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Farshid Mojaver

GROWTH WITH WORK ETHICS

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Farshid Mojaver[•]

Institute for Research, Planning and Development (IRPD), Tehran, Iran and
Department of economics, University of California, Davis CA 95616
e-mail: f_mojaver@hotmail.com

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Abstract.

Economic development is the result of hard work, discipline and frugality – qualities, which can be learned through an education process. This is the gist of Max Weber's writings on the development of capitalism, which I have modeled in this paper. The model shows how an educational sector that produces a composite of work ethics and skills can lead to sustained growth. Human capital in this model reduces the disutility of effort exertion and thereby induces people to work harder. Along balanced growth path, effort exertion is constant in this mode. The model shows that growth is an increasing function of effort exertion which itself is a function of a number of efficiency parameters. Historical anecdotal evidence and a regression analysis looking at the effects of formal education on growth with a new interpretation are presented in support of the model.

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1. Introduction

Education and the accumulation of human capital is acknowledged by many growth models as the force that drives economic growth. Romer (1986, 1987, and 1991) introduced growth models with endogenous technological change where the accumulation of knowledge is the main engine of growth. Lucas (1988, 1990) argues that the accumulation of human capital (defined as the general skill level) through schooling increases the marginal productivity of labor, which results in a sustained growth rate.

But historical evidence is not fully consistent with the skill/knowledge explanation of growth. Landes remarks (1969:61), "If anything, the growth of scientific knowledge owed much to the concerns and achievements of technology; there was far less flow of ideas or methods the other way". Schmookler (1966) analyzed nearly 1,000 major inventions in four industries (farming, railroading, petroleum refining and paper-making) around the world between 1800 and 1957. The four industries represent both old (agriculture and paper) and the new industries; some relying substantially on science (petroleum and paper) and some not so much. Schmookler does not find a single invention where the stimulus was a scientific discovery.

Instead, Clark (1987) presents evidence that most of the growth in the agricultural productivity of the United States and Britain before 1850 was derived from the intensification of labor. In a cross country study of the textile industry between the late nineteenth to the early twentieth century, Clark (1987, 1991) shows evidence of a strong correlation between (i) labor productivity and work intensity in the textile industry, and (ii) the growth in GDP per capita and the progress of labor productivity in the textiles, meaning that the success of labor intensification in the textile industry serves as a good proxy for the success of the economy as a whole.

Most growth models, however, neglect the phenomenon of work intensity. They typically assume that individuals' supply of labor is inelastic.[1] This paper proposes a growth model consistent with the observation that growth, at least in its early stages, increases with work intensity and progress in work related values. The proposed model here departs from the existing models in the literature by assuming that the individuals consumption-leisure preferences change through the accumulation of a certain type of human capital i.e., work ethics. It is assumed that the marginal disutility of labor is a decreasing function of work ethics. Work ethic is defined as set of work related values that can be learned and though an educational process. The endowment of human capital determines the level at which individuals are willing to exert labor and the efficiency of labor in the production process. These propositions are consistent with Max Weber's view of economic development. And the models proposed here are in the spirit of his writings.

2. Traditionalism versus Modern Capitalism

The main thrust of the paper rests on the idea that the emergence of modern economy (e.g. sustained growth) presupposes a new set of motivation and a new system of ethics. This idea was best presented by Max Weber first. He begins with the observation that productivity gains in capitalism start with the intensification of labor. Without a change in attitudes, the backward bending labor supply curve limits the scope of labor intensification through pecuniary means.

> "A man does not by nature wish to earn more and more money, but simply to live as he is accustomed to live and to earn as much as is necessary for the purpose. Whenever modern capitalism has begun its work of increasing the productivity of human labor by increasing its intensity, it has encountered the immensely

[1] Lucas (1990) is a notable exception where leisure is considered as a choice variable in his model. In the balanced growth path, however, leisure is assumed to be a constant.

> stubborn resistance of this leading trait of pre-capitalism labor."[2,3]

Weber cites examples of the type of backward traditional forms of labor of his contemporaries and the extent to which those forms frustrate employers.

> An almost universal complaint of employers of girls, for instance, German girls, is that they are almost entirely unable and unwilling to give up methods of work inherited or once learned, in favor of more efficient ones, to adapt themselves to new methods to learn to concentrate their intelligence, or even to use it at all. Explanations of the possibility of making work easier, above all more profitable to themselves, generally encounter a complete lack of understanding. Increases of piece-rates are without avail against the stone wall of habit.[4,5]

Thus it is not only the quantity of labor that matters, but also a 'developed sense of responsibility is absolutely indispensable' for the development of capitalism. Weber emphasizes that the ability of mental concentration, feeling of obligation to one's job a cool self-control and frugality enormously increases performance. Labor must be performed as if it were an absolute end in itself. The advent of modern capitalism is marked not only by the presence of willing workers but also by the presence of restless entrepreneurs who made the pursuit of riches the ultimate goal of their lives.

> Man is dominated by the making of money by acquisition as the *ultimate purpose of life* . . . The making of money within the modern economic order is, so long as it is done legally, the result and the *expression of virtue* and proficiency in a calling. It is an obligation which the individual is supposed to feel toward the content of his professional activity . . . Such a state of mind in

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[2] Max Weber (1905/1956), pp. 60.

[3] Adam Smith was also aware of these facts but he tends to attribute traditionalism to the lack of private property and security since "A person who can acquire no property, can have no other interest but to eat as much, and to labor as little as possible" Adam Smith (1776/1987), pp. 39).

[4] Max Weber (1905/1956) pp. 62.

[5] A similar concern is expressed by Moser, an American visitor to India in the 1920's. He reports on the refusal of Indian workers to tend as many machines as they could and writes "It was apparent that they could easily have taken care of more, but they won't . . ., they cannot be persuaded by any exhortation, ambition, or the opportunity to increase their earnings." (Moser (1930), pp. 101).

> ancient times and in the Middle Ages would have been proscribed as the lowest sort of avarice and as an attitude entirely lacking in self respect. [Italics added.]

If such behaviors are irrational and contrary to human nature, then how did they develop? By education, Weber responds.

> Such an attitude is by no means a product of nature. It cannot be evoked by low wages or high ones alone, but can only be the product of a long and arduous process of education.[6]

Thus, according to this view the main function of the education system in capitalism is to shape a set of values, and to form habits useful for the maintenance and growth of capitalism. Here, the success of the educational system is measured with not only what students know in the way of science and mathematics, but also how well they are motivated to do hard work, and to take initiative and responsibility.

Weber gives an account of the development of intrinsic work ethics in the 17th and 18th century Europe that had to do with the religious glorification of hard work, and 'the earning of more and more money, combined with the strict avoidance of all spontaneous enjoyment of life,'- an idea that appears 'entirely irrational' from the standpoint of personal happiness or utility.

