Endogenous Growth and Relative Returns to Entrepreneurial and Professional Human Capital*

by

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Abstract

We develop a growth model in which both entrepreneurial and professional human capital contribute to long-term endogenous economic growth and the growth rate depends on the ratio of returns to the two types of human capital. A testable theoretical result is that the growth rate is negatively related to the ratio of professional human capital returns to entrepreneurial-human capital returns if the ratio is below its steady state value, and vice versa. The empirical result with Singapore industries favors further deepening of investment in professional human capital relative to entrepreneurial type. The cross-sectional regression with the international data produces the evidence for a negative relationship between the growth rate and the human-capital-return ratio determined by the level of GDP.

I. Introduction

Human capital, no matter whether it is acquired ability or genetic endowment, enhances productivity not only by upgrading educational level of labor force and work skills (professional type) but also by instilling and disseminating entrepreneurship (entrepreneurial type). Although numbers of studies explore independent contributions of human capital as a whole to economic growth, the existing literature on growth has seen very limited effort to compare the individual contribution of entrepreneurial human capital with that of professional human capital; in particular, entrepreneurs as an indispensable productive factor have not received their due in economic growth analysis. Indeed, Baumol (1990) provides an insightful historical research on the contribution of entrepreneurial human capital to productivity growth and how it is affected by the prevailing institutional features that determine the allocation of entrepreneurship among its competing uses. Schmitz (1989) presents a model in which endogenous entrepreneurial activity acts as a key factor to determine economic growth through imitating and implementing knowledge; the study by Schmitz represents an attempt to incorporate entrepreneurship into the formal modeling of endogenous growth.

This paper seeks to contribute to our understanding of the interaction between the output growth rate and the relative magnitude of entrepreneurial and professional human capital, or the ratio of their respective returns. Along the line of the endogenous growth literature such as the AK model,[1] we explore the dynamics of the ratio of rates of return to two types of human capital when it deviates from the steady state value and trace a testable relationship between the output growth rate and the ratio of the two human-capital returns. In empirical analysis, we further provide some

preliminary evidence for the theoretical result using both the panel data of occupational wages survey in several main industries of Singapore and the international data of cross sections. Unlike some existing business literature that distinguishes between managers and entrepreneurs, we tend to treat both managerial and entrepreneurial functions as the interrelated traits of the entrepreneurship in the business running. We believe that this treatment is appropriate in measuring entrepreneurial human capital.

The paper proceeds as below. Section II presents the basic elements of the growth model that integrates the professional and entrepreneurial human capital. Section III develops the theoretical result of transitional dynamics underlying the later empirical analysis. Section IV provides preliminary empirical evidence of the model. Section V offers a brief set of conclusions.

II. Equilibrium and the Steady State

Following Barro and Sala-I-Martin (1996), we present a one-sector framework below with the focus on the role of rates of return of different human capital in economic growth. In a competitive closed economy, it is assumed that households carry out production directly and all of the capital stock (both physical and human capital) must be owned by households in the economy. To focus on the role of human capital, in particular, its dichotomy between professional capital and entrepreneurial capital, we hold the stock of physical capital constant and set it to unity for normalization. We can think of professional human capital as the number of professionals multiplied by their professional knowledge or experience, and entrepreneurial human capital as the number of entrepreneurs multiplied by the entrepreneurship of the representative entrepreneur. Here, what matters to productive inputs is no longer just the quantity of the inputs; the quality of them often become

dominant, instead. As a matter of fact, even assuming that the total labor force as well as the number of professionals and entrepreneurs are constant, production technology can still exhibit constant returns to professional and entrepreneurial human capital. Thus, even though there is no exogenous technical progress, the economy can still maintain a positive output growth.

Now, consider a benevolent social planner (government)'s problem as one that maximizes lifetime utility of the representative household by choosing the path of consumption, subject to the resource constraint and those that govern the evolution of the stock of human capital. Formally, we have

$$\begin{aligned} &\max_{C} U(0) = \int_0^{\infty} e^{-\rho t} u(C)dt \\ &s.t.\ (a)\ \dot{H}_p = I_p - \delta H_p \\ &\quad (b)\ \dot{H}_e = I_e - \delta H_e \\ &\quad (c)\ A\left(H_p\right)^{\beta}\left(H_e\right)^{1-\beta} = C + I_p + I_e \\ &\quad (d)\ \lim_{t\to\infty}\left[\mu_p(t)H_p(t)\right] = \lim_{t\to\infty}\left[\mu_e(t)H_e(t)\right] = 0 \end{aligned} \tag{1}$$

where U(0) is the value of the objective function as seen from the initial period, ρ is the discount rate, C is consumption at time t (for simplicity, time element has been eliminated from all the relevant variables.), u(C) is a standard utility function which relates the flow of the household's utility to the quantity of consumption, H_p and H_e are respectively stocks of professional human capital and entrepreneurial human capital at time t, I_p and I_e are respectively the gross investment in professional human capital and entrepreneurial human capital, and δ is the depreciation rate for both types of human capital (due to losses from unemployment and underemployment, skill and knowledge depreciation, and mortality, etc.). The LHS of (1c) is the Cobb-Douglas production function with A as productivity parameter, and β as the output elasticity of

professional human capital. In short, (1a) and (1b) are dynamic equations for two types of human capital, (1c) is the resource constraint, and (1d) gives the transversality condition.

