \gamma_t D_t + \sum_{t=n}^{N} \psi_t region\ code_{ti} + u_1\end{aligned} \tag{4}$$

$$Real\ Esate\ Investment_{it} = \omega_0 + \sum_{t=n}^{N} \omega_t D_t + \delta_1 HPI_{it} + \sum_{t=n}^{N} \sigma_t region\ code_{it} + u_2$$

where D_t is the year dummies in which n ranges from 1991 to 2008, and region code is as explained in section 4.2.5.3. In the following table, the focus falls upon the coefficient of each variable, hence the results for Fixed-Effect dummy indicator or those of instrument variables are not included so to avoid confusion.

In the general estimates, education return is 0.757% for one additional year of education. Such estimated result appears to be higher than the counterpart estimate in Cross-Sectional result.[4] The return of experience is 0.0513%, nonlinearly increasing (with squared term significantly negative), higher than its counterpart (0.0263%) in Cross-Sectional result, lower than that in Taiwanese result, and lower than education return. Once again, such difference between return of education and that of experience is robustly observed in Cross-Sectional Estimates, and similarly observed in Taiwanese counterparts(education: 0.177%, experience: 0.144% in Taiwan). The marginal impact of age on wage remains negative (-0.172%), after taking Fixed-Effects into account. Gender gap is still significantly observed (6.097%), higher than that estimated in Cross-Sectional result(0.809%), and higher than that in Taiwanese Fixed-Effect estimates (0.588%). As for real property investment does not remain significant in Fixed-Effect estimates. Lastly, HCI still remain significantly positive, yet appears to be of smaller impact (0.00822%).

As for the result of Cohort analysis in Fixed-Effect estimates, education return still decreases in Cohorts as in Cross-Sectional estimates, yet with less significance (CohortI: 0.536% and CohortII: 0.371%. while it is insignificant for CohortIII). The estimated coefficient of education returns is higher than their Taiwanese counterparts for the significant terms, which might be regarded as an upward correction of Cross-Sectional estimates, after incorporating the Fixed-Effects which might account for the non-recorded, non-measurable factors. Nonetheless, at current stage, it may be too reckless to conclusively compare the education returns of these two countries

[4]Similar differences between Fixed-Effect estimates and Cross-Sectional Estimates is also observable in Taiwanese results

on a robust basis. Experience, as more significantly shown in the Fixed-Effect estimates, increases in Cohorts (CohortI: 0.0130%, CohortII: 0.0422%, and CohortIII: 0.102%), while this might be similarly observed at less significant level in Taiwanese result. Such might be intuitively correct, i.e., for younger workers, one extra year of experience is relatively more valuable than that for older generations. Age, since the Cross-Sectional estimates of its coefficient for Cohort II is not significant, it might be still reasonable to conclude that the results of age coefficient in Cross-Sectional estimates and those in Fixed-Effect estimates are consistently similar. In Fixed-Effect estimates, age appears to be of negative impact for older Cohorts, and of positive impact for the younger (Cohort I: -0.127%, Cohort II: -0.0720%, and Cohort III:0.157%). Such results can be observed in Taiwanese counterpart, though the significant level being lower and marginal impact being smaller in Taiwanese result. Gender gap also survives in the Fixed-Effect estimates, decreasing in Cohorts as similarly observed in Cross-Sectional results, and being larger than Cross-Sectional results, though the coefficient for last Cohort being insignificant (Cohort I: 4.948% and Cohort II: 3.418%). Such decreasing pattern in Cohort is also observable in Taiwanese result. As for real property investment, though less significant as opposed to their Cross-Sectional counterparts, it might still be reasonable to conclude that it is increasing in Cohort, though Cohort I is insignificant (Cohort II: 0.398% Cohort III: 0.865%). This result, is nevertheless inconsistently observed in Taiwanese Counterpart. Such asymmetric results between two countries is similarly observed in Cross-Sectional estimates, which could be regarded as supporting evidence that the nature of real property investments made by the UK industries are different than that in Taiwan: the former might focus on business expansion or increasing production level, which might be of positive impact on labour wage, whereas the latter might have negative impact, as Taiwanese corporations are said to possess the tendency to shift investment into real estate market to earn arbitrage profit, which might crowd out investment on business thereby deteriorate wage. Lastly, HCI appears to be increasing in Cohorts(Cohort I: 0.00930%, Cohort II: 0.0160%, and Cohort IIII: 0.0224%), which is similar with the coefficients of real property investment. This might be interpreted as the younger Cohorts need relatively more human capital investment than older Cohort, whose human capital might already have been established, as abilities developed. This result can be robustly observed in Cross-Sectional result. A summarizing coefficient plot for the comparison between Cohorts is available in Figure 28.