Theodore Veblen (1899/1934) on the other hand offers a secular explanation of work ethics (primarily extrinsic work ethics) based on peoples' psychological propensities. Veblen argues that people above the line of bare subsistence, do not use surplus to expand their lives, to live more wisely, intelligently, and understandingly. Instead, they use it to impress other people with the fact that they have a surplus. Veblen explains the basis for such impulse as the following:

> Man in his own apprehension is a center of unfolding impulsive activity - "teleological activity". He is an agent seeking in every act the accomplishment of some

[6] Max Weber (1905/1956:62)

> concrete, objective, *impersonal end*. By force of his being such an agent he is possessed of a taste for effective work, and a distaste for futile effort... This aptitude or propensity may be called the instinct of workmanship. Whenever the circumstances or traditions of life lead to an habitual comparison of one person with another in point of efficiency, the instinct of workmanship works out in an *emulative or invidious comparison* of persons . . . In any community where such an invidious comparison of persons is habitually made, visible *success becomes an end, sought for its own utility as a basis of esteem*. Esteem is gained and disgrace is avoided by putting one's efficiency in evidence. The result is that the instinct of workmanship works out in an emulative demonstration of force.[7] [Italic added.]

Thus, according to this view, work ethic is rational in the sense that it is based on the psychological propensities of men and its pursuit leads to personal satisfaction.

Interestingly enough Adam Smith's views on human motivations in economic activity, contrary to the popular perception, are not essentially different from that of Veblen or Weber. In his Theory of Moral Sentiment Adam Smith argues that human beings by nature are predisposed to form hierarchical and cohesive structures. This is often expressed in the form of willingness to submit to norms of propriety and in status seeking. It is status that is "the end of half of the labor of human life". Thus this is the source of human motivation to deserve, to acquire and to enjoy the respect and admiration of the others (or at least half of it if not all). But how one can get this respect? "Two different roads led to the attainment of this so much desired objective;" Smith responds, "the one by study of wisdom and practice of virtue; the other by acquisition of wealth and greatness". Then when Smith says " little else is requisite to carry a state to the highest degree of opulence from the lowest barbarism, but peace, easy taxes and a tolerable administration of justice; all the rest being brought about by

[7] Veblen (1899/1934) pp.16.

the natural course of things" his presumption is that wealth is viewed as a vehicle to achieve status, respect, and greatness in the society[8].

A "diligent pursuit of proficiency" and wealth, however, is not the only possible channel for personal emulation. History of mankind is full of examples of ways and means by which people have chosen to gain social status without resorting to productive activities. Conspicuous consumption and leisurely activities are two examples of other emulation channels that historically have been chosen.

Hayek (1973) suggests that a societal process of coordination and an improvement of individual quest for status will naturally (e.g. by the elimination of the unfit) lead to the adoption of the most socially efficient games - the ones that minimize the social cost of status seeking and maximize potential positive externalities. This may explain the prevalence of modern capitalism once it appeared in England first, however it does not preclude the necessity of the development of certain standards of ethics and accepted norms of behavior in the society prior and parallel to the development of capitalism itself.

Critics of Weber argue that first, there is nothing peculiar about the teachings of Calvin and early Puritans and whatever differences are observed in them in the late 17th and 18th century did not exist in the 16th century, and second these presumable differences could have not developed in a vacuum.[9] Protestant Ethic itself is the result of the development of capitalism. However, the issue of whether or not the spirit of capitalism preceded capitalism is not essential to the main point of this paper. Even if economic conditions preceded the advent of work ethics and even if one believes that the creation of work ethics were motivated by capitalistic interests and that intellectual,

[8] More recently Akerlof and Krenton (2003) consider non-pecuniary sources of work incentives. They and argue that workers' self-image as jobholders, coupled with their ideal as how their job should be done, can be a major work incentive. In a theoretical model they show how identification with the firm, or with the job, or with the work groups can flatten reward schedules as they solve the "principal-agent" problem.

[9] For more argument on this issue see Robinson H. M., *Aspects of the Rise of Economic Individualism*, (1959), Kelly & Millman, Inc. New York.

religious, legal and social forces were in fact utilized by capitalism to serve its interest, one still can not escape the fact that these changes were instrumental for the further development of capitalism. This point is particularly relevant for less developed countries.

In this paper I adhere to a weaker Weberian proposition that (i) work ethic and hard work are necessary conditions for the development of capitalism, and (ii) work ethic can be created by a deliberate design of an education system including that of formal schooling.

3. A Weberian Growth Model

This Section illustrates how long term growth can be achieved via an educational sector that teaches principals of work ethic. Here human capital is defined as the extent to which the principal of agility, responsibility, punctuality, self-discipline and proficiency are internalized and practiced by in workers. A worker endowed with such ethics strives for proficiency for its own sake as well as a source of income. Thus human capital is taken to represent both ethical and cognitive skills.[10]

Consider a closed economy populated with N identical, infinitely-lived individuals with preferences over goods, effort exertion and human capital, represented by

$$\text{MAX} \quad \int_0^{\infty} [\exp -(\rho - n)t] \; U(c_t, e_t, h_t)dt \qquad \rho > n \qquad (1)$$

[10] Motivation for proficiency, of course, is not the same thing as the proficiency itself. However I make this leap on the grounds that in the education process people acquire both willingness to learn and cognitive skills. Here I assume that the time spent on this activity is subsumed under general education.

Where

$$\begin{bmatrix} U_{11} & U_{12} & U_{13} \\ U_{21} & U_{22} & U_{23} \\ U_{31} & U_{32} & U_{33} \end{bmatrix} = \begin{bmatrix} - & - & + \\ - & - & + \\ + & + & - \end{bmatrix}$$

Here n is the population growth rate, ρ is the discount rate, h_t is human capital, e_t is work effort, and c_t is consumption at time t, all in per capita terms. The utility function is assumed to be increasing in c_t and h_t, and decreasing in e_t. The inclusion of human capital, in the utility function is justified on the grounds that (i) the fulfillment of ethical duties is a source of gratification, and (ii) knowledge of codes of impropriety can lead to self-gravitation and self-respect and also to status and respect of fellow man.

The utility function is assumed to be quasi-concave with the second and cross derivatives as stated in (1). In particular, it is assumed that the marginal disutility of effort decreases with the accumulation of human capital (i.e., $U_{23}>0$). As we shall see, the latter assumption plays a crucial role in modeling Weberian hypothesis. Marginal utility of consumption is assumed to increase with human capital. This is consistent with Smith, Weber and Veblen thought that consumption can be viewed an expression of status, proficiency, workmanship or even virtue. Increasing marginal utility of consumption is also consistent with Becker (1965) in which consumption and human capital are viewed as complements. Labor supply in terms of hours of work per unit of time is assumed to be fixed (at one) for each individual, level of effort exertion however, is unbounded.