The associated Hamiltonian expression is

$$J = u(C)e^{-\rho t} + \mu_p(I_p - \delta H_p) + \mu_e(I_e - \delta H_e) + \nu\left[A\left(H_p\right)^{\beta}\left(H_e\right)^{1-\beta} - C - I_p - I_e\right] \tag{2}$$

where μ_p and μ_e are the present-valued shadow price of investment in professional human capital and entrepreneurial human capital, respectively; that is, they represent the value of an increment of investment available at time t in units of utils at time 0; ν is the shadow price of aggregate income representing the value of an increase in aggregate output at time t measured in units of utiles at time 0. Applying the maximum principle produces a set of the optimum conditions:

$$u'(C)e^{-\rho t} = \nu \tag{3}$$

$$\mu_p = \mu_e = \nu \tag{4}$$

The Euler equations require

$$\dot{\mu}_p = \mu_p\delta - \nu A\beta\left(H_p\right)^{\beta-1}\left(H_e\right)^{1-\beta}$$

(5)

$$\dot{\mu}_e = \mu_e\delta - \nu\ A(1-\beta)\left(H_p\right)^{\beta}\left(H_e\right)^{-\beta} \tag{6}$$

Substituting (4) into the Euler equations (5) and (6), and rearranging, yields

$$\frac{H_e}{H_p} = \frac{1-\beta}{\beta} \tag{7}$$

which is the optimum ratio of entrepreneurial human capital to professional human capital.

It follows that, at the ratio of $(1-\beta)/\beta$, marginal products of two types of human capital are equal to each other, that is,

$$MP_e = MP_p = A\beta^{\beta}(1-\beta)^{1-\beta} \tag{8}$$

In addition, professional human capital and entrepreneurial human capital share same net rate of return at the steady state, which is given by

$$r^* = A\beta^{\beta}(1-\beta)^{1-\beta} - \delta \tag{9}$$

Also, with the optimal constant ratio of two human-capital stocks, we can obtain a closed-form expression of the growth rate of consumption if a specific utility function is used. Considering a constant elasticity of substitution function, $u(C)=(C^{1-\theta}-1)/(1-\theta)$, where θ is the magnitude of the elasticity of marginal utility, with $\theta>0$.[2] Substituting u(C) into (3) and calculating the steady state growth rate of consumption γ_C produces

$$g_C = g^* = \frac{1}{\sigma}\left[A\beta^{\beta}(1-\beta)^{1-\beta} - \delta - \rho\right] \tag{10}$$

Furthermore, when the ratio of two stocks of human capital equals its steady state value, $(1-\beta)/\beta$, the ratio of aggregate output to the stock of professional human capital is also a constant. This implies that output and the two types of human capital grow at the same rate. Finally, the transversality condition in our model, i.e., the limit expressions in (1d) above, requires $r^*>\gamma^*$; that is, the net rate of return to human capital must exceed the growth rate of consumption to avoid unbounded utility so that investment in human capital is sufficiently attractive relative to consumption. If the transversality condition holds, then, it can be shown that consumption is linearly related to either professional or entrepreneurial human capital.[3] Therefore, all

quantities, including two types of human capital, consumption, and output or income, grow at the same constant rate, γ^*.

III. Transitional Dynamics

In a competitive economy, the rate of return to a production input factor is equal to the marginal product of the factor; in particular, without considering uncertainty, all the factors should earn the same return for its marginal contribution to production in the steady state. Nevertheless, compared with professional human capital, the rate of return to entrepreneurial human capital is exposed to more uncertainty and thus subject to more variation. An efficient resource allocation requires that the rate of return earned by entrepreneurial human capital exceeds that of professional human capital by a risk premium ω (ω>1) at any point of time. Using the wage rates (in terms of output), after being adjusted by the risk premium, to measure the rate of return to the two human capital stocks, then, they equal the corresponding marginal products, respectively.[4] Accordingly, we further obtain the relation between the ratio of the two human capital stocks and the wage ratio of them.

$$\frac{w_p}{w_e} = \frac{\beta}{1-\beta}\frac{1}{\omega}\frac{H_e}{H_p} \tag{11}$$

Particularly, using (7), the steady-state wage ratio is

$$\left(\frac{w_p}{w_e}\right)^* = \frac{1}{\omega} \tag{12}$$

Note that the steady state equilibrium in the previous section is obtained under the binding resource constraint. Once the human-capital stock ratio deviates from its steady state value, $(1-\beta)/\beta$, for some reason, negative gross investment at an extremely high rate in one of the two stocks is necessary to restore the value instantaneously. However, it is rather unrealistic to have such a disinvestment in any type of human capital that the human capital derogates at a rate faster than its depreciation rate by a great margin. Hence, we impose the restriction for non-negative gross investment in any type of human capital.

