# How Much Does Schooling Disutility Matter?*

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**Abstract**

Studies on structural education choice models are often inconsistent in choosing whether and how to include disutility of education, especially in an environment with risk and wealth inequality. We show that adding a disutility term to the education decision, a human capital investment option, is equivalent to assuming a relationship between wealth, risk, and education. Utility gain from education is increasing in the riskiness of future consumption. A riskier environment further propels an agent to choose the human capital investment option that maximizes future income. If the degree of risk increases heterogeneously across multiple human capital investment options, risk aversion and the precautionary savings motive can compound or negate each other depending which option has a greater increase in risk.

*JEL classification*: D11, I2, J24.

*Keywords*: structural estimation, human capital theory, disutility of schooling, education choices, precautionary saving

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# 1 Introduction

Many structural models include a utility cost when an agent attends school, largely for the purpose of matching observed patterns in education choices.[1] The theoretical implications and consequent implicit structural limitations imposed by introducing a disutility of education term to agents' decision problems, are largely unknown, especially in a framework with uncertainty and inequality.[2] We aim to fill this gap by creating a simple two-period decision model to investigate how the disutility term links wealth, risk, and education choices.[3]

The primary message of this paper is that including disutility of education in a dynamic model breaks the direct association between financial return and utility return to education, allowing risk and precautionary saving motive to impact education choice. Education serves as a saving/insurance device that transfers current wealth into human capital for future earnings. A heightened future consumption risk further increases the expected consumption *utility* in addition to any increase in lifetime income. If going to school yields a greater financial return than other saving vehicles, an increase in consumption risk implies an increase in the utility return to education *if a disutility term is present*. The agent is more likely to go to school. Without a disutility term, this increase in the utility return of education does not matter because the agent will just choose whichever education option maximizes her lifetime budget constraint.

We investigate two forces affecting education decisions in an environment of uncertainty: risk aversion reduces the appeal of the option with higher relative risk, while a rise in precautionary saving increases the importance of a higher financial return. If, for example, the variance of consumption is higher after schooling instead of working in the first period, schooling will be less attractive than if it had the same risk as working. However, if both schooling and working experience an increase in risk, but to different degrees, agents will increase their precautionary saving differently for the different options. Focusing on the case where schooling has a positive financial return, if working becomes riskier relative to schooling then both forces compound and the utility return to education increases further. If the relative risk of schooling increases, but only moderately, the precautionary saving motive

[1] See for example Macdonald (1981), Card (1994), Card (2001), Johnson (2013), Hai and Heckman (2017), Cai and Heathcote (2018), Guo (2018), and Abbott et al. (2019). Cunha et al. (2006) demonstrate that the higher the human capital, the easier it is to gain more via education. They also show that human capital investment is time sensitive. Learning in school may become more difficult after passing a certain age. These effects can thought of as "disutility" of schooling.

[2] To the best of our knowledge, Belley and Lochner (2007) is the only paper that examines the relationship between disutility, wealth and education, and they do so in a risk-free environment.

[3] For the purposes of this paper we are agnostic as to whether students actually experience this disutility. Our primary motivation is to highlight the consequences of including or excluding it.

dominates the effects of risk aversion and attending school still becomes more appealing despite the increase in relative risk. Even if the increase in risk after schooling is sufficiently large so that the risk aversion factor is dominant, its influence will be partially counteracted by the precautionary saving motive.

Our results build on Belley and Lochner (2007), who show that concave consumption utility implies that the utility returns to education decrease in wealth. The absolute difference between consumption with and without education is constant, but the proportional difference in consumption is smaller with higher base wealth. Consequently, holding human capital constant, a wealthier individual who faces disutility of education will be less inclined to go to school than one currently holding no assets because of the smaller increase in utility. Similarly, if education provides positive utility then a wealthy agent will be more likely to attend school than one with no initial endowment if doing so provides a negative financial return.

The above results demonstrate that adding a disutility term in a structural education model embeds these connections between wealth, risk, and education into any counterfactual simulations. Causal inference requires an identification of which results are assumed and which come from the data. The literature is often less than totally cautious in considering the inclusion and estimation of the disutility term. If disutility exists in the data, omitting the disutility term in a model may underestimate the impact of wealth and risk on education choices.[4] Similarly, projects which include a disutility term but who do not discipline the term with wealth and risk related data create an inconsistency between the assumptions used to estimate the disutility term and the implicit assumptions in the model used to analyze its implications.