In particular we consider the following separable functional form:

$$U(c, e, h) = W(c)V(e, h)$$

$$\text{where } W(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma}, \quad V(e, h) = \left(1 - a(h)e\right)^{\alpha} \quad \text{and} \quad a(h) = \frac{De}{h^{\phi}} \qquad (1')$$

$h^{\phi}>De$, $0<\phi<1$, $0<\alpha<1$, and $0<\sigma$[11]. a(h) can be viewed as a taste parameter which, for a given endowment of human capital, determines the degree to which workers dislike

[11] The restrictions $\sigma>0$ and $0<\varphi<1$ sufficiently insure the conditions of $U_{11}=W_{11}V<0$ and

effort exertion. However, tastes and perceptions about work can change through an education process. The expression h^{ϕ} can be interpreted as the maximum level of effort potentials perceived by a typical worker, where the perception itself is a function of human capital endowment of the individuals in the society. Consistent with the Weberian view of capitalistic development and observations made by Clark (1987), this interpretation suggests a maximum level of effort exertion beyond which workers can not be persuaded to work harder by any means.

Utility increases with education because education defines what is dignified, honorable, and respectful. Educated people view themselves as respectful individuals and are viewed as such in eyes of their peers, not so much because of having the education per se but because of behaving in a certain way. That certain way has to do with attitude toward work, its intensity and quality. But acquisition of propriety comes at a price which is harder work. If the function of the educational system was limited to make people work harder and feel good about it too, growth would be limited to the extend work effort could be increased, which is limited. But the focus of Weberian education is not only of quantity of work but also with its quality. Some of this quality has to do with cognitive skills and some have to do with work manners such as punctuality, reliability, discipline, self-initiation and so forth.

There are two sectors in this economy producing a final good and education. A fraction, u_t, of the available capital stock k_t, and a fraction, v_t, of effective labor $e_t h_t$ are employed in production of final goods according to a constant return to scale production function $F(v_t k_t, u_t e_t h_t)$. The remaining physical capital and effective labor are used in the production of human capital according to $G[(1-v_t)k_t,(1-u_t)eh]$. The production functions F and G are assumed to be twice differentiable, strictly increasing in both arguments, strictly concave and homogenous of degree one.

$U_{33}=WV_{22}<0$ necessary for utility function to be quasi concave. Similarly, the restriction $0<\alpha<1$ guarantees the conditions of $U_{22}=WV_{11}<0$ and $U_{12}=U_{21}=W_1V_1>0$. Under these restrictions it can be illustrated that V(.) and hence U(.) functions are quasi concave.

Production of the final good is divided among consumption c, and investment $\dot{k}$ (from here on the time subscript t will be suppressed):

$$\dot{k} = F(vk,ueh) - c - nk \qquad (2)$$

Accumulation of human capital per head is given by:

$$\dot{h} = G[(1-v)k,(1-u)eh] - nh \qquad (3)$$

The optimal allocation of resources in this economy is achieved by choosing quantities v, u, c, e, k, and h. From maximization of (1) subject to (2) and (3) it follows that value of marginal product of capital (and also that of effective labor) are equal in both sectors. That is, $F_1 = pG_1$, (and $F_2 = pG_2$), where p is the relative price of education in terms of consumption goods (i.e., λ_2/λ_1).

I assume that the ratio of physical capital per worker to effective labor k/eh, is constant in the balanced growth path. I also assume that the fraction of effective labor and of capital devoted to the production process in each sector (u and v), are constant in the balanced growth path of the economy. That is:

$$\frac{\dot{k}}{k} = \frac{\dot{h}}{h} + \frac{\dot{e}}{e} \quad and \quad \dot{u} = \dot{v} = 0$$

Constancy of k/eh also implies that the shadow price of human capital in terms of final goods p is constant in the balanced growth path. Constancy of k/eh also guarantees the constancy of marginal products. It follows that in the balanced growth path the optimal level of effort exertion e is given by:

$$e = \frac{pF_1}{F_2}\left(\frac{1}{1+\phi}\right) \qquad (4)$$

From this equation it is clear that on the balanced growth path effort exertion is constant.

To get a more concrete result we assume F(vk,ueh) is given by $A(vk)^{\beta}(ueh)^{1-\beta}$ and G[(1-v)k,(1-u)e] is given by $B[(1-v)k]^{\gamma}[(1-u)eh]^{1-\gamma}$. Divide both sides of (3) by h, substitute $(1-v)/(1-\gamma)G_2$ eh for G and substitute for e from (4) then we have:

$$\frac{\dot{h}}{h} = F_1 \frac{1-u}{(1+\phi)(1-\gamma)} - n \tag{5}$$

The growth rate of physical capital is also a decreasing function of human capital since it is the sum of two falling growth rates:

$$\frac{\dot{k}}{k} = \frac{\dot{h}}{h} + \frac{\dot{e}}{e}$$

Now let's turn to the determination of the growth rate of consumption. The consumption growth rate takes the following form:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}[F_1 + \psi(h) - \rho]$$
$$\psi(h) = \frac{\alpha\phi De}{(h^{\phi} - De)}\frac{\dot{h}}{h} \tag{6}$$

where $\psi(h)$ approaches zero as h grows large. Equation (6) indicates that the growth rate of consumption, while falling along its balanced growth path in the limit, approaches a constant that is equal to the gap between net marginal product of capital and the consumer discount rate.

Now, let's characterize the asymptotic behavior of the model. In the balanced growth path with constant effort exertion, the growth rates of the two types of capital are equal to g:

$$g = \frac{\dot{h}}{h} = \frac{\dot{k}}{k} = F_1 \frac{(1-u)}{(1+\phi)(1-\gamma)} - n \tag{7}$$

Growth rate of consumption is also a constant given by:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}[F_1 - \rho] \tag{8}$$

In (5), replace F_2 by pG_2, substitute for values of F_1 and G_2, and solve for eh/k:

$$\frac{eh}{k} = \left[\frac{1-\gamma}{\beta}\left(\frac{v}{u}\right)^{1-\beta}\left(\frac{1-v}{1-u}\right)^{\gamma}(1+\phi)\bar{e}\frac{B}{A}\right]^{\frac{1}{1-\beta+\gamma}} \tag{9}$$

Solving for (1-v)/(1-u) from the efficiency condition $F_2/F_1 = G_2/G_1$ and substituting in the above equation and rearrange terms we obtain:

$$F_1 = \beta A\left(\frac{ueh}{vk}\right)^{1-\beta} = \Gamma\left[(1+\phi)\bar{e}\right]^{\varepsilon} B^{\varepsilon} A^{1-\varepsilon} \tag{10}$$

$$where \quad \Gamma = \beta\left[\frac{1-\gamma}{\beta}\left(\frac{1-\beta}{1-\gamma}\frac{\gamma}{\beta}\right)^{\gamma}\right]^{\frac{1-\beta}{1-\beta+\gamma}} \quad and \quad \varepsilon = \frac{1-\beta}{1-\beta+\gamma}$$

