Human Capital and Total Factor Productivity

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Executive Summary

- This article attempts to measure Human Capital by the discounted income streams of employed individuals, i.e. to take into account both the variations in employment as well as future income. We generate a value function of human capital instead of a series of headcount figures.

- The approach requires a dissection of the surveyed sample by age (15-24, 25-39, ≥40) and by educational attainment (Primary & Below, Lower Secondary, Upper Secondary, Post Secondary – nondegree, Post Secondary - degree) at the same time. This information is available from the GHS survey only from 2005:Q3 onwards.

- As expected, individuals with post secondary qualifications have substantially higher average human capital. The distributional patterns of 2005:Q3 and 2011:Q1 are largely the same for both males and females.

- The growth rates among male cohorts are more heterogeneous than female counterparts. For males, the segment Primary & Below has the most volatile human capital across all age cohorts. The segments lower and upper secondary see similar growth rates and are the least volatile.

- For males, the growth in human capital of the post secondary cohorts is more procyclical than the rest. The comparative advantage of the post secondary females is less obvious than the male counterparts.

- The processed human capital is then fitted to a growth model defined by the typical Cobb Douglas production function. Doing growth accounting over output and physical capital stock on a per efficient labor terms, we get an estimate of average annual TFP growth of 2.1% (2006-2010 excluding 2008 when the financial tsunami took place). This is near the ballpark (2.3% - 3.6%) of findings for HK by other major research works.

1. Introduction

In the past two decades, there has been sustained interest in the studying of human capital. One reason for this fad is that Barro (1991) found, for a host of countries, evidence of economic growth that could not be explained by either physical capital or labor inputs, and there is a pressing need to explain such anomaly. At the same time, the flourish of the endogenous growth theory (Romer, 1986) also provided a convenient tool for economist to investigate the issue. From a more pragmatic point of view, the emergence of the knowledge based economy also calls for a unified approach to measure intangible production inputs.

Early efforts in the literature focus on the cost of (investing in) human capital, see for instance Barro and Lee (1993), and this measurement approach remains popular among academic researchers even by now. Major candidates include years of schooling and literacy rates, but some studies (Benhabib and Spiegel, 1994) found those to be poor proxies. Recent modifications include using interactions of enrolment rates and drop rates, see the survey by Wößmann (2003). Another strand of research tries to measure the income content attributed to human capital investment. Le et al. (2005) is one example of how this can be achieved. Normally, income based measurement induces more variation in the series and can better capture the heterogeneity in human capital among countries.

This paper seeks to compile a human capital series of HK and to assess its ability in producing meaningful total factor productivity figures. The approach is as discussed in Le et al. (2005)[1]. Essentially, human capital is proxied by the discounted income streams of various cohorts as classified by age and educational attainment.

2. Modeling Human Capital

Whether the focus is on educational capacity or earnings capacity, research in human capital have switched from a static/current perspective to a more forwarding looking one. Similar treatment of physical capital is not new, and institutions like the OECD have long advocated the use of the perpetual inventory method (PIM) in evaluating the stock content of capital. Wößmann (2003), for instance, contains information on how to assess educational attainment via the PIM approach. This article attempts to measure human capital via the income track and augment it with the PIM concept[2]. Following Le et al. (2005), the average human capital for the cohort containing individuals aged a and educational attainment e_i is:

[1] We tried the easy version of the original paper, as the more complicated one involves detailed information on enrolment and completion of courses taken by full and part time students, classified by age and educational background. These are not available from GHS surveys and population census reports.

[2] The choice is partially dependent on data availability in HK, and on the assertion that income can better reflect the heterogeneity in quality of education.

$$h_a^{e_i} = W_a^{e_i} Y_a^{e_i} + S_{a,a+1}^{e_i} h_{a+1}^{e_i} d \qquad (1)$$

where

- $W_a^{e_i}$ is the probability of engaging in paid work, defined as the employment rate times the labor force participation rate (LFPR) of that cohort.
- $Y_a^{e_i}$ is the average current annual income of employed individuals in that cohort.
- $S_{a,a+1}^{e_i}$ is the probability for surviving one more year from age a (to $a+1$).
- d is the discount factor $(1+g)/(1+\delta)$ with g being the income growth rate and δ the discount rate.