As for the comparison between sub-periods, education returns decrease over periods (Before1995: 0.834%, 1996∼2005: 0.669% and After 2005: 0.431%), such pattern is similar with (while the value being higher than) the returns estimated

in Cross-Sectional Results. Experience retains being nonlinear and increasing (Before1995: 0.0589%, 1996∼2005: 0.0463% and After 2005: 0.0575%), the value of which are larger than Cross-Sectional counterparts, with the pattern between subperiods being less similar than the Cross-Sectional ones. Age appears to be of negative impact on wage(Before1995: -0.183%, 1996∼2005: -0.150% and After 2005: -0.0979%), which seems diminishingly influential as periods being. Such negative marginal impact seems slightly different (yet with larger value) than the counterpart in Cross-Sectional result, where age has positive marginal impact on wage before 1995. Gender gap still survives at each subperiods, and remain larger than the counterpart in Cross-Sectional result(Before1995: 7.053%, 1996∼2005: 5.380% and After 2005: 3.582%), yet the diminishing pattern in periods is not similarly observed in the Cross-Sectional results. Real Property Investment however, become insignificant for all sub-periods. Once again, such insignificancy defies the hypothesis that corporations in the UK obtaining arbitrage profit in real property market so that causing labour suffering wage loss. Lastly, HCI remains positive and demonstrating increasing pattern over periods, (Before1995: 0.00705%, 1996∼2005: 0.00822% and After 2005: 0.0276%). Though such pattern is less obviously observed in Cross-Sectional Results, still, by both results of Cross-Sectional and Fixed-Effect, it can be robustly concluded that HCI is positively correlated with wage. A summarizing coefficient plot for the comparison of each period is available in Figure 29.

Table 4: Fixed Effect Estimator by Different Cohorts and Periods

	general	Cohort I	Cohort II	Cohort III	Before1995	1996∼2005	After 2005
	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD
eduyear	0.757***	0.536***	0.371***	-0.222	0.834**	0.669***	0.431***
	(0.0992)	(0.0910)	(0.109)	(0.159)	(0.269)	(0.102)	(0.127)
exp	0.0513***	0.0130***	0.0422***	0.102***	0.0589***	0.0463***	0.0575***
	(0.00220)	(0.00261)	(0.00500)	(0.0125)	(0.00822)	(0.00259)	(0.00443)
exp2	-0.00133***	-0.000137	-0.00158***	-0.00534***	-0.00125***	-0.00125***	-0.00167***
	(0.0000609)	(0.000120)	(0.000282)	(0.000972)	(0.000145)	(0.0000769)	(0.000139)
Age	-0.172***	-0.127***	-0.0720*	0.157**	-0.183**	-0.150***	-0.0979**
	(0.0244)	(0.0255)	(0.0293)	(0.0499)	(0.0651)	(0.0252)	(0.0314)
gender	6.097***	4.948***	3.418***	-1.306	7.053***	5.380***	3.582***
	(0.749)	(0.776)	(0.891)	(1.251)	(2.108)	(0.768)	(0.951)
lnrpropinv	-0.0970	0.00445	0.398***	0.865***	0.0423	-0.0977	0.168
	(0.0885)	(0.0572)	(0.0718)	(0.120)	(0.146)	(0.0951)	(0.131)
HCI	0.00822***	0.00930***	0.0160***	0.0224***	0.00705***	0.00822***	0.0276***
	(0.00184)	(0.00146)	(0.00156)	(0.00219)	(0.00206)	(0.00196)	(0.00408)
Λ	13.33***	9.696***	7.592**	-5.634	15.14**	11.63***	7.290**
	(1.839)	(1.771)	(2.466)	(3.993)	(5.118)	(1.886)	(2.330)
_cons	-4.440***	-2.126	-4.849**	-2.343	-7.758*	-3.278**	-3.061*
	(0.903)	(1.247)	(1.803)	(2.107)	(3.261)	(1.004)	(1.502)
N	73995	30609	30853	12533	9498	47061	17436
="* p<0.05	** p<0.01	*** p<0.001"					