And hence growth rate of the economy is:

$$g = \frac{1}{\sigma}\left[\Gamma\left[(1+\phi)\bar{e}\right]^{\varepsilon} B^{\varepsilon} A^{1-\varepsilon} - \rho\right] \tag{11}$$

Where $0<\Gamma<1$ and $0<\varepsilon<1$. From (7) and (8) solve for F_1 and then using (11) solve for the optimal level of effort exertion.

$$e = \left[\frac{\rho - \sigma n}{\Gamma(1+\phi)^{\varepsilon} B^{\varepsilon} A^{1-\varepsilon}\left(1 - \frac{\sigma(1-u)}{(1+\phi)(1-\gamma)}\right)}\right]^{1/\varepsilon} \tag{12}$$

Note that when in the production of human capital physical capital is not employed that is when $\gamma = 0$ then $\varepsilon = 1$ and $\Gamma = 1$, and hence: $F_1 = \Gamma(1+\phi)\bar{e}B$

From (11) it is clear that marginal productivity of capital, hence the growth rate of the economy grows with the level of effort exertion. Given a certain level of effort exertion, growth increases with production efficiency parameters A, B and the utility parameter ϕ. The lower the efficiency of an economy (both in production and in

reduction of disutility of effort), the higher the optimal level of effort exertion in the balanced growth path. The higher the share of effort allocated to the production of human capital,(1-u), the higher the effort exertion. An increase in discount rate reduces the growth and increases the optimal level of effort exertion. An increase in σ has a similar effect. That is an increase elasticity of intertemporal substitution of consumption $1/\sigma$ increase the growth rate and reduces the level of optimal effort exertion (for plausible values of other parameters such as discount rate, and population growth rate).

5. Education and Growth

In the growth model of the previous section I identified two mechanisms by which education can lead to economic growth. One is related to increasing work intensity (in the LDC's and sustaining its high level in the DC's) and the other, has to do with increasing the productivity of each unit of effort. Both of these two tasks can be achieved via an educational system. However for the first one an educational system is required that targets individuals' value system and for the second an educational system that targets cognitive/skill abilities.

As our Weberian model illustrated the presence of these mechanisms, i.e. ethical and cognitive education, are both necessary for obtaining a non-diminishing growth. In addition, these models imply that in the early stages of economic development ethical skills ascertain higher growth potentials than cognitive skills. As work intensities rise with the general level of economic development, the growth related function of work ethics becomes limited, while that of cognitive skills keeps on rising.

The direct test of these hypotheses requires data on work intensity, work ethics and cognitive skills of individuals at the national level, none of which are available. The lack of data on work intensity does not pose a serious problem. Effort exertion is fixed in the DC's. In the LDC's where work intensity rises with work ethics, we can use education as a proxy for work ethics. The main difficulty, however, is to identify

sectors which produce ethics and skills in any measurable way. Formal schooling in the literature is typically used as a measure of skills in the labor force and we can do the same here. But what about the ethical skills?

Ethical teachings and the formation of one's value system, clearly, it starts at home and then continues during one's life. The parental ethical teachings have perhaps the most profound and long lasting effect. These values are in turn reinforced or reshaped by various social institutions. One of these institutions is formal schooling. We have no measure of the share of ethical values that are shaped at home. In any case, such data wouldn't be very helpful since family education is not the subject of policy control. We need to identify an institution, which first, has an impact on the ethical learning of individuals at the margin and second has measurable outputs. Formal schooling seems to be a good choice for such an institution. A number of scholars have argued that formal schooling in a capitalist system is designed to shape habits and attitudes that are useful in the work environment. Bowles and Gintis (1976), in particular, argue that the primary emphasis of the elementary and secondary education is on the development of attitudes best suited for the work environment while the emphasis in the higher education is more on the development of cognitive skills.

In my empirical investigation I use time series data on 30 countries to analyze the relationship between national income and stocks of physical and human capital. I will use the number of students enrolled in elementary, secondary and higher education as a proxy for both ethical and cognitive skills in the labor force.

The empirical study presented here is not fundamentally different from the human capital studies that take school enrollment as a proxy for the skill level in the labor force. The main difference lies in the interpretation of the results. The evidence of positive association between education and income in these studies could be taken as evidence in support of the Weberian models developed here. To demonstrate this argument, however, I will present some studies which have shown that formal schooling

do in fact lead to the development of ethical skills in addition to the cognitive ones, flowed by my own empirical findings.

5.1 The Behavior Shaping Function of Formal Education

In their educational classic *Schooling in Capitalist America* (1976) Bowles and Gintis argued that economic value of education has been grossly misunderstood by orthodox economics of education. The widely observed association between personal earnings and schooling is often attributed to the influence of education on the levels of cognitive knowledge in the working population. But effective performance in most jobs, argued Bowles-Gintis, depends very little on directly usable cognitive skills and much more on certain non-cognitive personality traits. Schools are like mini-factories that produce the same behavioral traits and values that are prized in the labor market. For example, factories are organized hierarchically, and so are schools; and obedience is require in factories, and so do schools. The relationship between dominance and subordinancy in education differs by level. The rule orientation of high school, Bowles and Gintis argued, reflects the close supervision of low-level workers; the internalization of norms and freedom from continual supervision in colleges reflect the social relationships of white-collar technical, supervisory and managerial work.

Gintis (1971) presents some interesting studies in support of his theory. For instance he presents data showing that cognitive variables never account for more than 30% of the variance in grade point average. Gough (1951) finds that "overachiever" (students whose grades exceed that predicted by their IQ) consistently rewarded for being "dependable," "reliable," "honest," and "responsible". Studies of Smith (1976 a & b) show that discipline is independently rewarded through grades. In predicting post-high-school performance Smith finds that ethical variables such as "not a quitter," "responsible," "insistently orderly," "determined-preserving," - do three times better (in terms of R^2) than any combination of thirteen cognitive variables, including SAT

verbal, SAT mathematical, and high school class rank. And finally, there is significant evidence showing that such non-cognitive variables are also the main indicators of good job performance in the capitalist economy (see Bowles-Gintis p. 138-140).

There is also considerable evidence that in the past century and half at least, the community leaders in Britain and the United States have been similarly aware of the function of schools in preparing youth psychologically for work. In England, Sunday schools were promoted by the Church of England in many villages in the 1970's and 1800s. Their function is uniformly described as being to kindle in the children of the poor "a spirit of industry and piety." Sunday school teachers at Caistor were instructed

> to tame the ferocity of their unsubdued passions [of children] - to repress the excessive rudeness of their manners - to chasten the disgusting and demoralizing obscenity of their language - to subdue the stubborn rebellion of their wills - to render them honest, obedient, courteous, industrious, submissive, and orderly.[12]
>
> (Russell, 1960:5, 7)

Andrew Ure the nineteenth century fervent supporter of industrialization, in praise of such schools wrote:

> The unrivalled growth of the factory establishment of Stockport . . . may be fairly ascribed, in no small measure, to the intelligence and probity of the recent race of operatives trained up in the nurture of its Sunday schools.
>
> (Ure 1835:412)

Johnson (1970) argues that in the Victorian period in England those who determined the elementary school curriculum also determined the 'patters of thought, sentiment and behavior of the working classes'. Elementary schools were regarded as successful in the eyes of the dominant groups in society if the pupils emerged 'respectful, cheerful, hard-working, loyal, pacific and religious'.[13] Stannard (1990) argues that public elementary

[12] R. C. Russell, History of Elementary Schools and Adult Education in Nettelton and Caistor (Caistor, 1960) p 5, 7.