Thus, the first term in (1) gives the expected current income, and the second component gives the discounted income stream of a typical individual in the cohort concerned. To obtain a measure of human capital for the entire economy, we can simply aggregate all cohorts based on the actual number of employed individuals.

The employment rates, the LFPRs, the average incomes are available from the GHS surveys, and the survival probabilities are taken from the Life Tables. There are altogether 30 cohorts, classified by gender (male and female), by age (15-24, 25-39, and ≥40), and by education background (primary & below, lower secondary, upper secondary, post-secondary – nondegree, and post-secondary – degree). We assume a retirement age of 65, and starting from the current income of individuals aged 64, we can calculate recursively the average human capital of all those aged below 64 using equation (1). The income growth rate is set at 2.4% which is the growth rate of per capital GDP in the past decade. The discount rate equals to 5%.

3. Findings

The sample runs from 2005:Q3 – 2011:Q1. The compilation results are summarized by the following diagrams. Figure 1 and 2 give the distribution of cohorts in the starting and ending periods. For both male and female, the distributions are such that:

i. Individuals with post secondary qualifications have substantially higher average human capital,
ii. the human capital of the post secondary cohorts peak in the age profile 25-39, whereas those with lower educational attainment basically have their human capital declining all the way with increase in age,
iii. the distributional patterns of 2005:Q3 and 2011:Q1 are largely the same.

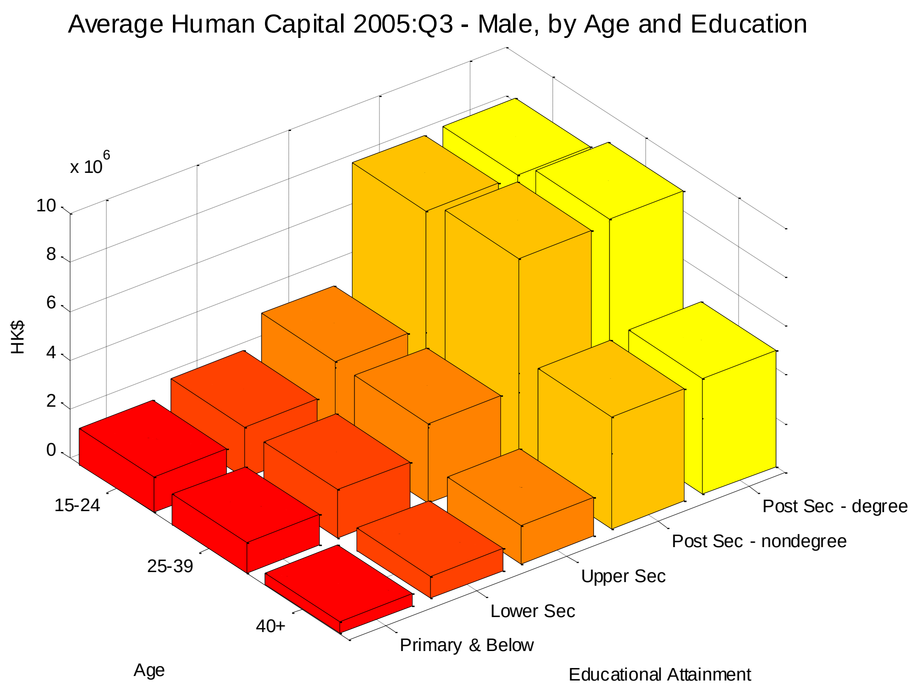
Figure 3 and 4 show the changes in average human capital over time for the different cohorts. In brief,

i. The growth rates among male cohorts are more heterogeneous than female counterparts.

ii. For males, the segment Primary & Below has the most volatile human capital across all age cohorts. The segments lower and upper secondary see similar growth rates and are the least volatile.
iii. For males, the growth in human capital of the post secondary cohorts is more procyclical than the rest.
iv. The comparative advantage of the post secondary females is less obvious than the male counterparts.
v. Into 2011, the average human capital falls substantially for the Primary & Below cohorts, males and females alike.

Figure 5 plots the aggregate human capital over time from 2005:Q3 to 2011:Q1 and its year on year growth rates. The aggregation is done using the actual number of employed individuals in each cohort in the quarter concerned. The compiled series experienced an acceleration in growth rate from around 2% to 6% just before the financial tsunami.