Relatively low return to entrepreneurial human capital

When entrepreneurial human capital is initially abundant relative to professional human capital, its rate of return is relatively low, that is,

$$\frac{w_p}{w_e} > \frac{1}{\mathsf{w}}\left[= \left(\frac{w_p}{w_e} \right)^* \right]$$

The optimal response of the social planner to the discrepancy in the wage ratio is to reduce the stock of entrepreneurial human capital by adopting a zero gross investment in H_e; consequently, the stock of entrepreneurial human capital declines at its depreciation rate. With this constraint, we can reset up the social planner's Hamiltonian expression, resolve the resulting dynamic optimization problem, and, using the result in (11), finally get the dynamic system in the wage ratio w_p/w_e and the ratio of consumption to entrepreneurial human capital C/H_e:

$$\left(\frac{\dot{w}_p}{w_e} \right) = \frac{w_p}{w_e}\left[-A\left(\frac{1-\mathsf{b}}{\mathsf{b}}\mathsf{w}\frac{w_p}{w_e} \right)^{1-\mathsf{b}} + \frac{C}{H_e}\frac{1-\mathsf{b}}{\mathsf{b}}\mathsf{w}\frac{w_p}{w_e} \right] \qquad (13)$$

$$\left(\frac{\dot{C}}{H_e}\right) = \frac{C}{H_e}\left\{\frac{1}{\theta}\left[A\beta\left(\frac{1-\beta}{\beta}\omega\frac{w_p}{w_e}\right)^{1-\beta} - \delta - \rho \right] + \delta \right\} \tag{14}$$

The two demarkation curves for this dynamic system are given by

$$\left(\frac{\dot{w}_p}{w_e}\right) \gtrless 0 \;\Leftrightarrow\; \left(\frac{w_p}{w_e}\right) \gtrless \frac{\beta}{1-\beta}\frac{1}{\omega}\left[\frac{A}{\left(\frac{C}{H_e}\right)}\right]^{\frac{1}{\beta}} \tag{15}$$

$$\left(\frac{\dot{C}}{H_e}\right) \gtrless 0 \;\Leftrightarrow\; \left(\frac{w_p}{w_e}\right) \gtrless \frac{\beta}{1-\beta}\frac{1}{\omega}\left[\frac{\rho + \delta(1-\theta)}{A\beta}\right]^{\frac{1}{1-\beta}} \tag{16}$$

Figure 1 Adjustment dynamics when the rate of return to entrepreneurial human capital is relatively low

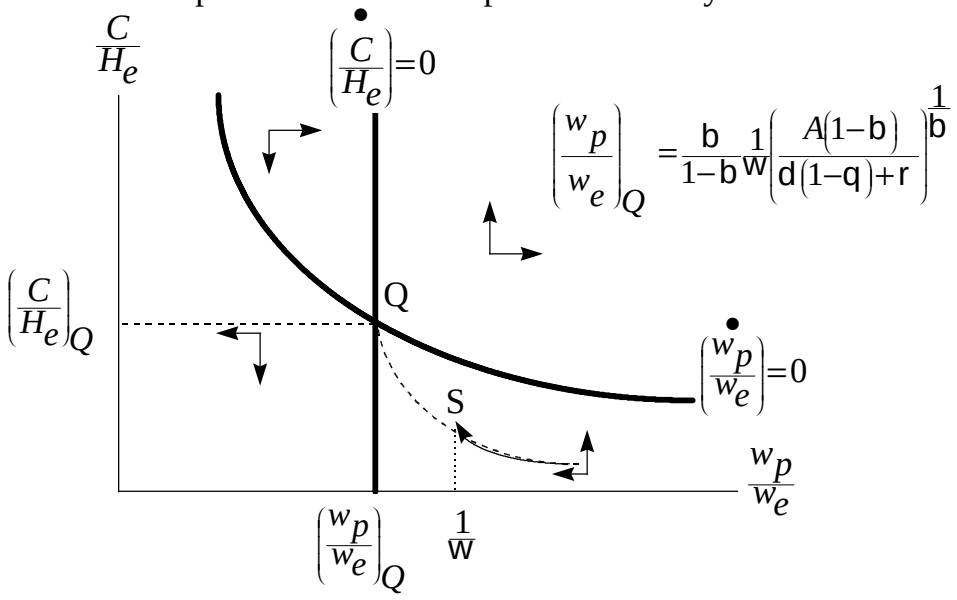


Figure 1 depicts the associated phase diagram, in which the two demarkation loci divide the space into four regions and the arrows show the directions of motion in each region. The model exhibits saddle-path stability. Starting at an initial state with the wage ratio above $1/\omega$, the economy would tend to converge along the saddle path towards a quasi-target, point Q, with w_p/w_e monotonically decreasing and C/H_e monotonically increasing as H_e falls at the depreciation rate and H_p rises at a declining rate towards γ^*. This is because

$$g_p \equiv \frac{\dot{H}_p}{H_p} = A\left(\frac{H_e}{H_p}\right)^{1-b} - \frac{C}{H_p} - d \qquad (17)$$

Note that γ_p is positive, with $[\partial\gamma_p/\partial(H_e/H_p)]>0$. But, this transitional course will stop at point S where the economy achieves the steady-state wage ratio and the constraint of non-negative gross investment ceases to be binding.