[13] R. Johnson, "Educational policy and social control in early Victorian England", *Past and Present*, 49 (1970), 96-119.

school in the mid-Victorian period in England played a crucial role in disseminating, and securing the acceptance of, bourgeois values. Education was seen, he argues, as a means of persuading the working class that its real interests lay in the perpetuation of the capitalist system. With the victory of the middle-class and the dominance of the bourgeois values the concern for social order diminished and a broader view of the scope of elementary education emerged. Nevertheless the essential social role of the school remained the teaching of the principles of industry and moral integrity.

Bowles and Gintis (1976) have collected extensive evidence of such view some of which I would like to present here. In a statement signed by 77 college presidents and city and state schools superintendents published by the U.S. government in 1874 the function of schooling was defined as the following:

> In order to compensate for lack of family nurture, the school is obliged to lay more stress upon discipline and to make far more prominent the moral phase of education. It is obliged to train the pupil into habits of prompt obedience to his teachers and the practice of self-control in various forms.
>
> (c.f. Bowles-Gintis 1976:38)

In the mid 18th century U.S it was commonly believed that an educated worker is a better worker. In 1841, Homer Bartlett, agent of the Massachusetts Cotton Mills wrote:

> From my observations and experience, I am perfectly satisfied that the owners of manufacturing property have a deep pecuniary interest in the education and morals of their help . . . I believe it will be seen that the establishment, other things being equal, which has the best educated and most moral help will give the greatest production at the least cost per pound.
>
> (c.f. Bowles-Gintis p. 162)

5.2 Empirical Findings

The empirical studies analyzing the effect of education on growth have typically used school enrollment as a measure of human capital (meaning skill levels) in the individuals. In a cross-sectional study, Barro (1989) analyzes at the relationship between GNP growth rate and the initial levels of physical and human capital stocks. He employs the growth rate of real per capita GNP over the 1960 and 1985 period as the dependent variable and the 1960 levels of GNP per capita as a proxy for the initial physical capital stock, and the 1960 school enrollment rates at the elementary and secondary levels as a proxy for the initial level human capital stock. Barro shows that growth has a strong and negative correlation with the initial GDP per capita and a strong and positive correlation with human capital. These findings are consistent with our Weberian model where the ratio of effective labor and physical capital per head (i.e., eh/k) is fixed in the balanced growth path. With effort exertion fixed at its optimal level the fixity of human-physical capital ratio implies that growth rate is negatively correlated with higher than average physical capital and positively correlated with higher than average human capital.

In a similar study Mankiw, Romer and Weil (1990), thereafter MRW, show that an augmented Solow model which includes the accumulation of human as well as physical capital provide an excellent description of the cross country data. MRW use the log of difference GDP per working-age person 1960-85 as the dependent variable, the log of the investment, population and schooling for the 1960-1985 period and the log of GDP in 1960 as the explanatory variables. Schooling here is defined as the average percentage of the working-age population in the secondary school for the period 1960-1985. MRW show a strong positive correlation between income growth and the growth rates of physical and human capital accumulations, which again is totally consistent with our Weberian model. I use time-series cross-section data on real GDP, real investment and the number of students enrolled in the elementary, secondary and

higher education, in 30 countries and for the period covering from 1950 to 1988. The data on education comes from the UNESCO publications and that of GDP and investment come from Summers and Heston (1988). The criterion used for the selection of countries in the sample are the availability and the quality of data, particularly that of the educational data. The oil-exporting and the politically disrupted economies are excluded from the data set.

Despite all the efforts, the quality of educational data is still far from being satisfactory. The total years of schooling and the split between the elementary and secondary education are typically different for different countries. Elementary education, for example, is defined as eight years of schooling and some others as four years. What makes it worse is that the number of schooling years considered for the elementary or the secondary education changes for some countries. One often observes an abrupt change in the number of students enrolled in a country for a certain level of education. By means of linear interpolation I tried to keep the definition of the elementary and secondary education consistent in each country. And then there is the problem of missing data. The educational data the 1950-1960 period is scattered for most countries. Since our time series data on education is already very short and education takes some years to have an effect on income, I did not discard the 1950-60 data on education. Instead, I used linear extrapolation for making up for the missing data.

I have three more years of observation on real GDP (1950-88) than for the student enrolment figures (1950-85). Since investments in the human and physical capital are likely to take more than three years to be effective, I did not truncate my GDP data set and instead used an at least three year lag in the explanatory variables. Table 1 shows the regressions for real GDP levels. The explanatory variables are the number of students enrolled in the elementary $L1_{t-15}$, secondary $L2_{t-8}$ and higher education $L3_{t-3}$, and gross real investment I_{t-3}. All variables are in the log format and

lagged as indicated. A Generalized Least Squares procedure was applied in the estimation of the model. The model was assumed to be cross-sectionally homoskedastic and Time-wise Autoregressive. I used an AR(1) process to find an estimate of the correlation coefficient for each of the cross sections separately. This procedure is described by Kmenta [1986, Eq. 12.26].

The R-square between the observed and predicted values are all in excess of .99 and hence not informative. When the error terms are serially correlated the interpretation of the standard R-square becomes difficult. Instead, I have reported the Buse R-square, which is a measure of the proportion of "weighted variation" in the dependent variable explained by the regression [see Buse (1973) and Judge et. al. (1985), p. 32, Eq. 2.3.16]. The standard errors are given in the parenthesis. Runs were made for all countries in the sample and for sub-samples of the LDC's and DC's (regressions 1, 2 and 3 respectively). Table 1 shows the estimated coefficients for investment and the three levels of education are all positive and highly significant in all the three runs. The sum of the coefficients is generally less than one. The coefficient of gross investment is about 1/3 and that of the sum of the educational variables is less than 2/3. Realizing that the contribution of the uneducated labor force is missing from the equation, one can conclude that the observed pattern of the estimated coefficients imply an underlying constant returns to scale Cobb Douglas production function in the sampled economies.