In addition to their methodological significance, the above connections from risk and wealth to human capital investment through disutility provide an alternative explanation for intermittent schooling choices documented by the recent empirical literature (e.g. Light, 1995*a*,*b*; Monks, 1997; Dynarski, 1999; Seftor and Turner, 2002; Jepsen and Montgomery, 2012; Johnson, 2013; Arcidiacono et al., 2016; Yang, 2017). Changing wealth/human capital conditions, relative disutility of schooling, and relative risk between work and education can induce agents to enter or exit school. Our results can also be extended to a variety of choices. For example, in college major choices, a larger financial return is required to induce an agent to choose a major with higher risk or larger disutility. This adds a new angle to the literature on the Roy Model of college major choice by suggesting sorting based on differential risks

[4]This is not to say that all models should include education disutility. Including a disutility term when none exists would also create problems. Our point is that the decision of whether to include disutility in a model should be taken with care.

and disutilities across choices and agents as well as financial return.

## 1.1 Related Literature

We investigate the impact of risk aversion and precautionary savings motives on human capital investment choices. Belley and Lochner (2007) has the most relevance to our work. They provide a first order investigation detailing the direct impact that the financial return of educaiton choice needs to overcome its utility loss. In addition to our different focus in risk aversion and precautionary savings, we relax a number of simplifying assumptions from Belley and Lochner (2007) (e.g. assuming that the product of the discount rate and one plus the interest rate is 1) which allows us to explore the comparative statics of the model in richer detail. They impose these assumptions because their main focus is on the impact of credit constraints, while we are interested in exploring the relationship between disutility of schooling and schooling decisions. Most importantly, Belley and Lochner's model does not include risk, and we show that the variance of future consumption has a significant impact on education decisions if a disutility term is present.

Levhari and Weiss (1974) and Bilkic, Gries and Pilichowski (2012) examine the relationship between risk and education choices, but without differentiating the utility cost from the other costs. Our results demonstrate that disutility of schooling connects wealth and precautionary saving motives to education choices, providing some guidance for the construction of structural models embedding the disutility term.

Recent empirical studies explain varying educational choices using heterogeneous risk aversion and risk levels for individuals with different demographic backgrounds (Brodaty, Gary-Bobo and Prieto, 2014; Schweri, Hartog and Wolter, 2011; Jung, 2015; Hartog and Diaz-Serrano, 2015; Belzil and Leonardi, 2007; Mazza and Ophem, 2018; Mazza, van Ophem and Hartog, 2013; Heckman and Montalto, 2018; Chen, 2008). We show that, when a disutility term is present, heterogeneity in wealth alone can create a difference in education choices. Studies estimating risk aversion and education choices may be vulnerable to omitted variable bias if they specify the utility function without a disutility term.

Additionally, almost all of this previous work has focused on the implications of risk aversion for education decisions without considering the implications of the third derivative of the utility function. Our discussion of Leland's (1978) precautionary saving motive is new, and allows us to make more specific predictions for the interaction between risk and education choices than theoretical models which consider risk aversion alone.

## 2 Model

We create an individual decision model rather than a general equilibrium model in order to focus on the implications of schooling disutility for education decisions. The decision maker is an agent with a two period lifetime. She is endowed with a certain amount of human capital ($h_1$) and initial wealth ($s_1$). At the start of the model ($t = 1$), she decides whether to work or to attend school in addition to optimally choosing consumption ($c_1$) and savings ($s_2$) facing consumption price 1 and interest rate $r$. We normalize the effective wage to 1 as a change in wage does not qualitatively affect our results. If she works then she receives income according to the efficiency units of labor she supplies (i.e. $h_1$, as wage is normalized to 1). Their human capital remains constant across periods ($h_1 = h_2$). If she chooses to attend school then she must pay tuition $\kappa$, and allocate the rest of consumption and saving/borrowing from endowment $s_1$ and second period income $h_2$. Second period human capital after schooling increases according to $h_2 = g(h_1)$, where $g(h_1)$ is a continuous, increasing, and concave function following Cunha and Heckman (2007). To represent uncertainty about the future, the agent faces an exogenous shock $\epsilon$ to consumption realized only in the second period.[5] Because of the two period lifespan, the agent will always work in the second period, receiving income $h_2$ in addition to (potentially negative) savings from period one $(1 + r)s_2$. Following Johnson (2013), we introduce disutility of schooling $d > 0$ to the utility function if the agent chooses school.[6][7] The agent's problem is to maximize lifetime utility considering the increasing, concave, and twice continuously differentiable consumption utility function $u(c)$ and discount rate $\beta$.

