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Stay in school or start working? — The human capital investment decision under uncertainty and irreversibility☆

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ABSTRACT

At any moment a student may decide to leave school and enter the labor market, or to stay in the education system. The timing of their departure determines their level of academic achievement and formal qualification. Education is a multi-stage process of investing in an accumulative human capital stock. How long can I expect to go to school? How much will I invest in my education? To answer these questions we apply the real option approach. We depart from recent literature by (1) adding accumulated education costs and determining the expected time of market entry, (2) considering complete earnings profiles including entry-level wages, sheepskin effects and earning dynamics, and (3) discussing the option value of schooling while introducing potential career opportunities or threats of unemployment modeled as major uncertain events connected with particular formal education achievements.

1. Introduction

Education is obtained during a long process of personal maturation and the accumulation of knowledge and abilities. Hence, formal schooling is a learning and investment process that often lasts into one's mid-twenties. When a young person makes plans for the future one of the biggest problems is uncertainty.[1] The success of a long education is as uncertain as the process of earning income during a long working life. As time goes on, students repeatedly consider whether to continue their education or enter the labor market. During this sequential process of decision making each moment's conditions determine the eventual attainment level.

Recent literature shows that real option theory can be applied to take into account uncertain time processes and irreversibility in schooling and human capital accumulation decisions. While Weisbrod (1962) and more formally Comay et al. (1973) suggested this way of thinking more than 30 years ago, a transfer of formal option theory – as established by Dixit and Pindyck (1994) – was suggested only recently. Hogan and Walker (2007) apply real option theory to human capital decisions. In their model, at any time a student has the option to leave school to work for wages that reflect the years spent in school. The decision to leave school is irreversible, so once the student has finished education they cannot return. They conclude that high returns on education and increasing risk will cause students to stay in school longer. They also analyze how progressive taxation and education subsidies affect schooling decisions and show that progressive taxes tend to reduce educational attainment. Jacobs (2007) uses the real option approach as well. However, unlike Hogan and Walker (2007) he uses a discrete time approach and states that the decision to start learning is irreversible. The option value stems from the fact that an individual could wait to enroll and would only do so once the returns are sufficiently large to compensate for the lost option value. The sunk cost of the investment consists of tuition costs and foregone labor earnings.

More recent empirical literature on human capital investments suggests that the functional form of the Mincer model no longer adequately

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[1] The first analysis of investment in human capital under uncertainty was conducted by Levhari and Weiss (1974). Later, e.g. Eaton and Rosen (1980) extended this framework. Williams (1978) examined risky investments in education using a two-period, mean-variance portfolio model. Groot and Oosterbreek (1992) discussed the effects of uncertain future earnings and the probability of unemployment on the duration of schooling, considering several sources of risk, and Hanchane et al. (2006) developed a continuous time dynamic programming model which accounts for several sources of uncertainty with regard to earnings and labor market conditions. They showed that the global effect of uncertainty is negative, except when a sufficiently high risk premium exists.

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describes labor earnings for U.S. workers.[2] Heckman et al. (2003, 2006) test and reject the assumptions for using the Mincer model to estimate the internal rate of return. Heckman et al. (2008) emphasize that estimates should account for non-linearity and non-separabilities in earnings functions, income taxes, and tuition. In line with these findings is the idea of introducing risk and other non-pecuniary elements into the empirical model.[3] In addition, Heckman et al. (2006) explain why option values should be included in the decision, and show how option values invalidate the internal rate of return as an investment choice criterion. “Our analysis points to a need for more empirical studies that incorporate the sequential nature of individual schooling decisions and uncertainty about education costs and future earnings to help determine their importance. We report evidence on estimated option values from the recent empirical literature using rich panel data sources that enable analysts to answer questions that could not be answered with the cross section data available to Mincer in the 1960s.” (Heckman et al. (2006) p. 6). However, all these findings encourage a closer look at the impact of real option theory on human capital investment decision under uncertainty and generate a more comprehensive theoretical framework.

Departing from the model suggested by Hogan and Walker (2007) we discuss how uncertain time processes determine the duration of schooling and – with the timing decision to leave school – the accumulation of human capital. We extend their framework by 1) adding accumulated education costs during schooling, 2) considering complete earnings profiles including entry level wage, sheepskin effects and earning dynamics, and 3) discussing the option value of schooling introducing potential career opportunities or threats of unemployment modeled as major uncertain events connected with particular education achievements.