I tried a number of lag structure in the explanatory variables. The particular lag structure given in Table 1 produced the highest t-ratios. From this experiment I can tell that any lag structure within two years of the numbers given in Table 1, would produce similar results. Looking at the coefficients in regression 2 and 3, it appears that the effectiveness of the secondary education is higher in the LDC's while that of higher education is higher in the DC's. This is consistent with our Weberian theory and the Gintis-Bowles hypothesis. The elementary education on the other hand seems to have a

stronger effect in the DC's which is of course contrary to our expectations. And investment seems to have about the same effect in both sub-samples. However, because of the different correlation coefficients estimated in the two sub-samples, these results are not reliable. In order to test for the significance of the difference of these coefficients a new regression was designed as the following:

$$\begin{bmatrix} y_1 \\ \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 & 0 \\ x_2 & x_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \\ \beta_2 - \beta_1 \end{bmatrix} + \begin{bmatrix} u_1 \\ \\ u_2 \end{bmatrix}$$

where y and x are the vectors of the dependent and independent variables and the subscript 1 and refer to variables in the LDC's and DC's respectively. The $(x_1, x_2)'$ makes up the vector of explanatory variables used in regression 1 and the $(0, x_2)'$ vector is a new set of explanatory variables whose coefficient, i.e., $(\beta_2-\beta_1)$, indicates whether the explanatory variables in the two sub samples have differential effects on their respective dependent variables. A significant and negative value for $\beta_2-\beta_1$, for example, indicates that the explanatory variables in the first sub-sample x_1, exert an stronger influence on their respective dependent variable y_1 than the explanatory variables in the whole sample $(x_1, x_2)'$ do on their dependent variables $(y_1, y_2)'$. In Table 1, L10, L20, L30, and I0 are the L1, L2, L3 and I analogues of $(0, x_2)'$.

The results of this model are given in regression 4. The estimated coefficients, by and large confirm our findings in regressions 2 and 3. The negative coefficients for L20 and I0 indicate that the secondary education and investment are more effective in the LDC's and the positive coefficients for L10 and L30 indicate that the elementary education and higher education in the DC's are more effective than those in the LDC's. Aside from the secondary education where the difference of educational effectiveness i.e., L20 is statistically insignificant, it appears from regression 4, that education at all levels in the DC's is more effective.

Judging from the correlation matrix of the explanatory variables, the educational variables are highly correlated with each other. This correlation is particularly strong between the secondary and higher education. In the DC's these correlations are much higher and they extend to the investment levels as well. Despite the high correlations the level of significance are fairly high in Table 1. It must be realized that the figure for the elementary education L1, includes all those students that will undergo the secondary education L2, as well. Similarly the number of students that will go to higher education L3, are included in L2. In order to test for the effect of elementary education alone (people that receive elementary education but not higher), the elementary and secondary but not higher education, and the accumulative effects of all three of the educational levels the following explanatory variables were constructed. $L1N_t$ is the number of students enrolled in the first level education net of those that will peruse secondary education or $L1_{t-6}$-$L2_t$, $L2N_t$ is the number of students in the secondary education net of those that will pursue higher education levels or $L2_{t-3}$-$L3_t$. The results of these runs are given in Table 2. The explanatory variables L1N0 and L2N0 in regression 30 are the analogous of L10 and L20 in Table 1. The negative coefficients of L1N0 and LN20 indicate that the effect of the elementary and the secondary education net of higher levels of education are indeed higher in the LDC's. While the positive coefficient of L3 indicates that the effectiveness of higher education maintains to be higher in the DC's. These results are fully consistent with out Weberian hypothesis. The level of significance in these coefficients, however, is not very high. When L2N was dropped from the equation the results essentially remained the same. But when L1N and L3 were dropped out of the equation and L2N was retained the coefficient of L2N became positive and significant once more.

6. Summary

The Weberian growth model developed here illustrates the possibility of economic growth with ethic-skill human capital. This model leads to a balanced growth path in which the economy grows at a constant rate and the level of effort exertion becomes a constant. One of the implications of our Weberian model is that the growth contribution of ethical education is higher in the LDC's. To test for this hypothesis I presupposed the Bowles-Gintis hypothesis and used the elementary and secondary school enrollment rates as proxies for ethical education and the college enrollment rate as a proxy for cognitive skills in the labor force. In our regression analysis we showed that the enrollment rates - all three of them - are important variables in explaining the variations in the GDP levels. These variables explain more than 60 per cent of the variation in the GDP levels in the sample countries. We found that the growth contribution of college education is higher in the DC's while that of investment is higher in the LDC's.

These results are entirely consistent with our Weberian theory. The comparison of the figures for the effectiveness of elementary and secondary schooling in the LDC's and DC's, however, does not conclusively confirm our expectations. When the gross enrollment rates are used the effectiveness of education at all levels appears to be higher in the DC's and when the enrollment rates net of students perusing higher education is used the result is just the opposite.

Actually, it is not difficult to think of reasons why education in the LDC's is not as effective as one might expect. In teaching work ethics, the most effective method is perhaps, teaching by example. Here, the teacher himself should be the primary example of work ethics. To be effective he has to teach with passion and total conviction that honesty, hard work, differed gratification, and respect for the law and order are good virtues that ought to be held regardless of the outcome. In addition, he has to show by the way of reason and example that such virtues indeed bring prosperity, social respect and happiness. But in a society that is overwhelmed with corruption, political instability

and lawlessness none of these can be achieved easily. As the number of the people with work ethics constitute a smaller and smaller fraction of the total population the task of teaching work ethics becomes exceedingly difficult. Faced with the stone wall of the disbelief and pessimism of the adult population and the scarcity of qualified instructors for training the young, the task of ethical education is monumental. Moreover, unless there are some objective grounds for its premises to hold, there is little hope that any significant number of people would learn and practice work ethics.

In some countries the habit formation function of schooling was understood from early on. The establishment of compulsory primary education during the Meiji period in Japan, for example, was accomplished with the clear intention of the state to "train the people so that each individual person may fully understand his duty as a Japanese subject, practice ethics and become qualified to enjoy welfare."[14] But it is far from clear that every nation that has compulsory educational system is seeking similar objectives. Every nation naturally makes effort to pass on the set of ethical values that are cherished in that society. These values, however, are not necessarily in accordance with or even consistent with the principals of productive efficiency. Under these circumstances more schooling might lead to an even stronger distaste for productive activities. The educated in South Asia, for example, tends to 'regard their education as a badge that relieves them of any obligation to soil their hands.'[15] Under this light the problem of the "educated unemployment" prevalent in a number of the LDC's can be better understood.

[14] Arinori Mori Japan's first Education Minister in the new system. See Makato Aso and Ikuo Amano (1972) *Education and Japan's Modernization*. p. 20.

[15] See Gunner Myrdal (1968), *Asian Dream: An Inquiry Into the Poverty of Nations*. p. 1648.