$$
\begin{aligned}
&\max u(c_1) + \beta E_\epsilon u(c_2 + \epsilon) - \mathcal{I}(\text{Attend School})d \\
&\text{s.t.} \\
&(1 + r)c_1 + c_2 \leq (1 + r)B_1 + B_2 \\
&c_1, c_2 \geq 0
\end{aligned}
$$

[5]We do not include bankruptcy in this model, so this article contains an implicit assumption that the range of epsilon is small enough relative to $s_1$ and $h_1$ that bankruptcy is not a concern.

[6]Disutility is constant here, whereas it is generally assumed to be a decreasing function of human capital in the empirical literature. Imposing such a relationship would not significantly change our results. See Cunha et al. (2006) for a comprehensive account of the labor literature on lifecycle human capital production. Similarly, wealth can change in-school consumption, but there is no intuitive reason why it should directly impact disutility of schooling. If we were to allow disutility to vary with human capital, then we would expect disutility to be negatively correlated with wealth via a positive correlation between initial human capital and wealth.

[7]Our results carry through in sensible ways if we allow $d < 0$, but this detail does not add much insight and so we make this restriction to simplify the statement of the propositions.

where

$$B_1 = \begin{cases} s_1 - \kappa & \text{if school} \\ s_1 + h_1 & \text{if work} \end{cases}$$

and

$$B_2 = \begin{cases} g(h_1) & \text{if school} \\ h_1 & \text{if work} \end{cases}$$

$\mathcal{I}$(Attend School) is an indicator function representing the education decision. $B_1$ and $B_2$ are the net income in the first and second period respectively. Together they determine the agent's lifetime budget constraint. We assume that an agent who is indifferent will choose to attend school rather than working. Because $u(\cdot)$ is increasing, it is trivial to show that the budget constraint will hold with equality.

## 2.1 Belley and Lochner (2007) in our framework

Our results build on Belley and Lochner (2007), so it is necessary for the reader to understand some of their findings in order for us to explain ours.[8] As the authors of that paper demonstrate, a minimal necessary constraint for the agent to choose to attend school is that the *financial return* to education is positive. That is, that the lifetime budget constraint $(1 + r)B_1 + B_2$ is larger with education in the first period rather than working, which in turn means that total consumption is greater with education. Taken as an inequality this is equivalent to stating that

$$g(h_1) - (2 + r)h_1 \geq (1 + r)\kappa \tag{1}$$

The left side of Equation 1 describes the marginal gain of in lifetime income from schooling net the opportunity cost of lost wages and interest earnings, and the right side describes the direct tuition cost. When Equation (1) is satisfied then the financial return to education is positive.

As $g(h_1)$ is concave, the left hand side is increasing for small $h_1$ before eventually reaching a maximum and decreasing. This relationship is illustrated in Figure 1. For $h_1 < \underline{h}_1$, the agent is not giving up much in the way of wages in order to attend school, but returns to schooling are also small so attending school is not worthwhile relative to the tuition and opportunity cost. For $h_1 > \bar{h}_1$, the returns are large, but the forgone wages are also large, so the agent prefers to work. The agent will seek education if and only if $h_1 \in [\underline{h}_1, \bar{h}_1]$. This comparison of the financial returns to the cost of education is shown visually in Figure 1.

[8] As this section is a primer on results from another paper, we skip a number of intermediate derivation steps. See Belley and Lochner (2007) for more detail.