Figure 1: Distributions of Average Human Capital 2005:Q3



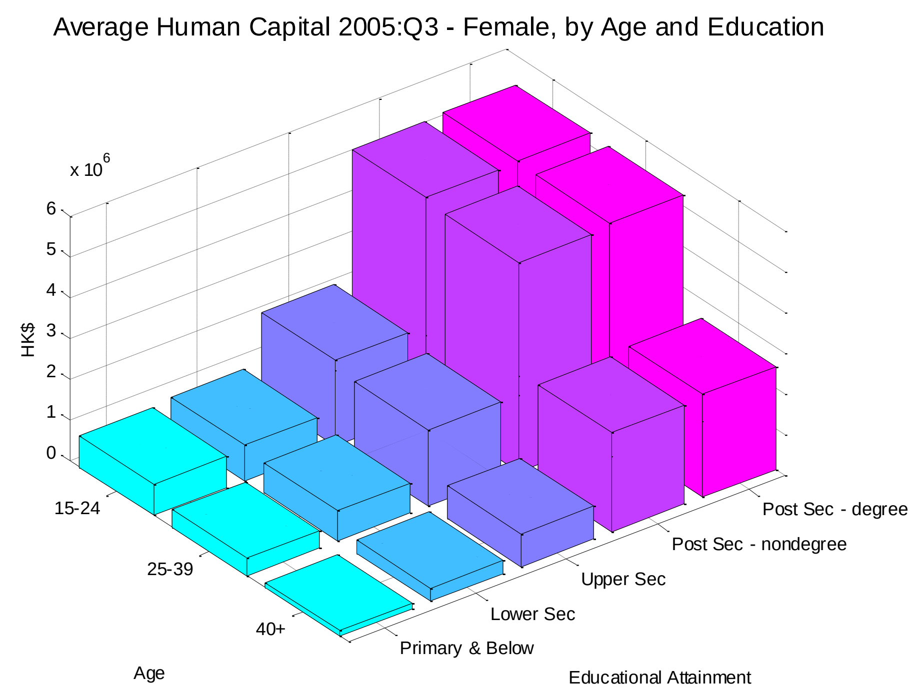
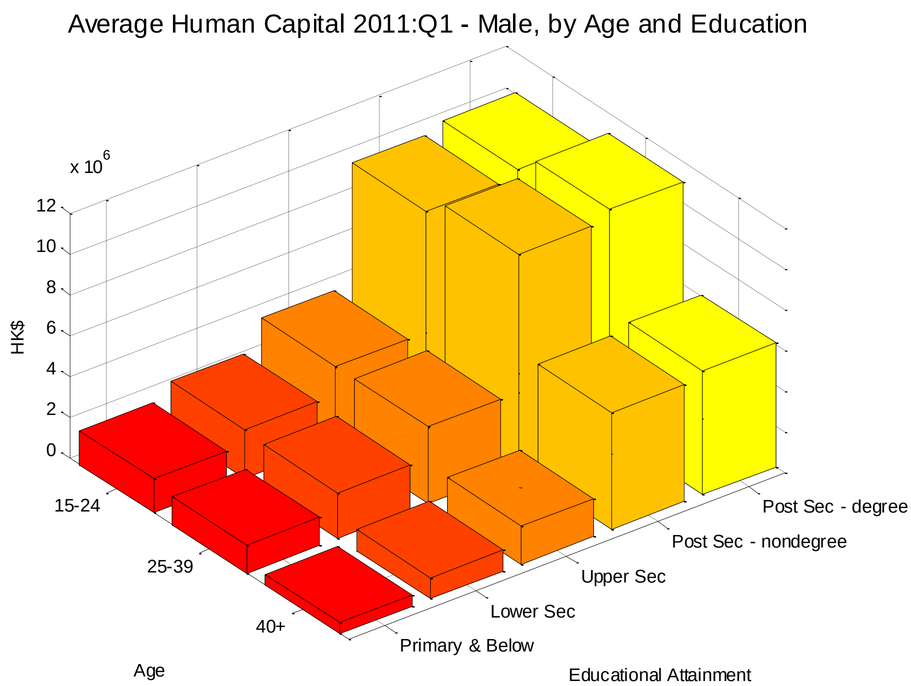