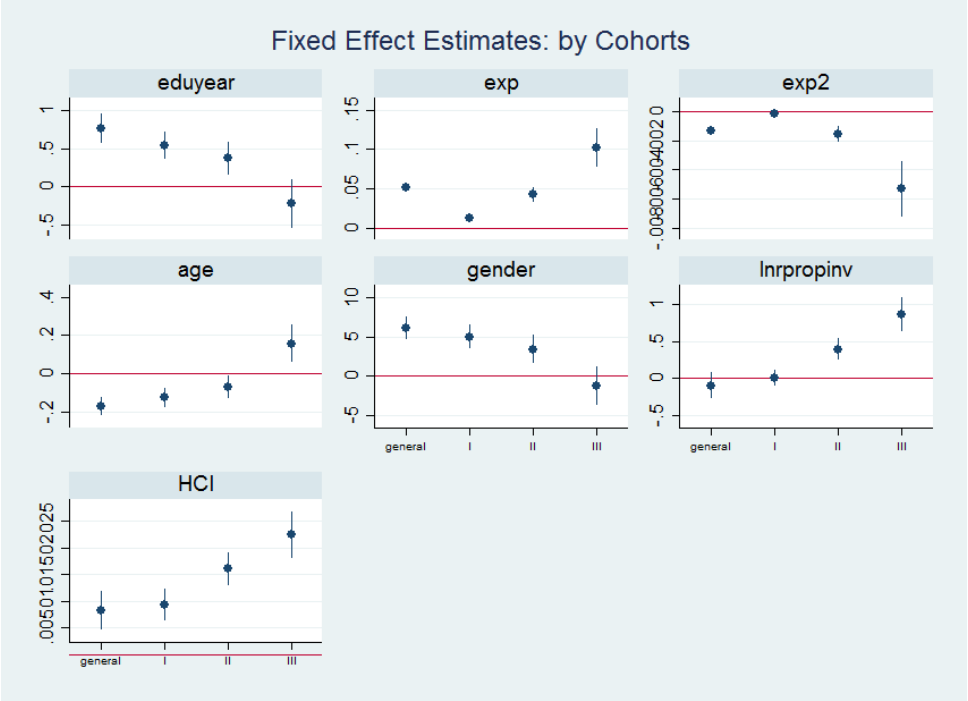


Figure 28: Coefficient Plots of Fixed-Effect Estimates: by Cohorts

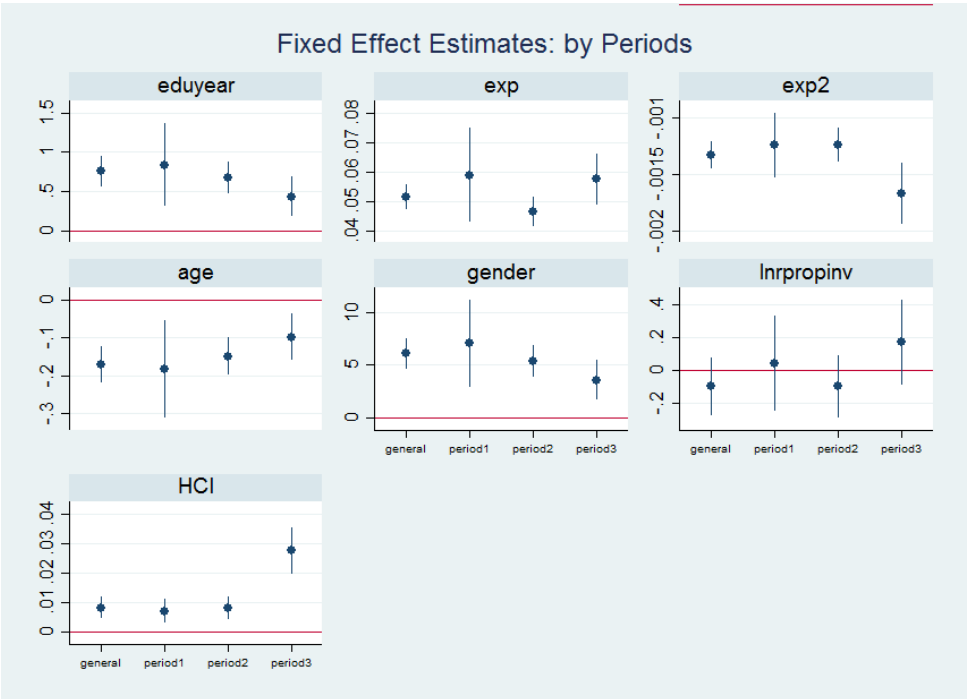


Figure 29: Coefficient Plots of Fixed-Effect Estimates: by Periods

Appendix .8. Robustness Test for Other IVs in the UK Dataset

In table 5, a simple robust test of our choice of instrument for education attainment, is implemented by using alternative instrument variables such as: a dummy indicator of School Leaving Age (SLA), and the precise timing of birth. Firstly, in 1973, the United Kingdom, the schools were regulated to raise the school leaving age from 15 to 16. Empirical economists, such as Harmon and Walker(1995), use a dummy indicator as their choice of IV, being 0 if the interviewees face minimum SLA of 15, and 1 if they face minimum SLA of 16(Harmon & Walker 1995). Harmon and Walker argues that, these type of policy changes would in fact cause the education quality to be differed between these two types.
Alternatively, when studying the US education return, Angriest and Krueger find that the length of education attainment of U.S. citizens might vary in accordance with their precise timing of birth, which in turn could cause impact on education the students might receive. In the UK, according to a report released by the department of education in 2010, children born in August are the youngest within each school year group, and have lower average attainment than their older peers throughout schooling(Deaprtment-For-Education 2010). The report argues that more of these "summer-born" pupils tend to fail to achieve the standard at GCSE than those "autumn-born"s. That said, the implication of same length of education attainment might be differed due to different months of birth of each individual respectively.

In the following table, three similar yet different results of OLS regression are exhibited. The first is the one with our selected IV for education, i.e., the education policy dummy indicators. The second is that with ROSLA dummy indicator instead, while the said variable is defined as above. Lastly, the the regression is now using Month of Birth (MOB) as the IV for education attainment in the first stage. Readers could notice that, the evaluated magnitude of education return is slightly different, albeit the IVs are not the same. Also, for all the variables, the magnitudes and the directions of coefficients are very close among different regressions, while the significant levels are almost identical. Furthermore, in the first stage, all IVs are all significant. With that being said, our choice of IVs, i.e., education policy indicators, are performing similarly with these two alternative, hence a level of robustness is achieved.