Relatively high return to entrepreneurial human capital

When entrepreneurial human capital is initially in shortage relative to professional capital, its rate of return is relatively high, that is,

$$\frac{w_p}{w_e} < \frac{1}{w}\left[=\left(\frac{w_p}{w_e}\right)^*\right]$$

The optimality problem facing the social planner in this case is similar to the previous one. In order to achieve efficiency, zero gross investment in professional human capital is needed so that H_p declines at its depreciation rate. Incorporating this constraint into the social planner's Hamiltonian expression and solving it as before produces

$$\left(\frac{\dot{w}_p}{w_e}\right) = \frac{w_p}{w_e}\left[A\left(\frac{1-\beta}{\beta}\omega\frac{w_p}{w_e}\right)^{-\beta} - \frac{C}{H_e}\right] \tag{18}$$

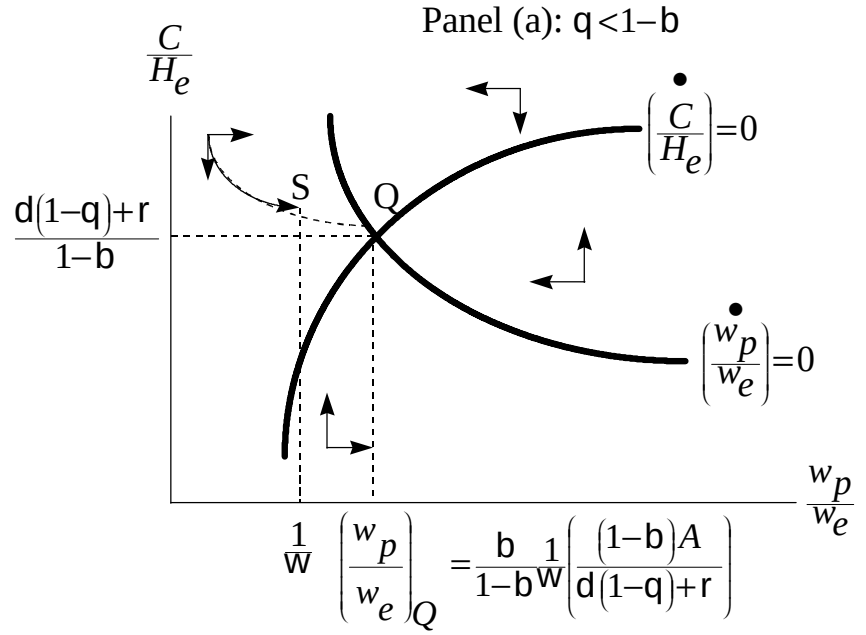
$$\left(\frac{\dot{C}}{H_e}\right) = \frac{C}{H_e}\left\{\frac{1}{\theta}\left[(1-\beta-\theta)A\left(\frac{1-\beta}{\beta}\omega\frac{w_p}{w_e}\right)^{-\beta} - \delta(1-\theta) - \rho\right] + \frac{C}{H_e}\right\} \tag{19}$$

Although the demarkation curve implied by (18) turns out to be the same as that given by (15), the associated dynamics of the wage ratio is different. The two demarkation curves are determined by

$$\left(\frac{\dot{w}_p}{w_e}\right) \gtrless 0 \;\Leftrightarrow\; \left(\frac{w_p}{w_e}\right) \lessgtr \frac{\beta}{1-\beta}\frac{1}{\omega}\left[\frac{A}{\left(\frac{C}{H_e}\right)}\right]^{\frac{1}{\beta}} \tag{20}$$

$$\left(\frac{\dot{C}}{H_e}\right) \gtrless 0 \;\Leftrightarrow\; \left(\frac{w_p}{w_e}\right) \lessgtr \frac{\beta}{1-\beta}\frac{1}{\omega}\left[\frac{(1-\beta-\theta)A}{\delta(1-\theta)+\rho-\theta\frac{C}{H_e}}\right]^{\frac{1}{\beta}} \tag{21}$$

Figure 2 Adjustment dynamics when the rate of return to entrepreneurial human capital is relatively high