Figure 2: Distributions of Average Human Capital 2011:Q1



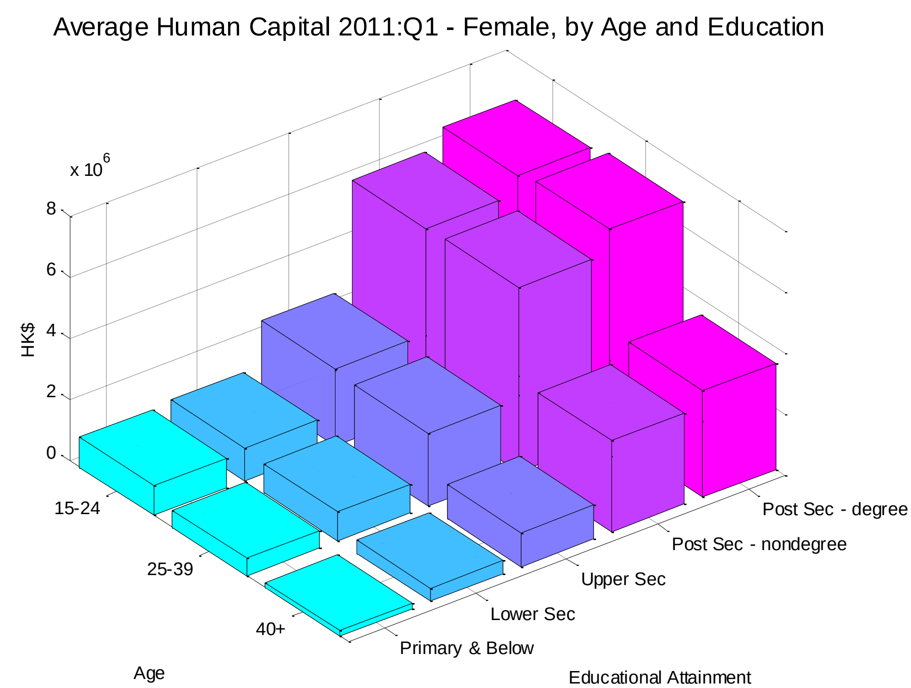


Figure 3: Annual Growth Rates of Average Human Capital – Male

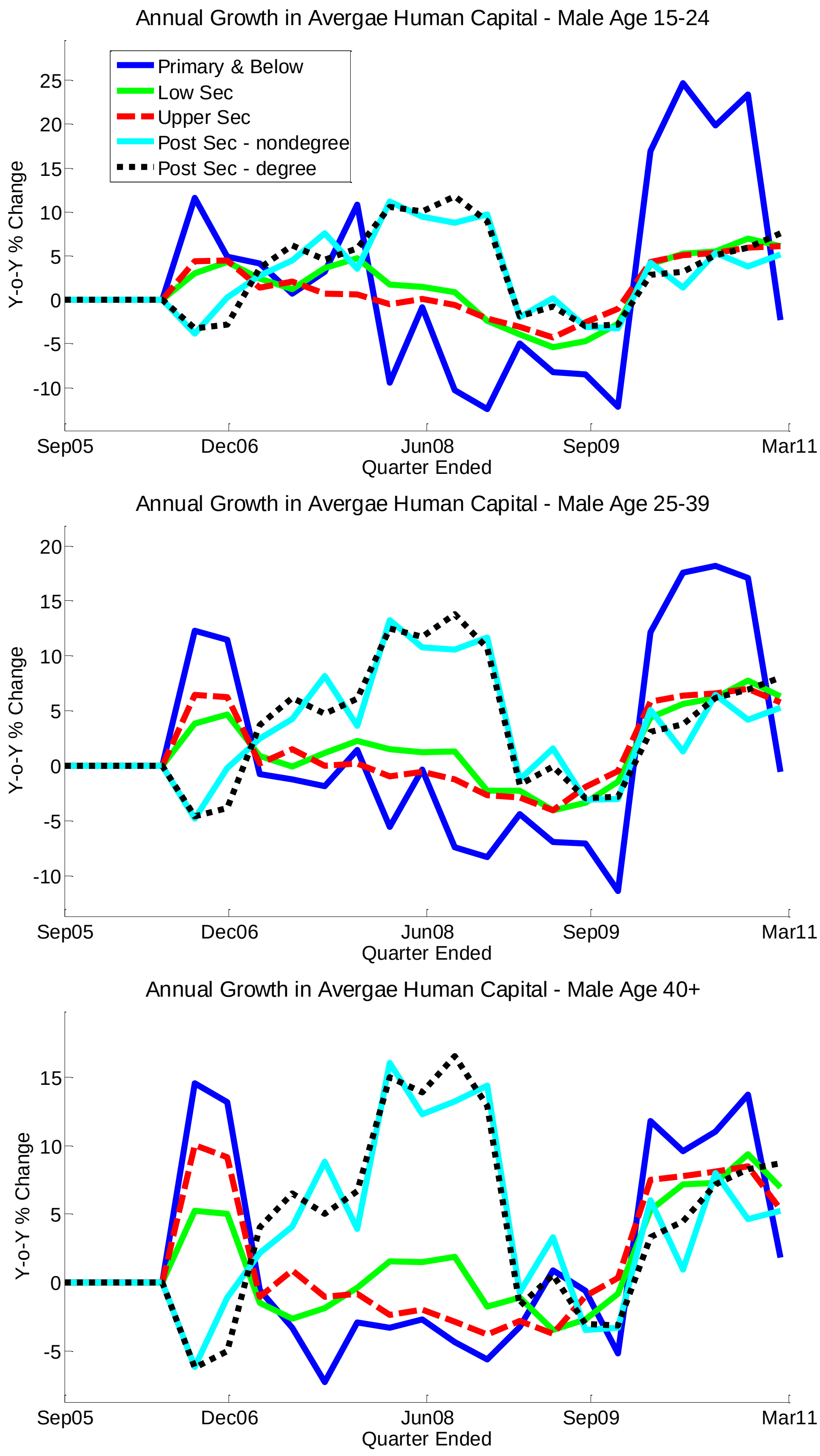


Figure 4: Annual Growth Rates of Average Human Capital – Female