Table 5: Robustness check for IVs: ROSLA and precise timing of birth

	(1)	(2)	(3)
		lnrwageUSD	
eduyear	0.0358***	0.0726***	0.0524
	(0.00697)	(0.00364)	(0.0417)
exp	0.0263***	0.0234***	0.0256***
	(0.00170)	(0.00162)	(0.00485)
exp2	-0.000781***	-0.000607***	-0.000704***
	(0.0000614)	(0.0000557)	(0.000207)
Age	-0.00901***	-0.00844***	-0.00948***
	(0.000569)	(0.000509)	(0.00220)
gender	0.809***	0.841***	0.857***
	(0.0124)	(0.0125)	(0.0344)
lnrpropinv	0.538***	0.582***	0.639***
	(0.0267)	(0.0241)	(0.119)
lambda	0.648***	0.782***	0.722***
	(0.0233)	(0.0146)	(0.126)
HCI	0.0195***	0.0199***	0.0213***
	(0.000736)	(0.000665)	(0.00303)
_cons	-0.00599	-0.959***	-1.355
	(0.248)	(0.250)	(0.847)
eduyear			
R1998	0.250***		
	(0.0596)		
R1988	3.366***		
	(0.0417)		
ROSLA		4.390***	
		(0.0334)	
MOB			-0.0201***
			(0.00482)
_cons	9.460***	7.401***	10.61***
	(0.0188)	(0.0280)	(0.0349)
lnrpropinv			
hpi	0.128***	0.128***	0.128***
	(0.00215)	(0.00215)	(0.00215)
_cons	9.637***	9.637***	9.637***
	(0.0113)	(0.0113)	(0.0113)
N	106904	106904	106890
Standard errors in parentheses			
="* p<0.05	** p<0.01	*** p<0.001"	

Appendix .9. Industrial Dummies and Speed of Tariff Reduction

Even though the previous result might present significant evidence with robustness, one might argue the legitimacy of including the indebtedness in real property at industrial level, into survey level data set. Such hierarchical ambiguity sometimes could be misleading, even distorting the empirical result(Raudenbush & Bryk 2002). As the industry indebtedness data is merged by industry code and interview date, it still preserves some variation among individuals within each industry. Hence, a direct application of Hierarchical Linear Model (HLM) or Multilevel Mixed Effect Model (MMEM) might not be optimal. However, it might still be worth to have a double check, as to examine if the identified effect would survive the inclusion of industry Fixed Effect(FE), which account for wage level differences between industries. Ergo, the following modification would include the industry FE, and the interaction terms between the FE and the industrial indebtedness.

Furthermore, in the previous part, the FTAs seem to have less significant impact on wage via education or industrial indebtedness. Is it possible that the impact caused by FTA takes some time to "sink in", and thus become influential on wage. In the following modification,the interaction terms between FTA (WTO, ECFA) dummies and time, and the quadratic term of time are included, as to see, how wage is affected by FTA dummies as time being, and how such marginal changes would be different as time being.

$$\begin{aligned}\ln W =&\beta_0 + \beta_1 education\ year + \beta_2 experience + \beta_3 experience^2 \\ &+ \beta_4 Age + \beta_5 gender + \beta_6 Property\ Loan \\ &+ \sum_{i=0}^{12} \beta_{7+i} industrycode_i \times Property\ Loan \\ &+ \beta_{20} time \times WTO + \beta_{21} time^2 \times WTO \\ &+ \beta_{22} time \times ECFA + \beta_{23} time^2 \times ECFA + \beta_{24}\Lambda + \epsilon\end{aligned} \tag{5}$$

where "i" is the industry code, and "time" represent n $\in$ [0,12], indicating the n-th period of interview [5]

Education attainment years are estimated with dummy indicator of times for the promulgation of Martial law in 1987, and that for the education reformation in 1999:

[5] A detailed lists of industry code is included in table 10. Please note that industry 1 is dropped to avoid dummy variable trap, whereas public sectors and Non-Profit Organizations (NPO) are not included.

