Higher Education and Non-Cognitive Skills

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VERY PRELIMINARY AND HIGHLY INCOMPLETE

Abstract

This paper proposes a new theory of higher education. Successfully completing a university level qualification requires substantial non-cognitive skills, such as self-control and patience. It is shown using a model of dynamic self-control preferences that the lower the minimum study requirement imposed by a degree programme and the longer it is, the more information about ability, self-control and patience is contained in the decision to enter university and in the grades obtained while there.

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1 Introduction

What is the purpose of higher education? While some degree programmes are clearly vocational, others seem to have little practical use. Spence (1973) famously argued that even education which did not raise productivity could be used to signal ability. Miller (2009) identifies a problem with this argument. Intelligence can be identified by IQ tests that can be administered in a matter of hours. Equally high school grades and college admissions tests or exams such as the SAT provide much information about individual ability. What exactly do several additional years of education add? Miller goes on to argue that undergraduate education is largely a form of conspicuous consumption. Total expenditure on tertiary education in the US had reached more than three percent of GDP in 2007. How much of it serves a useful purpose is therefore an important question.

In this paper I identify an additional outcome from higher education that does not seem to have been previously considered. Higher education differs from lower levels such as high school in form as well as content. It involves much less contact time, and much more independent work. This requires much greater self-discipline from students. At the same time, typical college programmes demand several years of attendance for an uncertain future reward. That is, higher education is a severe test of the non-cognitive skills of self-control and patience. Successful completion of a college degree therefore reveals significant information not only about ability but also about non-cognitive skills.

I outline a simple model where a student with dynamic self control preferences as introduced by Gul and Pesendorfer (2001, 2004) has to choose how much time to allocate toward studying. Individuals with such preferences suffer a temptation cost when in the unstructured and thus high temptation environment of a university. Thus, a programme that lowers its minimum study requirement becomes less attractive to students, even if this minimum study constraint is not binding. Further, the lower is the minimum study requirement, the more informative is college attendance about her level of self-control and about her rate of time preference.

This current work for simplicity assumes that individuals’ non-cognitive skills are fixed. Some work in psychology in contrast investigates the hypothesis that self-control can be increased with practice, for example, Muraven et al. (1999). Economic models that include this possibility include Doubrovina (2009) and Ozdenoren et al. (2012). The main hypothesis here is that higher education requires the exercise of self-control. If that exercise in fact also boosts self-control, then plausibly those successfully completing college degrees would have higher self-control than on entry. This paper has no formal results in this direction, but if this were the case it would seem only to strengthen the current results.

There are other alternative theories of education. Bowles and Gintis (2000), Bowles et al. (2001) also consider the interplay of education and non-cognitive
skills. They argue that education socialises workers, increasing non-cognitive skills that reduces the cost of effort. But the do not consider higher education or how it differs from other forms of education in terms of the autonomy it requires.

2 The Model

The basic assumption here is that there is a large population that varies in terms of cognitive and non-cognitive skills. The question is who decides to enter college and how much work effort is exerted by those who enter. I assume that students care about the grade average they obtain. The grade average depends on the whole range of cognitive and non-cognitive skills. As the grade average is one-dimensional it cannot therefore fully reveal the students’ skills which vary across domains. But it is shown that the quantity of information revealed depends on parameters of the college programme.

I assume the student has Dynamic Self Control (DSC) preferences as introduced by Gul and Pesendorfer (2001, 2004). The original specification due to Gul and Pesendorfer (2001) has the utility from choosing from a set $A$ being

$$U(A) := \max_{x \in A} u(x) + v(x) - \max_{y \in A} v(y),$$

where both $u$ and $v$ are von Neumann-Morgenstern utility functions. That is, consumption chosen is $x$, but the individual also suffers a temptation cost, equal to the difference between the value of the consumption chosen $v(x)$ and the maximum consumption possible $v(y)$.

In what follows let $u(\cdot) = \log(\cdot)$ and $v(\cdot) = \lambda \log(\cdot)$. This is similar to to Schlafmann (2013) who uses a CRRA specification. Importantly, therefore, the parameter $\lambda$ indexes the degree of the self-control problem faced, with $\lambda = 0$ implying standard preferences and increases in $\lambda$ representing less self-control.

I assume a continuum of potential students that are heterogeneous in terms of the self-control parameter $\lambda$, ability $a$ and time preference $\delta$. Specifically assume that there is there is continuous population distribution over $(a, \delta, \lambda)$ on $[\underline{a}, \bar{a}] \times [0, \bar{\lambda}] \times [0, 1]$ with density $f(a, \delta, \lambda)$.

There is free entry to university which admits all students that wish to attend. There are no tuition fees. The cost to attendance is in terms of foregone wages. The benefit is simply assumed increasing in the grades obtained from study. Thus, as we will see, individuals with higher cognitive and non-cognitive skills will self-select into university.