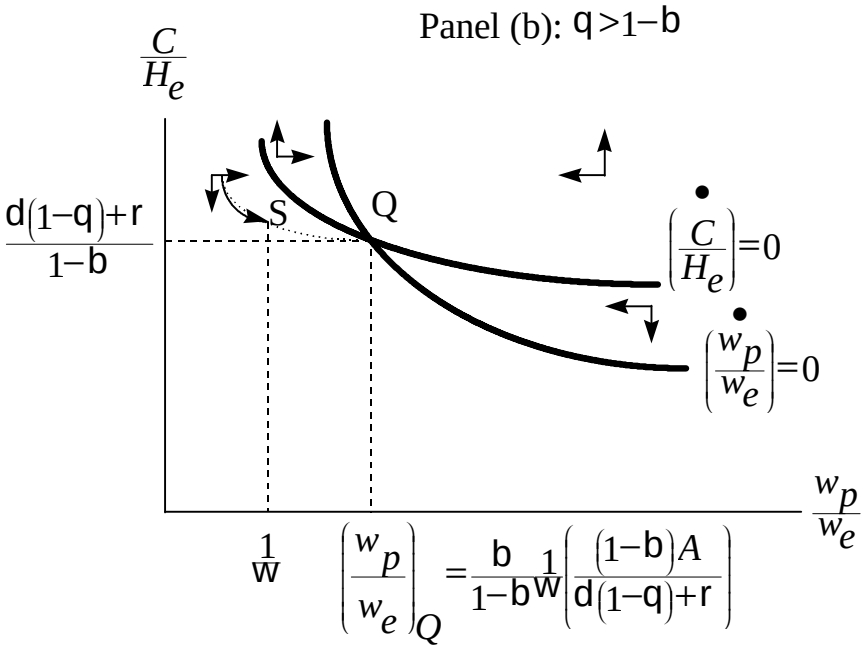


Figure 2 depicts the dynamics when $(w_p/w_e)<1/\omega$. Depending upon the relative magnitude of the output elasticity of entrepreneurial human capital, $1-\beta$, and the elasticity of marginal utility, θ, the demarkation curve for C/H_e may be either upward or downward sloping. As H_e/H_p thus w_p/w_e rises, if $\theta<1-\beta$, C/H_e increases in order to grow at the same rate as entrepreneurial human capital, as in panel (a); but, if $\theta>1-\beta$, C/H_e decreases in order to maintain the same growth rate as entrepreneurial human capital, as in panel (b). Even if the demarkation curve for C/H_e is downward sloping, we know, from (19) and (20), that it crosses the other demarkation curve from below as w_p/w_e rises. The economy's steady state in panel (a) exhibits a stable intertemporal equilibrium; it starts at an initial state with the wage ratio below $1/\omega$ and then moves along a phase trajectory noncyclically toward point Q. However, the steady state in panel (b) represents a saddle-point equilibrium; the economy flows along the saddle path toward point Q. During the transition, H_e rises at a declining rate toward γ^* while H_p falls at the depreciation rate since γ_e is positive and decreases in H_e/H_p:

$$g_e \equiv \frac{\dot{H}_e}{H_e} = A\left(\frac{H_e}{H_p}\right)^{-b} - d - \frac{C}{H_e} \qquad (22)$$

Accordingly, w_p/w_e monotonically increases and C/H_e monotonically decreases, as the economy converges to its steady state, denoted by point S, before it could further achieve the quasi-target, point Q. Once the steady state is achieved, the growth of stocks of two human capital, output, and consumption will be dominated by the long-run balanced growth path, γ^*, discussed in the preceding section; point Q in Figure 2 is no longer relevant.

Output growth rates versus the ratio of rates of return

Now we turn to investigating the relationship between the growth rate of output, among others, and the ratio of the two human capital stocks or their respective rate of returns. Given the Cobb-Douglas production function specified in the previous section, the growth rate of output, denoted by $\gamma_{Y,}$ is determined by the growth rates of entrepreneurial and professional human capital, respectively, that is, $\gamma_Y=\beta\gamma_p+(1-\beta)\gamma_e$. Basically, the pattern of correlation between the two variables is asymmetric when the ratio of the rates of return is below versus above its steady state value.

With w_p/w_e exceeding $1/\omega$, the growth rate of output is positively related to the human-capital ratio, H_e/H_p, and thus the wage ratio, w_p/w_e. Using (17) and (22), we obtain

$$g_Y = (r^* + \delta)\left(\omega\frac{w_p}{w_e}\right)^{1-\beta} - \beta\frac{C}{H_p} - \delta \tag{23}$$

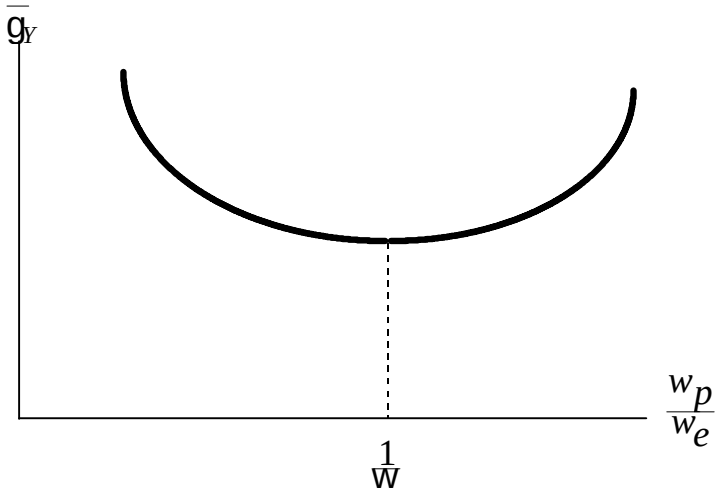
which possesses a positive slope term with respect to w_p/w_e. Analogously, with w_p/w_e falling short of $1/\omega$, the growth rate of output is negatively related to the human-capital ratio, H_e/H_p, and thus the wage ratio, w_p/w_e, because

$$g_Y = (r^* + \delta)\left(\omega\frac{w_p}{w_e}\right)^{-\beta} - (1-\beta)\frac{C}{H_e} - \delta \tag{24}$$

Also noting that γ_Y approaches the same value γ^* as w_p/w_e approaches $1/\omega$ from either side, we can plot the growth rate of output against the ratio between the two rates of returns to two types of human capital. The curve we obtain is of a U-shape as Figure 3 shows: the further w_p/w_e deviates from its steady state value, $1/\omega$, the higher the

output growth rate, γ_Y, is. As for the slope of the curve, it can also be shown from (23) and (24) that the first-order effect on the output growth of the deviation of the rate of return from the steady state could be asymmetric with respect to whether entrepreneurial human capital is more important than professional human capital (measured by the relative magnitude of output elasticity, or the relative share of output accruing to each human capital) and how further the ratio of the rate of returns between the two human capital is from its steady state value.