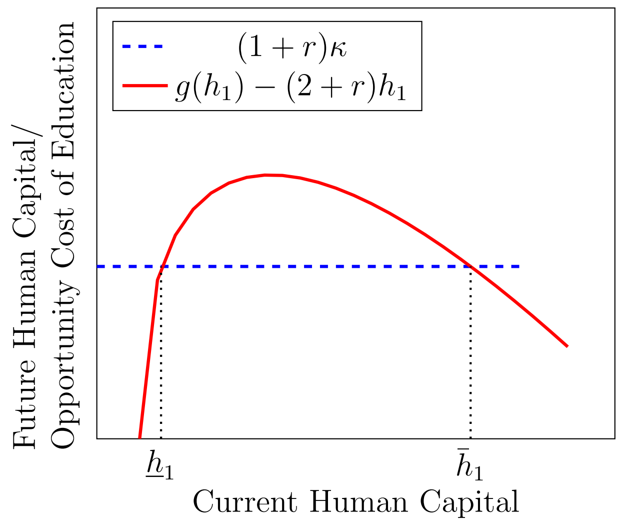



Figure 1: The return to education compared to the opportunity cost.

A positive financial return from education is necessary but not sufficient for the agent to choose education given the disutility term $d$. Let $c_t^e$ represent period $t$ consumption if the agent chooses to attend school and $c_t^w$ consumption if the agent works in the first period. These consumption choices will be determined by the an Euler equation coming from the first order condition of the maximization problem and the budget constraint given education. The agent will choose to attend school if the utility from doing so is greater than the utility from working. This results in the following condition

$$d \leq [u(c_1^e) - u(c_1^w)] + \beta \left[E_\epsilon u(c_2^e + \epsilon) - E_\epsilon u(c_2^w + \epsilon)\right] \tag{2}$$

The right hand side of Equation (2) represents the change in consumption utility from choosing to attend school (i.e. the *utility return* to education). The agent will go to school if and only if this return is greater than the disutility $d$ of attending school. If Equation (1) is not satisfied, then this difference is negative and the individual will not attend school. However, if Equation (1) is satisfied, but close to equality, then the difference can be positive but not sufficient to satisfy Equation (2); the increase in consumption utility in this case is not sufficient to compensate for the distutility of schooling. The net utility return to education is negative even though the financial return is positive.

The important detail is that while initial wealth $s$ does not appear in Equation (1), the binding budget constraint combined with concavity of the utility function means that the right hand side of Equation (2) is decreasing in $s$ when Equation (1) is satisfied. As shown in Figure 2, this means that the range of human capital where the agent chooses education in the first period is narrowing in $s$. The interaction between this narrowing interval and riskiness of the environment is the main focus of our paper.

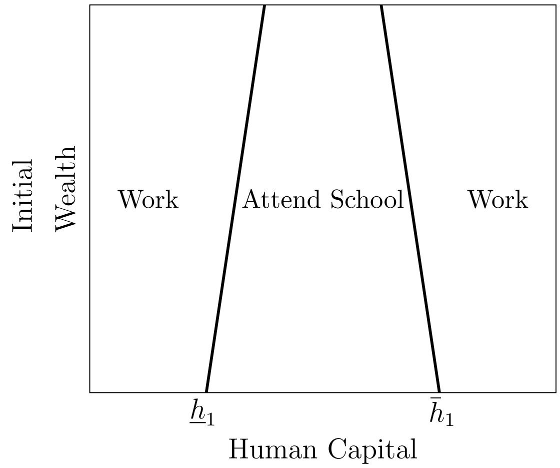



Figure 2: Education decisions as a function of initial wealth and human capital in the model with disutility of education