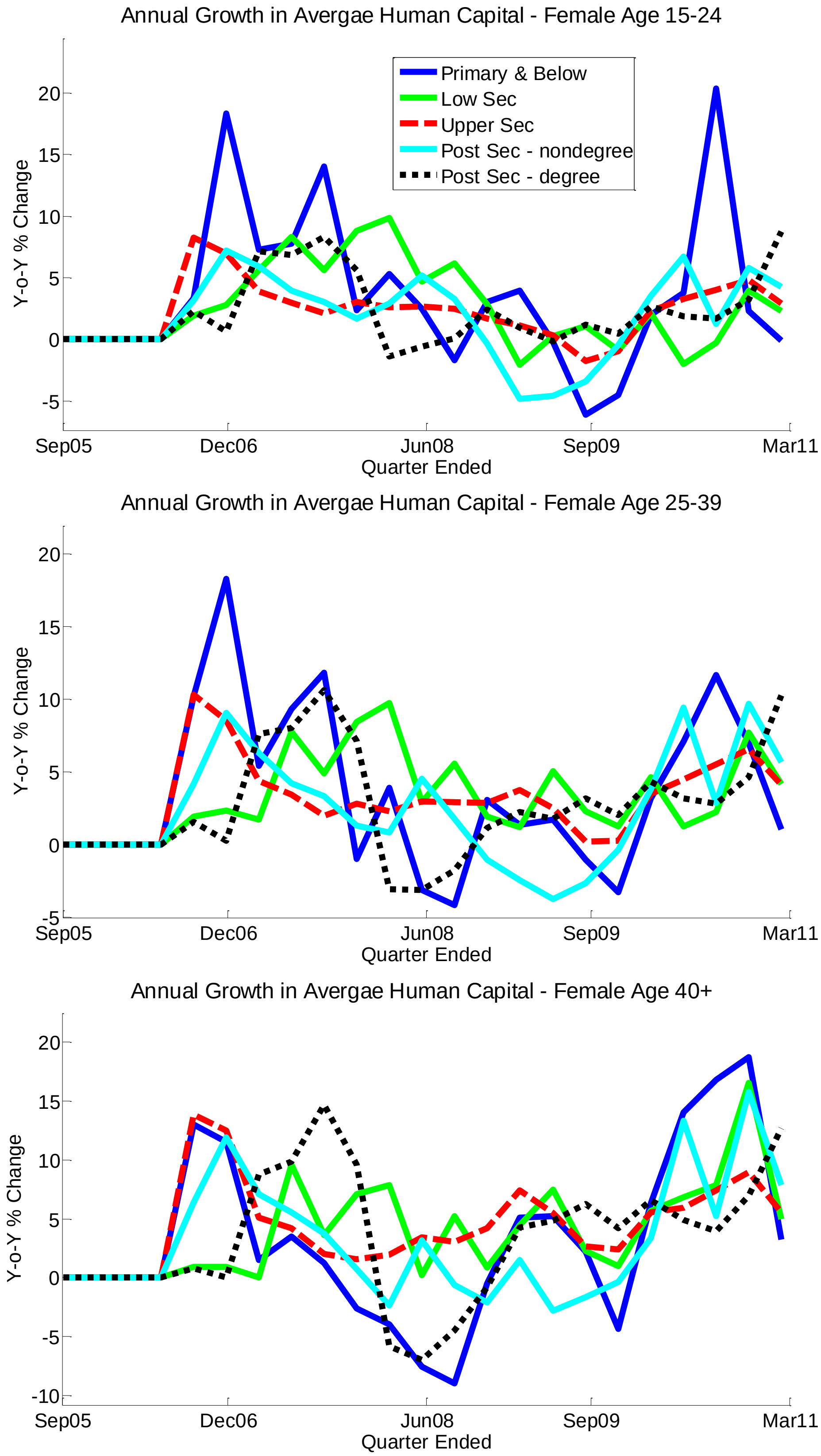
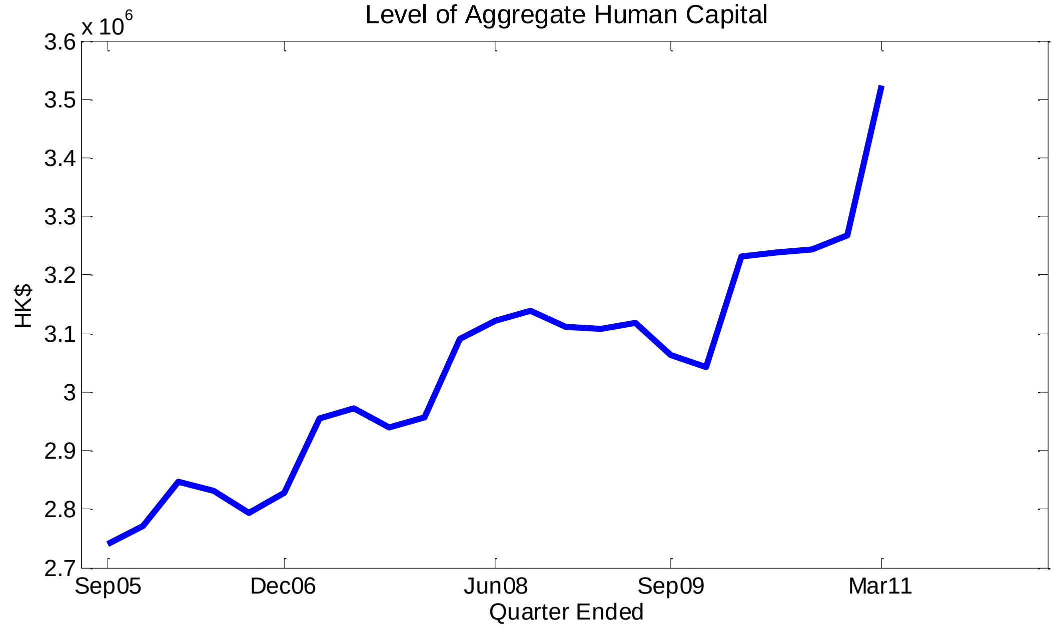


Figure 5: Aggregated Human Capital – 2005:Q3 to 2011:Q1



4. Relevance to TFP Measurement

In this section, we fit the compiled human capital series to a growth model and see if meaningful TFP estimates can be obtained. The major issues needed to be taken care of include: (i) choosing the growth model to estimate and determine the role of human capital in the model, and (ii) dealing with the time series structure of our sample, compare to mostly cross-sectional or panel data in other studies.