$$education\ year = \gamma_0 + \gamma_1 R1987 + \gamma_2 R1999 + \gamma_3 regioncode + u_1$$

and industrial property investment is estimated with the property loan of each industry the interviewee works in, using House Price Index of the region where the interviewee resides at the time when she receives her most recent monthly wage, and the regional code per se, as to estimate the arbitrage investment in the real estate market of each industry:

$$Property\ Loan = \omega_0 + \omega_1 HPI + u_2$$

From the result presented below, for the cross sectional estimator, it is obvious that the coefficient for industrial indebtedness still remain negative for the overall dataset, and for Cohort III, this is consistent with previous cross-sectional estimates. Also, it demonstrates significant differences cross industries: for the general estimates, all industries demonstrate negative coefficients; whilst for cohort III, except for industry number 7(wholesale and retail industry), the coefficient of industrial indebtedness ($\beta_6 + \beta_{7+i}$) for each i industry remains significantly negative. Similar yet less obvious result can also be observed in the FE estimator in table 7: the coefficient of industrial indebtedness is now insignificant, but that of Cohrot III is still negative for all industries, different in terms of values yet with even stronger impact.

As for the FTA's interactions with time and time squared.Derived from the result of cross sectional estimator in table 6, Figure 8 and 9 depicts how the marginal impact of FTA (WTO and ECFA) on wage would change over time. It appears that after Taiwan joins WTO at period 4(2002), such marginal impact is still positive, and increasing until period 6 (2004), and start to decrease afterward. Alternatively, the ECFA's impact on wage is positive. Attention should be paid to the fact that both coefficients seem to be very small (the WTO's coefficient ranges in (0, 1.2), which means the impact of WTO (WTO=1) would increase the wage by 1.2 % at highest by period 6, whilst that of ECFA ranges in (0, 2.2), implying the impact of ECFA (ECFA=1) would increase the wage by 2.2% at highest by period 14). Such positive yet limited impacts of FTAs do not contradict the previous conclusion, as FTA does not have significant impact on wage via education return or industrial indebtedness.

Table 6: Cross Sectional Estimator with Interaction Terms of Industry Dummy and Time