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Table 1: Dependent variable Log real GDP (1950-88)

	(1)	(2)	(3)	(4)
Number of countries	30	17 LDC's	13 DC's	30
Constant	8.931 (.25)	11.817 (.426)	9.425 (.321)	10.252 (.261)
$\ln(L1_{t-15})$	.285 (.018)	.282 (.038)	.491 (.031)	.38 (.035)
$\ln(L2_{t-8})$	.108 (.020)	.106 (.026)	.045 (.027)	.084 (.026)
$\ln(L3_{t-3})$	.197 (.016)	.147 (.019)	.249 (.021)	.134 (.019)
$\ln(I_{t-3})$	.357 (.014)	.252 (.018)	.231 (.022)	.277 (.017)
$\ln(L10_{t-15})$	---	---	---	.124 (.049)
$\ln(L20_{t-8})$	---	---	---	-.038 (.038)
$\ln(L30_{t-3})$	---	---	---	.138 (.028)
$\ln(I0_{t-3})$	---	---	---	-.10 (.023)
Buse[16] R^2	.90	.81	.97	.94
DW	1.42	1.36	1.48	1.43
est'd residual	.88	.89	.89	.79

[16] The assumed regression model is $y_{it} = x_{it}\beta + u_{it}$, where $u_{it} = \rho_i u_{it} + \varepsilon_t$ and ε_t is a white noise. The estimated model is $y_{it}^* = x_{it}^* \beta + \varepsilon_t$, where $y_{it}^* = y_{it} - \rho_i y_{it}$, and $x_{it}^* = x_{it} - \rho_i x_{it}$. Here the correlation of determination (Buse R), the Durbin-Watson statistic, and the square root of estimated residual, all three are defined over the pooled residual of the transformed model, namely $e\hat{} = y^* - y\hat{}^*$.

Table 2: Dependent variable Log real GDP (1950-88)

	(5)	(6)	(7)	(8)
Number of Countries	30	17 LDC's	13 DC's	30
Constant	8.543 (.205)	9.451 (.246)	9.39 (.339)	7.929 (.213)
$\ln(L1N_{t-15})$	.04 (.006)	.062 (.015)	.055 (.015)	.072 (.017)
$\ln(L2N_{t-8})$	.037 (.011)	.059 (.012)	.035 (.015)	.021 (.012)
$\ln(L3N_{t-3})$	.246 (.014)	.192 (.016)	.216 (.017)	.181 (.016)
$\ln(I_{t-3})$	.480 (.015)	.418 (.018)	.427 (.017)	.527 (.016)
$\ln(L1N0_{t-15})$	---	---	---	-.035 (.019)
$\ln(L2N0_{t-8})$	---	---	---	-.035 (.029)
$\ln(L30_{t-3})$	---	---	---	.283 (.019)
$\ln(I0_{t-3})$	---	---	---	-.057 (.013)
Buse R^2	.92	.88	.87	.98
DW	1.44	1.65	1.73	1.53
est'd residual	.84	.85	.86	.71

Table 3: Dependent variable Log real GDP (1950-88)

	(9)	(10)	(11)	(12)
Number of Countries	30	17 LDC's	13 DC's	30
Constant	7.758 (.209)	9.479 (.277)	5.176 (.361)	7.661 (.199)
$\ln(L1N_{t-15})$	.066 (.074)	.044 (.016)	.011 (.008)	.062 (.019)
$\ln(L3_{t-3})$	.239 (.014)	.217 (.017)	.279 (.023)	.200 (.015)
$\ln(I_{t-3})$	.532 (.015)	.44 (.014)	.687 (.026)	.550 (.016)
$\ln(L10N_{t-15})$	---	---	---	-.031 (.021)
$\ln(L30_{t-3})$	---	---	---	.221 (.020)
$\ln(I0_{t-3})$	---	---	---	-.062 (.011)
Buse R^2	.94	.86	.94	.96
DW	1.42	1.50	1.34	1.57
est'd residual	.86	.85	.80	.75

Table 4: Definition of Variables in Tables 1-3

$L1_{it}$ is the number of students enrolled in the elementary school (in country i & year t)

$L2_{it}$ is the number of students enrolled in the secondary education

$L3_{it}$ is the number of students enrolled in collage

I_{it} is gross annual investment

$L10_{it}$ is equal to $D1_i$*$L1_{it}$, where $D1_i$=1 for DC's and 0 otherwise

$L20_{it}$ is equal to D1*L2, where $D1_i$=1 for LDC's and 0 otherwise

$L1N_{it}$ is the number of students enrolled in the elementary school net of those that will pursue secondary education or $L1_{it-6}$-$L2_{it}$,

$L2N_{it}$ is the number of students in the secondary education net of those that will pursue higher education levels or $L2_{it-3}$-$L3_{it}$.

L1N0 and L2N0 are analogous to L10 and L20.

Less Developed Countries		Developed Countries	
1	INDIA	18	JAPAN
2	PAKISTAN	19	ITALY
3	KENYA	20	FINLAND
4	EGYPT	21	WEST GERM
5	THAILAND	22	NETHERLANDS
6	PHILIPPINES	23	FRANCE
7	MOROCCO	24	NORWAY
8	KOREA	25	BELGIUM
9	BRAZIL	26	U.K.
10	PORTUGAL	27	NEW ZEALAND
11	GREECE	28	AUSTRALIA
12	TURKEY	29	CANADA
13	CHILE	30	U.S.A
14	SPAIN		
15	MEXICO		
16	ARGENTINA		
17	IRELAND		

Appendix

The Model

Consumer's problem is to maximize

$$\int_0^{\infty} [\exp -(\rho - n)t]\ U(c_t, e_t, h_t)\,dt \tag{1}$$

subject to

$$\dot{k} = F[vk, ueh] - c - nk \tag{2}$$

$$\dot{h} = G[(1-v)k, (1-u)eh] - nh \tag{3}$$

The optimal allocation of resources in this economy is achieved by choosing quantities v, u, c, e, k and h in the following current-value Hamiltonian program:

$$H(v,u,c,e,h,k,\lambda_1,\lambda_2,t) = U(c,e,h) + \lambda_1[F(vk,ueh) - c - nk] + \lambda_2[G((1-v)k,(1-u)eh) - nh]$$

The necessary conditions follow by maximizing H with respect to the control variables **x**'=(v,u,c,e), the state variables **y**'=(k,h), and the costate variables **λ**'=(λ_1,λ_2):

$$(A.i)\quad \frac{\partial H}{\partial x} = 0, \quad (A.ii)\quad \dot{\lambda} = (\rho - n)\lambda - \frac{\partial H}{\partial y} \quad \text{and} \quad (A.iii)\quad \dot{x} = \frac{\partial H}{\partial \lambda}$$

Condition (A.i) can be written as

$$\lambda_1 F_1 - \lambda_2 G_1 = 0 \tag{i.1}$$

$$\lambda_1 F_2 - \lambda_2 G_2 = 0 \tag{i.2}$$

$$U_1 - \lambda_1 = 0 \tag{i.3}$$

$$U_2 + \lambda_1 u h F_2 + \lambda_2 (1-u) h G_2 = 0 \tag{i.4}$$

Substituting for λ_1 and $\lambda_2 G_2$ in (i.4) from (i.3) and (i.2) we obtain:

$$-\frac{U_2}{U_1} = h F_2 \tag{A.4}$$

From the first order condition (3.ii), we obtain the conditions for the growth of the shadow prices of the two goods and education:

$$\dot{\lambda}_1 = \rho\lambda_1 - \lambda_1 v F_1 - \lambda_2 (1-v) G_1 \tag{ii.1}$$

$$\dot{\lambda}_2 = \rho\lambda_2 - U_3 - \lambda_1 ue F_2 - \lambda_2 (1-u) e G_2 \tag{ii.2}$$