Figure 3 The relationship of output growth rate and human-capital return ratio



IV. Empirical Considerations

We now wish to examine some empirical evidence of the relationship between output growth and the ratio of returns to entrepreneurial and professional human capital. The source of panel data is the occupational wage survey in five industries of Singapore from 1986 to 1995, conducted by the Ministry of Labor in Singapore. Considering the fact that managers are taking increasingly more responsibilities of entrepreneurship in today's business world, we use managers' remuneration as a proxy variable for the return to entrepreneurial effort in the measurement of the ratio of returns to two types of human capital. Figure 4 exhibits a mixed pattern of the comovements between the output growth rate and the wage ratio: for the commerce and finance industries, they tend to move away from each other; for the construction industry, they seem to move together in the same direction; the manufacture and transportation industries, however, do not exhibit a clear pattern of dynamics. The associated correlation matrix in Table 1 supports the above observations with significantly positive correlation coefficient (0.8216) for the construction industry, significantly negative correlation coefficient (-0.5536) for the commerce industry, and weak correlations for other industries. The mixed evidence for correlation suggests that the aggregate economy is not far from its steady state position since 1986.

Figure 4(a) Wage Ratio for Singapore 5 Industries over 1986-1995

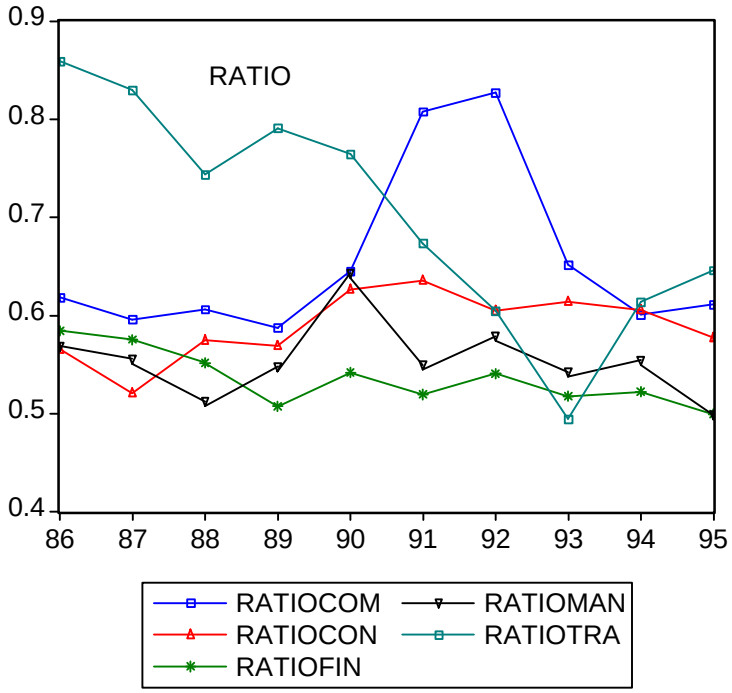
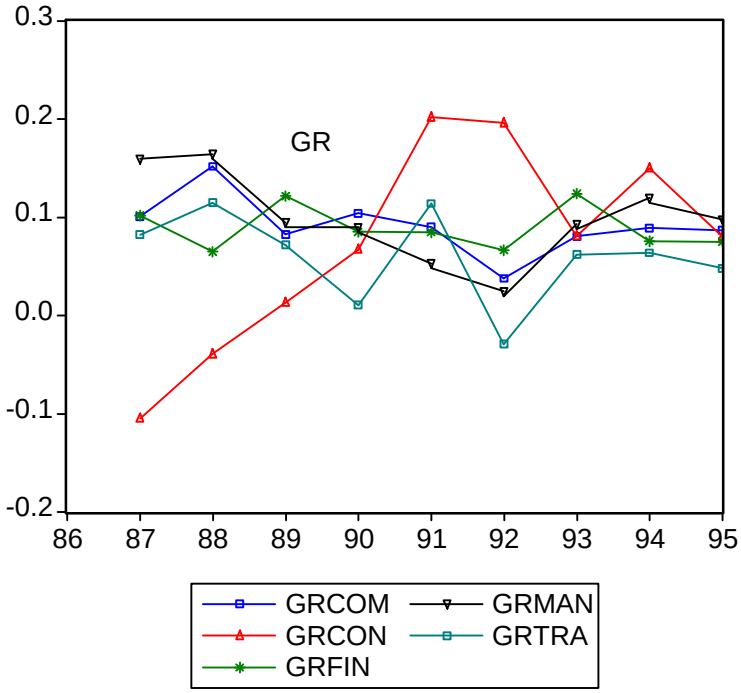