	general	Cohort I	Cohort II	Cohort III
	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD
eduyear	-0.0412	0.0938	0.198***	0.0664***
	(0.0340)	(0.152)	(0.0367)	(0.0112)
exp	0.110***	0.0252	0.0756***	0.0113
	(0.0131)	(0.0288)	(0.0185)	(0.0131)
exp2	-0.00286***	-0.000382	-0.00196***	-0.000484
	(0.000211)	(0.000813)	(0.000476)	(0.000630)
Age	0.0440***	0.0407	0.00280	0.0334***
	(0.00794)	(0.0983)	(0.00951)	(0.00801)
gender	0.367***	0.328	0.381***	0.218***
	(0.0645)	(0.822)	(0.0415)	(0.0281)
lnavgproploan	-8.429***	5.619	4.221*	-4.204***
	(1.221)	(5.466)	(1.830)	(0.817)
2.industrycode×lnavgproploan	0.402***	-0.0839	-0.0857	0.321***
	(0.0649)	(0.186)	(0.0595)	(0.0601)
3.industrycode×lnavgproploan	2.326***	-1.453	-1.118*	1.128***
	(0.330)	(1.446)	(0.498)	(0.215)
4.industrycode×lnavgproploan	3.291***	-2.008	-1.656*	1.719***
	(0.469)	(1.984)	(0.730)	(0.330)
5.industrycode×lnavgproploan	2.166***	-1.329	-1.012*	1.019***
	(0.300)	(1.322)	(0.457)	(0.194)
6.industrycode×lnavgproploan	1.191***	-0.746	-0.549*	0.466***
	(0.169)	(0.764)	(0.259)	(0.0849)
7.industrycode×lnavgproploan	0.0451**	0.0977	0.0434***	-0.0110
	(0.0144)	(0.0584)	(0.0106)	(0.0114)
8.industrycode×lnavgproploan	1.675***	-0.971	-0.749*	0.895***
	(0.233)	(0.978)	(0.348)	(0.168)
9.industrycode×lnavgproploan	0.721***	-0.332	-0.288*	0.410***
	(0.102)	(0.377)	(0.139)	(0.0773)
10.industrycode×lnavgproploan	1.615***	-0.957	-0.732*	0.740***
	(0.220)	(0.961)	(0.336)	(0.139)
11.industrycode×lnavgproploan	2.180***	-1.298	-0.957*	1.171***
	(0.307)	(1.300)	(0.434)	(0.221)
12.industrycode×lnavgproploan	3.055***	-1.779	-1.358*	1.744***
	(0.434)	(1.809)	(0.605)	(0.332)
13.industrycode×lnavgproploan	0.689***	-0.340	-0.278	0.207***
	(0.0859)	(0.359)	(0.143)	(0.0353)
time×WTO	0.351***	0.0824	-0.647	11.98***
	(0.0406)	(0.0484)	(0.377)	(1.753)
$time^2$×WTO	-0.0277***	-0.0146	0.0311	-0.804***
	(0.00407)	(0.00940)	(0.0203)	(0.0973)
time×ECFA	-0.959***	0.610	-0.217	6.360***
	(0.165)	(0.757)	(0.112)	(1.116)
$time^2$×ECFA	0.0953***	-0.0567	-0.00650	-0.229***
	(0.0149)	(0.0667)	(0.00932)	(0.0406)
lambda	-0.210	-0.793	0.282*	0.258**
	(0.265)	(4.210)	(0.112)	(0.0834)
_cons	79.19***	-47.47	-32.05*	0
	(11.05)	(50.44)	(15.36)	(.)
eduyear				
R1987	2.968***	7.424***	2.803***	11.95***
	(0.0652)	(0.762)	(0.0769)	(0.0731)
R1999	2.073***	0	4.455***	3.426***
	(0.0921)	(.)	(0.334)	(0.0869)
_cons	10.41***	10.58***	10.84***	0
	(0.0414)	(0.0612)	(0.0652)	(.)
lnavgproploan				
hpi	0.0131	0.0179	-0.00230	-0.0274
	(0.00867)	(0.0167)	(0.0164)	(0.0152)
_cons	10.93***	10.83***	11.04***	11.48***
	(0.0588)	(0.109)	(0.107)	(0.117)
N	9885	3566	3924	1994

* p<0.05 ** p<0.01 *** p<0.001

Table 7: Fixed Effect Estimator with Interaction Terms of Industry Dummy and Time