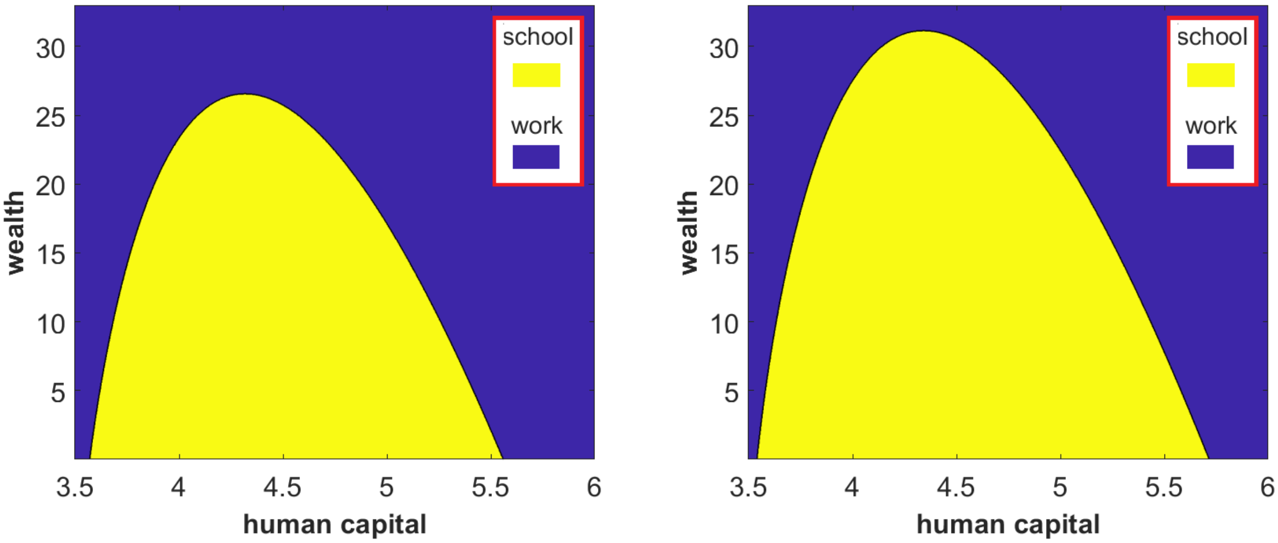
# 3 Risk aversion, precautionary saving and education

Given each education choice, consumption/saving decisions will be the solution to an Euler equation derived from the first order conditions of the utility maximization problem. Consider the agent's Euler equation for saving if she chooses to attend school:

$$u'(s_1 - s_2 - \kappa) = \beta(1+r)E_\epsilon u'((1+r)s_2 + g(h_1) + \epsilon)$$

Since $u(\cdot)$ is concave, saving must decrease as $g(h_1)$ increases. This is because human capital acts as a substitute for monetary saving via higher future income. In an empirical setting, this could mean that what appears to be borrowing behavior (spending money in order to attend school) is in fact driven by a desire to save. Additionally, if marginal utility is convex (meaning that the agent engages in precautionary saving), and there is disutility of schooling, then it is possible for an increase in risk (via increased variance of $\epsilon$) to increase the likelihood an agent goes to school. The increased risk will increase the agent's desire to save, which can be done most effectively via education if Equation (1) holds. However, the change in utility return only matters to the education decision if there is a wedge between the parameter sets where the financial return to education is positive and the sets where the utility return is positive (i.e. when $d \neq 0$).

**Proposition 1.** *If schooling increases wealth and there is a precautionary saving motive, then the utility returns to education are increasing in the riskiness of the environment. Mathe-*




Low Risk High Risk

Figure 3: Schooling decisions under risk. $\epsilon$ has lower variance in the graph on the left. Parameter values: $\gamma = 6$ $d = 0.01$ $\kappa = 0.5$ $r = 0.04$ $\beta = 0.98$ $\theta = 3$ $\alpha = 0.9$ $\epsilon_{\text{high risk}} = [-2.5, 2.5]$ $\epsilon_{\text{low risk}} = [-2.2, 2.2]$ utility function: $c^{(1-\gamma)}/(1-\gamma)$ human capital production: $g(h_1) = (\theta * h_1)^{\alpha}$

*matically, if* $u'''(\cdot) > 0$*, and Equation* (1) *is satisfied, then applying a mean preserving spread to* $\epsilon$ *increases the right hand side of Equation* (2)*.*

Figure 3 shows the results of a numerical example demonstrating this effect in an environment with a CRRA utility function and risk aversion parameter $\gamma$.[9] The brightly colored region represents parameter ranges where an agent would choose to attend school, and the darker region parameters where she would work in both periods. We see the narrowing pattern in wealth from Figure 2 in both images, but the schooling region is larger in the image on the right where the variance of $\epsilon$ is higher. If the agent is working in a field where a structural change implies both an increased risk of being fired and the potential for high future earnings (as happened for IT workers in the late 90s) then our results imply that a model simulating this increase in volatility will predict that she responds by investing in her human capital to insure against the downside risk.