Figure 4(b) GNP Growth Rate (GR) for 5 Industries over 1986-1995



COM—Commerce Sector CON—Construction Sector

FIN—Finance Sector MAN—Manufacturing Sector

TRA—Transport, Storage, and Communication Sector

Table 1 Correlation between wage ratio and GNP growth rate for 5 industries

	GRMAN	GRCON	GRCOM	GRTRA	GRFIN
RATIOMAN	**-0.331654**	0.183813	-0.233754	-0.563805	0.040469
RATIOCON	-0.662963	**0.821612***	-0.240818	-0.229519	-0.16629
RATIOCOM	-0.823126	0.738858	**-0.553643***	-0.323588	-0.308369
RATIOTRA	0.460304	-0.653593	0.462195	**0.254719**	0.014066
RATIOFIN	0.438457	-0.513767	0.319129	0.013797	**-0.195643**

Table 2 reports the results of regression analysis. Due to the limited sample size in terms of the number of years and industries, we use the pooled data that contain both time series and cross sectional data to regress the growth rate of "aggregate" output on the wage ratio between professionals and entrepreneurs. Three regression results are reported in the table:[5] GLS estimation with cross section weights, an iterated GLS estimation with cross section weights, and SUR (seemingly unrelated regression) estimation. All these methods uniformly suggest that there exists a weak but significant positive relationship between the output growth rate and the wage ratio of the two types of human capital; in particular, one-unit increase in the relative wage of professionals in terms of the wage of entrepreneurs tends to result in about 0.14 percentage increase in the output growth rate. The result implies, according to our theoretical framework in previous sections, that the increasing accumulation of entrepreneurial human capital relative to professional human capital is, to a great extent, contributable to the fast growth achieved during the period from 1986-1995. As far as the five main industries are concerned, there is a weak imbalance between entrepreneurial and professional human capital or between their respective returns. More balanced long-term growth entails a change in the existing relative redundancy of entrepreneurial human capital or relative shortage of professional human capital.[6]

Table 2 GLS Results for Singapore's Panel Data

Dependent Variable: DLOG(GNP)

	Cross Section Weights	Cross Section Weights (iterate to convergence)	SUR
Wp?/We?	0.142210 (13.6032)	0.147434 (14.55397)	0.138728 (19.11461)
Panel obs	45	45	45
R-squared	0.3363	0.4536	--
Log likelihood	108.0743	108.5407	107.7395
Durbin-Watson stat	1.451972	1.486120	--

Note: Figures in the parentheses are the t value.

To gain further insights on the relationship between output growth rate and the wage ratio of two human-capital inputs, we extend our investigation to international evidence. The panel data available to us are from *World Competitive Yearbook* (1996) and *World Competitive Report* (1995, 1994 editions), which covers 29 countries in 1993, 41 countries in 1994, and 40 countries in 1995. Based on the international data available, we use the annual gross salary of engineers to measure the wage of professionals and the annual gross salary of director in manufacturing for the wage of entrepreneurs.

Table 3 Descriptive Statistics of Wage Ratio (Wp/We) for Years of 1993-1995

(International Data)

	All(93-95)	**low(93-95)**	**high(93-95)**	**All (95)**	**low(95)**	**high(95)**	**All (94)**	**low(94)**	**high(94)**	**All(93)**	**low(93)**	**high(93)**
Mean	0.655207	0.608658	0.686239	0.64709	0.599612	0.678743	0.648527	0.600027	0.690414	0.675845	0.642961	0.690643
Median	0.676699	0.615	0.685038	0.671174	0.595041	0.67506	0.675729	0.610632	0.689041	0.682902	0.630754	0.688896
Max	1.002063	1.002063	0.800694	0.857134	0.857134	0.776798	1.002063	1.002063	0.800694	0.799974	0.781627	0.799974
Min	0.169226	0.169226	0.537632	0.270961	0.270961	0.583287	0.169226	0.169226	0.537632	0.484354	0.484354	0.538912
Sd	0.114344	0.159869	0.050721	0.108327	0.151416	0.048296	0.143144	0.194198	0.052322	0.068407	0.088709	0.053293
Obs	110	44	66	40	16	24	41	19	22	29	9	20

Low refers to the countries with less then average US$10,000 GDP per capita;
High refers to the countries with more than average US$10,000 GDP per capita.

Table 3 gives descriptive statistics of the evolution of wage ratio for all countries in the sample from 1993-1995 with both the pooled data and the data with decomposition between countries of more than $10,000 per capita GDP and countries of less than that. We note that the mean value of wage ratio for the pooled sample slightly declines over the period from 1993 to 1995, from 0.6758 in 1993 (column10) through 0.6485 in 1994 (column 7) to 0.6470 in 1995 (column4). In addition, the mean values of wage ratio for countries with low per-capita GDP are discernibly less than those for countries with high per-capita GDP.