	general	Cohort I	Cohort II	Cohort III
	lnrwageUSD	lnrwageUSD	lnrwageUSD	lnrwageUSD
eduyear	-0.0137	0.00474	0.00527	0.100
	(0.0227)	(0.0111)	(0.0122)	(0.123)
exp	0.222***	0.0220	0.0606***	-0.891
	(0.0308)	(0.0163)	(0.0141)	(0.592)
exp2	-0.00342***	-0.000290	-0.00124***	-0.0239**
	(0.000339)	(0.000167)	(0.000233)	(0.00842)
Age	0.00640	0.00584	-0.00402	10.02***
	(0.0254)	(0.0134)	(0.0115)	(0.569)
gender	0.188	-0.0209	0.354**	0
	(0.323)	(0.198)	(0.116)	(.)
lnavgproploan	0.110	0.0357	0.0830	-14.19***
	(0.0597)	(0.0251)	(0.0464)	(1.353)
invmills	-0.692*	-0.206	0.0135	-1.997
	(0.300)	(0.138)	(0.184)	(6.768)
2.industrycode#c.lnavgproploan	-0.0413	0.104	0.00925	-34.75**
	(0.228)	(0.0974)	(0.570)	(12.76)
3.industrycode#c.lnavgproploan	-0.214	-0.247*	0.270*	-77.72***
	(0.207)	(0.0966)	(0.131)	(3.051)
4.industrycode#c.lnavgproploan	-0.245	-0.0845	-0.0466	73.78***
	(0.132)	(0.0591)	(0.0794)	(9.175)
5.industrycode#c.lnavgproploan	-0.621	-0.536	-0.348	72.76***
	(0.617)	(0.359)	(0.229)	(7.339)
6.industrycode#c.lnavgproploan	0.293**	0.141***	0.240*	-15.75***
	(0.0961)	(0.0390)	(0.113)	(3.014)
7.industrycode#c.lnavgproploan	1.423***	0.535***	-0.365	-36.68***
	(0.304)	(0.142)	(0.221)	(2.111)
8.industrycode#c.lnavgproploan	-0.117	-0.0451	0.0232	2.888*
	(0.121)	(0.0564)	(0.0755)	(1.407)
9.industrycode#c.lnavgproploan	-0.164	-0.203*	-0.291*	-42.50***
	(0.206)	(0.0954)	(0.123)	(3.024)
10.industrycode#c.lnavgproploan	0.996	0.706	0.944**	-31.20***
	(0.714)	(0.490)	(0.313)	(2.711)
11.industrycode#c.lnavgproploan	-0.246	-0.0446	-0.0267	-33.39***
	(0.135)	(0.0793)	(0.0641)	(2.345)
12.industrycode#c.lnavgproploan	0.0823	-0.459**	-0.155	-18.38***
	(0.201)	(0.145)	(0.0847)	(4.562)
13.industrycode#c.lnavgproploan	0.439**	0.0815	-0.0396	-54.45***
	(0.147)	(0.0648)	(0.0962)	(2.623)
_cons	2.798**	5.765***	5.395***	-157.7***
	(0.875)	(0.448)	(0.515)	(16.10)
N	11932	5088	4212	2188

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

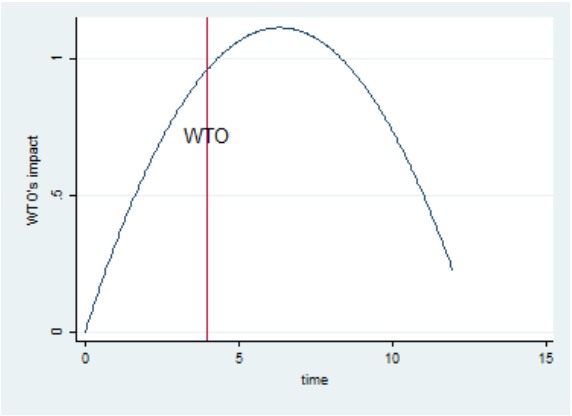


Table 8: WTO's Impact on Wage, Estimated with Cross Sectional Estimator

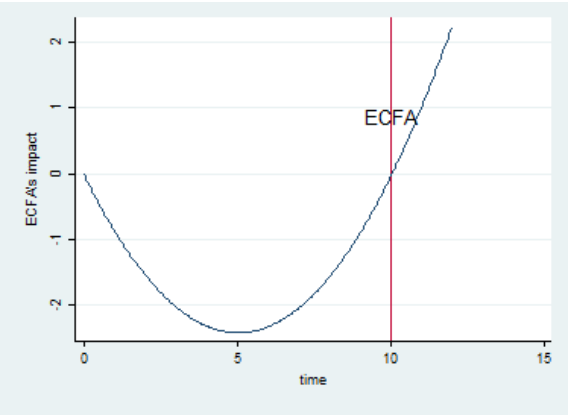


Table 9: ECFA's Impact on Wage, Estimated with Cross Sectional Estimator

Table 10: Industry Code

Industry Code	Industry
1	Agriculture, Forestry, Fishing, And Animal Husbandry
2	Mining And Quarrying
3	Manufacturing
4	Electricity Gas Water & Remediation Services
5	Water Supply And Pollution Control
6	Construction
7	Wholesale And Retail
8	Transportation And Warehousing
9	Accommodation And Food Service Activities
10	Information And Communication
11	Finance Insurance
12	Real Estate
13	Services

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