If we were to consider positive utility of schooling, then the relevant implication of proposition 1 is that the right hand side of Equation (2) agent is decreases after an increase in variance when Equation (1) is not satisfied. That is, if schooling provides a net loss to lifetime budget, but the agent might want to go to school anyway because of positive utility

[9]Because we do not model bankruptcy, the parameter ranges in the numerical example have been chosen so that there is no risk of negative 2nd period consumption.

from education, this becomes less likely if the environment is riskier.

## 3.1 Heterogeneous risk across choices

One of the simplifying assumptions that we have been making throughout this paper is that the risk profile does not depend on the education choice. There are many reasons why risk might vary depending on the human capital investment decision. Krueger and Perri (2006) and Heathcote, Storesletten and Violante (2010) document varying volatility of earnings across different skill types over time. Alternatively Huggett, Ventura and Yaron (2011) and a series of lifecycle structural papers following it introduce multiplicative second period risks, which mechanically means that variance will be higher for whichever human capital investment option has a larger lifetime budget constraint.

Given that the agent has risk averse preferences, it follows immediately that total utility for an option is decreasing in the level of risk associated with that option (as measured by the mean preserving spread definition of Rothschild and Stiglitz (1970)). Therefore if the risk associated with the schooling option is lower than the risk after working then this will make education more appealing relative to working for any parameter set.

**Remark.** *Proposition 1 does not apply when the riskiness of only one option has increased. In that scenario the agent is only saving more of her income if she chooses the option with the increased risk. The utility from consumption in the other option is unchanged. The intuition behind the proposition (that the financial return to education becomes more important as the riskiness of the environment increases) only applies if the agent is saving more of her income no matter her educational choice.*

While the implications of increasing the riskiness of one option are straightforward, the precautionary saving results from Proposition 1 can still apply when the riskiness of both options increases, but by differing amounts (as can happen when risk is multiplicative). Concave utility implies that the option which has the relative increase in risk loses appeal, while the increase in precautionary saving across both options implies that the financial returns to education (if they are positive) become more important. If Equation (1) is satisfied and working becomes riskier compared to schooling, then the precautionary saving motive and risk aversion will compound and the effect from proposition 1 will be stronger than if the increase in risk is symmetric. More interestingly, if the riskiness of schooling increases more than the risk of working, but the difference is not too large, then the precautionary saving result will dominate and the appeal of school will still increase. To formalize this define $\epsilon^i \stackrel{d}{=} \epsilon + \sigma^i * z$ where $z$ is a random variable with mean 0, $i \in \{e, w\}$ and $\sigma^i > 0 \ \forall \ i$.

$\epsilon^i$ is the mean preserving spread applying to choice $i$, with $\sigma^i$ representing the magnitude of the increase in variance.

**Proposition 2.** *If the risk of both options increases, and the risk of schooling does not increase by too much more than working, then the precautionary savings result still applies: If $u'''(\cdot) > 0$ and Equation* (1) *is satisfied, then for any given $\sigma^w$ there exists a cutoff $\delta^* > 0$ such that applying the mean preserving spreads $\epsilon^w$ and $\epsilon^e$ to working and schooling respectively increases the right hand side of Equation* (2) *if and only if $\sigma^e - \sigma^w < \delta^*$*

Proposition 2 implies that the precautionary saving results apply quite broadly. Even if the increase in risk given education is sufficiently large that the relative appeal decreases, this decrease will still be mitigated by the precautionary saving motive.

# 4 Discussion

In this section, we discuss the implications of our results in relevant literature studying the relationship between human capital investment and lifecycle inequality, the decision of entry and leaving a school, and decisions among multiple choices.