Solve for λ_2/λ_1 in (ii.1) and substitute into (ii.1) to obtain:

$$\frac{\dot{\lambda}_1}{\lambda_1} = \rho - F_1 \tag{5}$$

Take the log and then time derivatives of (i.3) and substitute for $\dot{\lambda}_2/\lambda$ from (5) to see:

$$-\frac{U_{11}}{U_1}\dot{c} - \frac{U_{12}}{U_1}\dot{e} - \frac{U_{13}}{U_1}\dot{h} = F_1 - \rho \tag{6}$$

Now solve for λ_1 and U_1 from (i.2) and (i.3) respectively and substitute in (ii.2) to obtain:

$$\frac{\dot{\lambda}_2}{\lambda_2} = \rho - \frac{U_3}{pU_1} - eG_2 \tag{7}$$

where $p=\lambda_2/\lambda_1$. Assuming that k/eh, u and v, being constant in the balanced growth path we have:

$$\frac{\dot{k}}{k} = \frac{\dot{h}}{h} + \frac{\dot{e}}{e} \quad and \quad \dot{u} = \dot{v} = 0$$

Constancy of k/eh also implies that the shadow price of human capital in terms of final goods $p=\lambda_2/\lambda_1$ is a constant in the balanced growth path. That is:

$$\frac{\dot{\lambda}_1}{\lambda_1} = \frac{\dot{\lambda}_2}{\lambda_2}$$

It follows from (5) and (7) that:

$$\frac{U_3}{U_1} = pF_1 - F_2 e \tag{8}$$

From the ratio of (A.4) and (A.8) one can see:

$$-\frac{U_3}{U_2} = \frac{pF_1}{F_2 h} - \frac{e}{h} \tag{9}$$

Considering the following utility function

$$U(c,\ e,\ h) = W(c)V(e,h)$$

$$\text{where} \qquad W(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} \qquad \text{and} \qquad V(e,h) = \left(1 - \frac{De}{h^{\phi}}\right)^{\alpha}$$

We can solve for the optimal level of effort exertion e in terms of the parameters of the model and human capital:

$$\frac{U_3}{U_2} = -\frac{\phi e}{h}$$

$$e = \frac{pF_1}{F_2}\left(\frac{1}{1+\phi}\right) \tag{10}$$

Let's assume Cobb-Douglas production functions of $A(vk)^{\beta}(ueh)^{1-\beta}$ and $B[(1-v)k]^{\gamma}[(1-u)eh]^{1-\gamma}$ for the goods and the education sector respectively. Divide both sides of (A.3) by h, substitute $(1-v)/(1-\gamma)G_2$ eh for G and substitute for e from (A.10) then we have:

$$\frac{\dot{h}}{h} = F_1\frac{(1-u)}{(1+\phi)(1-\gamma)} - n \tag{11}$$

With constant effort exertion in the balanced growth path, the growth rates of physical and human capital are equal to g:

$$g = \frac{\dot{h}}{h} = \frac{\dot{k}}{k} = F_1\frac{(1-u)}{(1+\phi)(1-\gamma)} - n \tag{12}$$

Growth rate of consumption is also a constant given by:

$$-\frac{W''}{W'}\dot{c} - \frac{V_1}{V}\dot{e} - \frac{V_2}{V}\dot{h} = F_1 - \rho$$

$$\sigma\frac{\dot{c}}{c} - \frac{\alpha D h^{-\phi} e}{\left(1 - Deh^{-\phi}\right)}\frac{\dot{e}}{e} + \frac{\alpha De}{\left(1 - Deh^{-\phi}\right)}\frac{\dot{h}}{h} = F_1 - \rho$$

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}\left[F_1 - \frac{\alpha De}{\left(1 - Deh^{-\phi}\right)}\frac{\dot{h}}{h} - \rho\right] \tag{13}$$

Growth rate of consumption falls with human capital. As h grows the second term in the brackets falls to zero and the large growth rate of consumptions approaches a constant. Actually consumption has the same growth rate as that of capital goods. To see this take the capital accumulation constraint and divide it by k to obtain $\dot{k}$/k=vA(vk)$^{\beta-1}$(ueh)$^{1-\beta}$-c/k-n. Solving for c/k and realizing that $\dot{k}$/k=g is a constant, we obtain the following expression; c/k=vF_1/β-g-n, which is a constant also. Therefore in the balanced growth path we have:

$$g = \frac{\dot{c}}{c} = \frac{\dot{k}}{k} = \frac{\dot{h}}{h} = \frac{1}{\sigma}[F_1 - \rho] \tag{14}$$

Now let's solve for F_1 in terms of the constant level of effort exertion. In (A.12), replace F_2 by pG_2, substitute for values of F_1 and G_2, and solve for eh/k:

$$\frac{eh}{k} = \left[\frac{1-\gamma}{\beta}\left(\frac{v}{u}\right)^{1-\beta}\left(\frac{1-v}{1-u}\right)^{\gamma}(1+\phi)\bar{e}\frac{B}{A}\right]^{\frac{1}{1-\beta+\gamma}} \tag{15}$$

Solving for (1-v)/(1-u) from the efficiency condition $F_2/F_1 = G_2/G_1$ and substituting in the above equation and rearrange terms we obtain:

$$F_1 = \beta A\left(\frac{ueh}{vk}\right)^{1-\beta} = \Gamma\left[(1+\phi)\bar{e}\right]^{\varepsilon} B^{\varepsilon} A^{1-\varepsilon} \tag{16}$$

$$where \quad \Gamma = \beta\left[\frac{1-\gamma}{\beta}\left(\frac{1-\beta}{1-\gamma}\frac{\gamma}{\beta}\right)^{\gamma}\right]^{\frac{1-\beta}{1-\beta+\gamma}} \quad and \quad \varepsilon = \frac{1-\beta}{1-\beta+\gamma}$$

Where $0<\Gamma<1$ and $0<\varepsilon<1$. From (A.14) and (A.12) solve for F_1

$$F_1 = \frac{\rho - \sigma n}{1 - \frac{\sigma(1-u)}{(1+\phi)(1-\gamma)}} \tag{17}$$

From (16) and (17) solve for the optimal level of effort exertion:

$$e = \left[\frac{\rho - \sigma n}{\Gamma(1+\phi)^{\varepsilon} B^{\varepsilon} A^{1-\varepsilon}\left(1 - \frac{\sigma(1-u)}{(1+\phi)(1-\gamma)}\right)}\right]^{1/\varepsilon} \tag{18}$$