A degree programme is characterised by $(T, \bar{s})$, its length $T$ to graduation, and a minimum commitment of time per period $\bar{s}$. For simplicity, this is modelled as
a constraint that must be met. It represents the minimum necessary attendance to complete the programme, for example, turning up for exams and assessments. Note that at most universities this requirement is quite minimal. Thus, for most of the analysis, it is assumed that this constraint is not binding. For now, I consider the case of a single programme and go on to consider the case of multiple competing programmes later.

If a student enters college, each period that she is enrolled she has a time endowment \( H \) to divide between \( c \) leisure and \( s \) study. That is, in each period, \( c_t + s_t = H \). The grade earned at time \( g_t \) is assumed equal to \( g_t = a \log s_t \). A student’s grade point average over the \( T \) periods of the programme is therefore

\[
\bar{g} = \frac{1}{T} \sum_{t=1}^{T} g_t = \frac{a}{T} \sum_{t=1}^{T} \log s_t. \tag{2}
\]

After \( T \) periods in the programme, the student graduates and thereafter receives a per period utility equal to her grade average. That is, for simplicity, all individuals are assumed infinitely lived.

The overall utility from entering the programme is thus

\[
U(P) = \sum_{t=1}^{T} \delta^{t-1} \left( \log c_t + \lambda(\log c_t - \log(H - \bar{g})) \right) + \frac{a\delta^T}{1-\delta} \frac{1}{T} \sum_{t=1}^{T} \log s_t. \tag{3}
\]

The optimal choices whilst in the programme are

\[
c_t = \frac{H(1+\lambda)}{1+\lambda+ak'} s_t = \frac{akH}{1+\lambda+ak'}, \tag{4}
\]

where \( k = \delta^{T+1-t} / (T(1-\delta)) \) and assuming that the constraint \( s_t \geq \bar{s} \) does not bind in any period. Clearly if it does then \( s_t = \bar{s} \) and \( c_t = H - \bar{s} \). Otherwise, the amount of time devoted to studying, and hence the grade achieved, is increasing in ability \( a \), patience \( \delta \) and decreasing in lack of self-control \( \lambda \).

Students have an outside option which is to work at an unskilled job at fixed wage which gives per period utility \( \bar{u} \). So an individual will prefer to enroll in college if

\[
\frac{\bar{u}}{1-\delta} \leq \sum_{t=1}^{T} \delta^{t-1} \left( \log c_t + \lambda(\log c_t - \log(H - \bar{g})) \right) + \frac{a\delta^T}{1-\delta} \frac{1}{T} \sum_{t=1}^{T} \log s_t. \tag{5}
\]

The first result characterises how the decision to enter college segregates in terms of ability and self-control. Let \( \delta \) be held constant. Now when the incentive compatibility constraint above (5) holds with equality, it defines an implicit function \( \lambda = C(a) \) in \((a, \lambda)\) space. Note that one has

\[
C'(a) = \frac{\delta^T \sum_{t=1}^{T} \log s_t}{T(1-\delta) \sum_{t=1}^{T}(\log(H - \bar{g}) - \log c_t)} > 0.
\]
Figure 1: Illustration of the effect of an increase of the minimum study requirement.

Note further that because the righthand side of (5) is increasing in $a$, there is a unique level of ability, denoted $a^*$, that solves the condition with equality when $\lambda = 0$. It is then easy to see who enters college and who does not. See Figure 1. Those to the southeast of the line $C(a)$ will enter and those to the north and west, with higher values of $\lambda$ temptation and lower values of ability $a$ will stay out.

Second, consider the effect of an increase of the minimum study requirement $s$. Clearly, the slope of $C(a)$ given above is increasing in the minimum study parameter $s$. However, the cutoff level of ability $a^*$, because it is defined for those without a self-control problem (i.e. with $\lambda = 0$), is unchanged. Thus, an increase in $s$ rotates $C(a)$ to the left, increasing entry. In the figure, $C_A(a)$ represents the case with $s = 0$ and $C_B(a)$ with $s > 0$.

**Proposition 1.** Suppose that the minimum study amount increases so that $s_B > s_A$. Then, the number of students entering university increases. The average ability and average level of self-control amongst attending students both fall.

**Proof.** An increase in $s$ leads to the IC condition moving outwards so that while $C_A(a^*) = C_B(a^*)$ otherwise $C_B(a) > C_A(a)$. Thus, there is a strict increase in the number of students attending. The average ability achieved by those students satisfying the incentive compatibility condition is given by

$$\int_{a^*}^{\bar{a}} \int_0^{C(a)} \lambda f(a, \lambda) \, d\lambda \, da$$

where $s(a, \lambda)$ is as given in (4). Now as $C(a)$ is increasing in $s$ as shown above the average value of $\lambda$ rises. 