Any study which includes a disutility term should keep the implicit assumptions that follow from doing so in mind when interpreting their results. If, for example, a researcher using this setting were to find an increase in school attendance after simulating the effects of policy which increases uncertainty about the future, then that result does not necessarily serve as empirical evidence for a positive relationship between risk and schooling decisions. As we show, it is likely a result of the structure of the model rather than an effect that is coming from the data.

Alternatively, studies investigating the relationship between wealth and income should consider the impact of not including a disutility term for skill acquisition when it might be present (e.g. Lee and Seshadri, 2019; Krebs, Kuhn and Wright, 2015; Huggett, Ventura and Yaron, 2011). All of our main results rely on the disutility term driving a wedge between financial and utility returns. Dropping it assumes away this channel, which could (for example) lead to an underestimation of the magnitude of the impact of family wealth on education decisions.

Similarly, researchers should maintain consistent assumptions between their estimation or calibration techniques and counterfactual analysis related to the disutility term. To estimate the disutility term, Johnson (2013), Hai and Heckman (2017), and Abbott et al. (2019) use demographic information, parental education, ability measure, and school choice; Guo (2018) uses time trend in consumption value of schooling; Blundell et al. (2016) use family background and parental liquidity shock for young age individuals, a set that is most relevant to wealth condition. Our results suggest if estimated disutility term does not account for the relationship between wealth and education decisions, counterfactual analysis could show an incomplete effect of initial wealth.

Most studies explain delayed college entry using financial costs by arguing that students are either at a borrowing limit or that they expect to be at one if they enroll in college (e.g. Johnson, 2013). Previous investigations into college dropout/stopout/re-entry explain these phenomena via time varying tuition related cost, uncertainty in college premium, and agents' ex ante uncertainty about their ability to complete college (Donovan and Herrington, 2019; Hendricks and Leukhina, 2018; Yang, 2017; Lee, Lee and Shin, 2014). In our model, the utility wedge created by disutility of schooling can vary across time as parameters of the decision problem change. For example, a student who has previously exited college might wish to re-enroll if her expectations about future risk increase or if she experiences a sudden drop in wealth. These factors also predict when a change in attitude (i.e. a change in disutility) will affect re-enrollment/dropout decisions.

There is a significant body of evidence showing that students consider expected returns when choosing their major (Montmarquette, Cannings and Mahseredjian, 2002). The Roy Model predicts that for any given skill distribution and relative price of the skills in the labor market, individuals self-select into majors where they have a comparative advantage based on their expected wages (e.g. Altonji, Blom and Meghir, 2012; Kirkeboen, Leuven and Mogstad, 2016). Recently, Fricke, Grogger and Steinmayr (2018), Saks and Shore (2005), and Cubas and Silos (2017) provide empirical evidence that college major and job selection depend on varying levels of disutility and risk associated with each choices. Extending Section 3.1 to college majors provides theoretical support for these findings. Choices with a higher career risk path may generate lower expected consumption utility, but from Proposition 2 consumption utility is less of a factor in the decision making of wealthier individuals, meaning that they are more likely to focus on career preferences (i.e. the utility/disutility of each major) when making education decisions. Different risks associated with each career path drive a second moment precautionary savings motive sorting that is worth further empirical investigation.

# 5 Conclusion

We present a two-period model where a decision maker decides between schooling and working in the first period in addition to optimizing her consumption/saving choices across periods. The utility return is decreasing in wealth and when there is a precautionary saving motive it is increasing in the variance of future consumption, meaning that introducing a disutility term makes education choices much more sensitive to the parameters of the model. When the increase in risk is heterogeneous across options, then risk aversion and the precautionary savings motive can compound or counteract each other, depending on which option has a higher increase in relative risk.

These results imply that adding a disutility term in structural estimation is equivalent to assuming a specific relationship between wealth, risk, and education decisions in counterfactual simulations. Therefore researchers investigating educational choices should carefully consider the implications of including or excluding this distutilty term when interpreting their results.

We can apply our model to explain a number of behaviors seen in recent empirical papers, including a relationship between wealth and education decisions as well as spells of working in between periods of school enrollment. We also add to the traditional Roy Model by suggesting that students may sort based on differential risk and disutilities across choices as well as financial return.