In order to discuss these problems we proceed as follows. In Section 2 we introduce the real option base model to determine the expected time of leaving school for a continuous process of schooling. In Section 3 we solve the base model, and discuss comparative statics. In Section 4 we extend the model by introducing different levels of formal qualification and discuss the implications for option values with respect to sheepskin effects and major random events connected with particular formal education achievements. In Section 5 we conclude.

2. Basic model

The level of education a student attains is a result of a dynamic sequential decision process. Even if an immediate labor market entry may have some benefits, it is possible that staying in school is the better option. To model this uncertain investment and timing decision problem, Hogan and Walker (2007) suggest the real option approach in terms of a dynamic programming model from which we depart. In our model the sequential timing decision has three elements: 1) accumulated investment costs of schooling, 2) the earning profiles, starting with the entry-level wage when working life begins and developing as a dynamic income stream, 3) the value of postponing the working life through longer education to potentially achieve a better income track, or of not to tie oneself to a specific uncertain earnings stream. In Section 4 we discuss that the option value of education can account for sheepskin effects, potential large opportunities or threats, and remaining flexible. However, as this decision is repeated, we look at a multi-stage sequence of decisions that add up to the entire duration of schooling and the eventual level of academic achievement.

2.1. Investment costs of schooling

In this model the individual costs of a successfully completed year of schooling are defined by C and, from today's perspective ($t=0$), accumulate each year until the end of the student's education.[4] The total investment expenditure $I(T)$ is dynamic and increases with each year of schooling. Hence, at time T, the end of formal education, the current value of total schooling costs[5] is

$$I(T) = \int_0^T Ce^{r(T-t)}dt + \bar{C}, \tag{1}$$

where r is the risk-free interest rate and $\bar{C}$ are the given costs of successfully graduating, finding adequate employment and entering the market.

2.2. Earnings profile

Education not only generates costs, but also provides access to different earnings profiles. On the one hand, schooling generates a differential in the entry-level wage when entering the labor market; on the other, it may lead to a change in the dynamics and risk of the income stream during working life.

2.2.1. Entry-level wage

The initial level of the income path, namely the entry-level wage, is the first element of the earning profile. As it is linked to educational achievement, an additional (successful) year of schooling leads to a higher entry-level wage and therefore to an increased level of the earnings stream.[6] However, many random elements determine the wage when entering the labor market. Hence, we describe the development of entry-level wages during formal education as a Brownian motion

$$d\tilde{Y} = \delta\tilde{Y}dt + \tilde{\sigma}\tilde{Y}dW \quad \text{for} \quad 0<t<T. \tag{2}$$

where $\tilde{\sigma} > 0$ and dW denote a constant volatility and the increments of a standard Wiener process, respectively. $\delta>0$ is the expected marginal differential in income level with respect to marginal schooling time and educational improvement (expected rate of market reward). This change in the level of the income path is part of the total income reward generated by the schooling process.

2.2.2. Dynamics and value of the income stream

The second element of the earnings profile is the dynamic development of the lifetime earnings stream. Because stylized facts indicate that it is linked to educational attainment, we use a random process with a trend and random elements. In general, individual income dynamics are driven by a stochastic earning process described by the geometric Brownian motion

$$dY = \alpha Ydt + \sigma YdW \quad \text{for} \quad T<t, \tag{3}$$

with dW denoting the increments of a standard Wiener process. Upon entering the market ($t>T$) the student faces a stochastic revenue stream which is characterized by an expected average growth rate $\alpha>0$ and elements of uncertainty depicted by a constant volatility $\sigma>0$. To simplify the model we assume α to be constant, whereas

[2] This development starts e.g. with Katz and Autor (1999).

[3] See e.g. Cunha et al. (2005), Carneiro et al. (2003), Belzil and Leonardi (2007a,b) or Hartog et al. (2007).

[4] Recent empirical studies suggest that education costs are an important ingredient of the education decision (see e.g. Heckman et al. (2008)). By including the annual accumulative cost of schooling we depart from Hogan and Walker (2007), who do not consider education costs.

[5] Education costs per period C could include accounting for in school utility. Hence C represent “general costs” per period so that the willingness to pay for the “utility of schooling” could be subtracted and the costs could be regarded as net costs including utility benefits.

[6] Wang and Bai (2003) examine how variations in uncertainty in labor productivity affect specific human capital investment and wage. They find a positive correlation between wage and specific human capital.