$\square$
We now look further into the interaction between ability and self-control. Thus, at this stage, the dynamic aspect and and the rate of time preference are not important. So let $T = 1$ and assume that $\delta$ is fixed at some level in $(0, 1)$ and is constant across individuals. Let $U(a, \lambda) = \log(H - s(a, \lambda)) + \lambda \log(H - s(a, \lambda)) - \log(H - \hat{s}) + ak \log s(a, \lambda)$ where $s(a, \lambda)$ is the optimal choice as given in (4) and $k$ as defined above is now equal to $\delta/(1 - \delta)$. That is, this is the equilibrium or indirect utility function written as a function of the two parameters $a, \lambda$.

A student’s effort from (4) will be $s = (akH)/(1 + \lambda + ak)$. So an “isoquant”, or level curve for grades, in $(a, \lambda)$ space in terms of a particular grade log $\hat{s}$ will be the same for effort $s$ as for the grade log $s$. So it is given by

$$\lambda = Q(a) = \frac{ak(H - \hat{s}) - \hat{s}}{\hat{s}}$$

which is increasing in $a$.

**Lemma 1.** For $\hat{s} = 0$ utility is decreasing on any isounquant and $C(a)$ and $Q(a)$ are single crossing, with $C'(a^*) < Q'(a^*)$.

**Proof.** In preparation.

Let us now consider what happens when the minimum study requirement increases. Let $\hat{s} > 0$ be the minimum study level such that the slope of $C$ given in (??), evaluated at $(a, \lambda) = (a^*, 0)$, equals the slope of the isounquant $Q$.

**Proposition 2.** Suppose the minimum study amount increases so that $\hat{s}_p > \hat{s}_a$. Then, if $\hat{s} \geq \hat{s}_p$, the number of students entering the programme increases. The support of the distribution of grades is unchanged but the average grade of students in the programme decreases. Given any grade level, average self-control is lower but ability is higher and information on self-control and ability decreases.

**Proof.** The derivative of the incentive compatibility boundary $C$ as given in (??) is increasing in $\hat{s}$. So an increase in $\hat{s}$ leads to the IC condition moving outwards so that while $C_p(a^*) = C_a(a^*)$ otherwise $C_p(a) > C_a(a)$. Thus, there is a strict increase in the number of students attending. But as shown in Lemma 1 for low $\hat{s}$ it is interior to the isounquant $Q$ passing through $(a, \lambda) = (a^*, 0)$. And for $\hat{s}_p < \hat{s}$, the new boundary $C_p$ will also be interior to $Q$. That is, the support of $s$ within the programme is unchanged. The average grade achieved by those students satisfying the incentive compatibility condition is given by

$$\int_{a^*}^{1} \int_{0}^{C(a)} s(a, \lambda) f(a, \lambda) \, d\lambda \, da$$

where $s(a, \lambda)$ is as given in (4). Now as $C(a)$ is increasing in $\hat{s}$ as shown above and because $s(a, \lambda)$ is clearly strictly decreasing in $\lambda$, the average grade falls.
The mean value of the self-control parameter $\lambda$ for a given value of $s$ with associated isoquant $Q$ will be

$$\mu = \int_0^\lambda \lambda f(Q^{-1}(\lambda), \lambda) \, d\lambda$$

where $\hat{\lambda}$ solves $Q^{-1}(\lambda) = C^{-1}(\lambda)$. Since $C_p(a) > C_a(a)$, we have $\hat{\lambda}_p > \hat{\lambda}_a$. Clearly, the mean value rises. Similarly, the variance is

$$\sigma^2 = \int_0^\lambda (\lambda - \mu)^2 f(Q^{-1}(\lambda), \lambda) \, d\lambda.$$  

Differentiating with respect to $\hat{\lambda}$, one has

$$(\hat{\lambda} - \mu)^2 f(Q^{-1}(\lambda), \hat{\lambda}) + \frac{d\mu}{d\lambda} \int_0^\hat{\lambda} 2(\lambda - \mu) f(Q^{-1}(\lambda), \lambda) \, d\lambda = (\hat{\lambda} - \mu)^2 f(Q^{-1}(\lambda), \hat{\lambda}) > 0.$$  

So the variance of $\lambda$ increases. The expressions for the mean ability and its variance are

$$\mu_a = \int_0^{\hat{\lambda}} Q^{-1}(\lambda) f(Q^{-1}(\lambda), \lambda) \, d\lambda; \quad \sigma^2_a = \int_0^{\hat{\lambda}} (Q^{-1}(\lambda) - \mu_a)^2 f(Q^{-1}(\lambda), \lambda) \, d\lambda.$$  

Both can be shown to be increasing in a similar manner as for $\lambda$.

References