Many studies considered a simple extension of the Solow model (Solow, 1957) with human capital explicitly embedded:

$$Y = AK^{\alpha} L^{\beta} H^{\gamma} \qquad (2)$$

where K, L and H denote physical capital, labor input and human capital, respectively. A is the TFP to be estimated. If $\beta = 1 - \alpha$, dividing (2) by L on both sides gives

$$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha} H^{\gamma} \qquad (3)$$

which measures how per capita output relates to physical capital per head and human capital. The specification makes sense if human capital does not involve head counts of one kind or another, as in the case of using enrolment ratios. If, however, H is a function of L, (3) may generate problematic results especially in the situations with small samples. Instead of considering per capita output, we can consider output per unit of *efficient* labor. First, write LH as the human capital augmented labor input[3]. We specify the model:

$$Y = AK^{\alpha}(LH)^{1-\alpha} \qquad (4)$$

$$\frac{Y}{LH} = A\left(\frac{K}{LH}\right)^{\alpha} \qquad (5)$$

so both output and physical capital are expressed in terms of per unit of efficient labor. Note that holding constant human capital, an increase in physical capital alone will increase per capita output but as long as $\alpha < 1$, there will still be diminishing marginal product of K.

Physical capital stock is assumed to follow the standard accumulation rule $K_t = I_t + (1-\theta)K_{t-1}$ with θ being the depreciation rate[4], set at 10%, and I is investment as proxied by GDFCF in the national accounts. H is modeled by the aggregate human capital as shown in Figure 5. We log transformed the equations (2), (3) and (5) but none of those deliver acceptable results in terms of goodness of fit, significance, and model validity. In particular, whereas running the regressions with variables expressed in levels could be alright for cross sectional data, the time series nature of our data certainly generates results that are contaminated by serial correlation. We thus turned to the following refinement of (5):

$$dln\left(\frac{Y_t}{L_tH_t}\right) = c + SD_t\mu + dln\left(\frac{K_t}{L_tH_t}\right)\phi + \varepsilon_t \qquad (6)$$

where d denotes first difference, c is the constant term, SD is the 3-variable vector of seasonal dummies, and ε is the error term. μ and ϕ are parameters to be estimated. According to (6), the quarter on quarter *growth* in TFP equals to $c + SD_t\mu + \varepsilon_t$. Table 1 states the result of the regressions using the modeled aggregate human capital. The Durbin-Watson statistic also hints that there is no serious problem of autocorrelation.

The growth model (6) accounts for over 96% of the variations in output per unit of efficient labor. The physical capital stock per unit of efficient labor is significant at the 5% level. The capital elasticity of output, in per unit of efficient labor terms, is about 0.57.

[3] Notwithstanding the aggregation, the term H is still conceptually an indicator of average human capital.
[4] The regression results do not seem to be too sensitive to the value of the depreciation rate.

Table 1: Regression Result of Growth Model in First Difference

	H = Aggregate Human Capital (this paper)	
Dependent Variable	$dln\left(\frac{Y_t}{L_t H_t}\right)$	
Estimates		**p-values**
$\boldsymbol{c}$	0.0334	0.0001
$\boldsymbol{\mu_1}$	-0.1291	0.0000
$\boldsymbol{\mu_2}$	-0.0348	0.0024
$\boldsymbol{\mu_3}$	0.0346	0.0028
$\boldsymbol{\phi}$	0.5470	0.0275
Summary Statistic		
$\boldsymbol{R^2}$	0.9647	
$\boldsymbol{\sigma^2}$	0.0003	
$\boldsymbol{Durbin-Watson}$	1.748	

As for the TFP growth, we add up the individual quarter to quarter growth rates obtained from $c + SD_t\mu + \varepsilon_t$ to get the annual TFP growth rates which we can use to compare with estimates in the existing literature. The average annual TFP growth is + 2.1% for 2006-2010, excl. 2008 and + 0.45% for all years from 2006-2010. Excluding the shock of the financial tsunami, the estimates we got is very much in line with existing findings by others. A comparison of these figures with estimates from other works is presented in Table 2.

Table 2: Comparison of TFP Growth Estimates

Studies	This Paper	Kim & Lau (1994)	Young (1995)	Drysdale & Huang (1995)	World Bank (1993)
TFP - Annual Growth %	2.10* (0.45)	2.4	2.3	3.1	3.6
Sample	2006-2010	1966-1990	1966-1990	1950-1988	1960-1989
2006	2.36				
2007	1.94				
2008	-6.16				
2009	3.52				
2010	0.56				

** The number is the average excl. 2008. The number in the bracket is the all inclusive average.*

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