We further perform two groups of regression analysis with pooled data and cross-sectional data, respectively, to determine the dependence of the wage ratio on the level of GDP and the role of the wage ratio in the GDP growth; Table 4 reports the results. The first group of regression models exhibits uniformly positive estimates of the effect of income on the wage ratio, with all of them significant at the 5% level. This result indicates that those relatively wealthy countries are more likely to have higher relative returns to professional human capital compared with entrepreneurial human capital than those less wealthy countries. According to the result, we posit the following intuition. When a country is at a low level of economic development stage with the existing resources in abundance, the entrepreneurs' effort toward uniting unutilized resources within successful business to produce and market appears to be more indispensable thus more relevant than the professionals' role. Accordingly, the returns to entrepreneurial human capital turns out to be relatively high. Once an economy reaches the developed stage, the professionals' contribution to innovation and implementation of advanced technology such as R&D becomes the key to further growth; therefore, market-determined return to professional human capital tends to increase.

Table 4 Regression Results for International Data

Dependent Variable: Wp/We (part I)				
Variable	1993-95	1995	1994	1993
C	0.333187 (4.262912)	0.305805 (2.466248)	0.290797 (1.87617)	0.456950 (4.68869)
Log(GDP)	0.035273 (4.155347)	0.037132 (2.775075)	0.039831 (2.329927)	0.023655 (2.262867)
obs	110	40	41	29
R-squared	0.137841	0.168509	0.122186	0.159417

Dependent Variable: GDP growth rate (growth) (part II)				
Variable	1993-95	1995	1994	1993
C	1.952676 (0.97001)	8.960223 (2.94039)	-1.956094 -0.656064	0.972921 0.153971
Wp/We	0.673287 (0.22260)	-9.735845 (-2.09546)	6.470943 1.440573	1.879399 0.202006
obs	110	40	41	29
R-squared	0.000458	0.103582	0.050523	0.001509

Note: Figures in the parenthesis are t-value.

Another aspect which our regression analysis deals with is the effect of the ratio of professionals' wage to entrepreneurs' wage on the GDP growth. As shown in Table 4, only the regression based on the 1995 cross-sectional data exhibits a negative and significant relationship between the growth rate and the wage ratio. As the wage ratio is positively related to the level of GDP of an economy, it follows that the high-growth economies observed are usually less developed and more entrepreneurship driven. Due to the cross sectional feature,

the result obtained here is certainly not directly applicable to our dynamic growth model. However, this outcome could be comparable with the theoretical result implied in our model that there is a negative relationship of adjustment between the growth rate and the wage ratio if the economy's wage ratio falls short of its steady state value. That is, what we obtain from the international cross sectional data could be considered as a counterpart for an economy's time series data when its GDP level, thus the wage ratio, lies below the steady state level.

V. Concluding Remarks

We have developed a growth model in which both entrepreneurial and professional human capital contribute to the long-term economic growth in a competitive environment, and the growth rate depends on the ratio of rate of returns to the two types of human capital. The model generates several testable theoretical results of an economy's adjustment paths when the economy deviates from its steady state. When the economy is at an imbalance with a redundancy of entrepreneurial human capital relative to professional human capital, the ratio of the rate of return to professional human capital to the rate of return to entrepreneurial human capital tends to fall while consumption per unit of entrepreneurial human capital rises; under the circumstances, output growth is positively related to the ratio of professional-human-capital return to entrepreneurial-human-capital return. When the economy is at an imbalance with a shortage of entrepreneurial human capital relative to professional human capital, the ratio of the rate of return to professional human capital to the rate of return to entrepreneurial human capital tends to rise while consumption per unit of entrepreneurial human capital falls; under the circumstances, output growth is negatively related to the ratio of professional-human-capital return to entrepreneurial-human-capital return.

Moreover, our empirical analysis with the panel data of Singapore industries produces the insightful result that favors further deepening of investment in professional human capital (compared with that in entrepreneurial human capital), the more extensive and intensive development of scientific and technological research and education, for example. The cross-sectional regression using international data establishes the strong evidence for the positive relationship between the GDP and the ratio of returns to professional human capital to returns to entrepreneurial human capital. It also further suggests that the return ratio determined by the level of GDP is negatively related to the GDP growth rate across countries in the 1995 sample investigated. If data had permitted more observations to be made on time dimension, one extension would be to use spline function to estimate a curvilinear relationship between the growth rate and the return ratio and characterize the feature of regime switching.[7]

In summary, our theoretical and empirical work has produced the following result: the high growth rate at the stage of low income level is associated with the low return ratio of professional human capital to entrepreneurial human capital, suggesting a relatively important role of entrepreneurs in economic development; however, the opposite tends to hold at the stage of high income level.

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Notes

[1] For the representative endogenous growth models with human capital, see Romer (1986), Lucas (1988), and Rebelo (1991).

[2] When $\theta \rightarrow 1$, $u(C) \rightarrow \log(C)$.

[3] Barro and Sala-I-Matin (1995, 142-143) provides a proof of this standard result when only physical and human capital are considered.

[4] This feature of modeling real wage in a growth model accords, in spirit, with Uzawa (1965), Lucas (1988), Saarenheimo (1993), and Eicher (1996).

[5] We impose the constraint of zero intercept on regression since zero capital ratio can lead only to zero growth, which accords with theoretical considerations as well as empirical intuition.

[6] Our result here and its implication match the recent effort of Singapore government in expanding professional education and readjusting business education.

[7] See Suits, *et al*.(1978) for the use of spline functions.