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# A Proofs

## Proof of Proposition 1

Define

$$B^e = (1+r)(s_1 - \kappa) + g(h_1) \tag{3}$$

$$B^w = (1+r)(s_1 + h_1) + h_1 \tag{4}$$

These are the budget sets for an agent who chooses education and one who chooses to work in the first period. Define the value function

$$
\begin{gathered}
V(B) = max_{c_1,c_2} u(c_1) + \beta E_\epsilon u(c_2 + \epsilon) \\
\text{s.t.} \\
(1+r)c_1 + c_2 \leq B \\
c_1, c_2 \geq 0
\end{gathered} \tag{5}
$$

Taking the derivative with regard to the budget constraint

$$
V'(B) = \left( u'(c_1)\frac{\partial c_1}{\partial B} + \beta E_\epsilon u'(c_2 + \epsilon)\frac{\partial c_2}{\partial B} \right) \tag{6}
$$

The inter-temporal consumption allocation will be determined by the Euler equation

$$
u'(c_1) = \beta(1+r)E_\epsilon u'(c_2 + \epsilon)
$$

Which means that $V'(B)$ can be simplified to

$$
V'(B) = u'(c_1)\left( \frac{\partial c_1}{\partial B} + \frac{1}{1+r}\frac{\partial c_2}{\partial B} \right) \tag{7}
$$

But since the budget constraint must always hold with equality, we can take the derivative of both sides of the budget constraint in the definition of the agent's problem with regard to $s$ to show that $(1+r)\frac{\partial c_1^e}{\partial B} + \frac{\partial c_2^e}{\partial B} = 1$. Dividing through by $1+r$, this then shows that the derivative further simplifies to

$$
V'(B) = \frac{u'(c_1)}{1+r} \tag{8}
$$

Utility in the environment where the agent works is $V(B^w)$, and utility upon receiving education is $V(B^e) - d$. Following theorem 2 in Milgrom and Segal (2002), Equation (2) can be rewritten as

$$
d \leq V(B^e) - V(B^w) = \int_{B_w}^{B^e} V'(x)dx \tag{9}
$$

Let $c_1(B)$ be the period 1 consumption assigned by the value function with budget $B$. Since we have shown that $V'(B) = u'(c_1(B))$,

$$
\int_{B_w}^{B^e} V'(x)dx = \int_{B_w}^{B^e} \frac{u'(c_1(x))}{1+r}dx \tag{10}
$$

Now let $\epsilon^*$ be distributed according a mean preserving spread of the distribution of $\epsilon$ and assume that $u'''(\cdot) > 0$. $c_1(B)$ and the analogous $c_2(B)$ are determined by the new Euler equation

$$u'(c_1(B)) = \beta E_{\epsilon^*} u'(c_2(B) + \epsilon^*)$$

Because $u'''(\cdot) > 0$, Leland's (1978) well known result on precautionary saving gives that $c_1(B)$ will be lower under $\epsilon^*$ than $\epsilon$ for any B. From concavity of $u(\cdot)$ this implies that $\int_{B_w}^{B^e} \frac{u'(c_1(x))}{1+r} dx$ is greater under $\epsilon^*$ than $\epsilon$. $\square$

## Proof of Proposition 2

Analogously to Proposition 1, define

$$\begin{aligned} V(B,\sigma) = max_{c_1,c_2} u(c_1) + \beta E u(c_2 + \epsilon + \sigma * z) \\ \text{s.t.} \\ (1+r)c_1 + c_2 \leq B \\ c_1, c_2 \geq 0 \\ \epsilon \sim F(\epsilon) \\ z \sim G(z) \\ E(z) = 0 \end{aligned} \tag{11}$$

The value function is now a function of the budget constraint and the distribution of risk. Similarly to Proposition 1, Equation (2) can be rewritten as

$$d \leq V(B^e, 0) - V(B^w, 0) \tag{12}$$

When we impose the mean preserving spread the right hand side becomes

$$V(B^e, \sigma^e) - V(B^w, \sigma^w) \tag{13}$$

Further, from Proposition 1

$$V(B^e, \sigma^w) - V(B^w, \sigma^w) > V(B^e, 0) - V(B^w, 0) \tag{14}$$

Using Jensen's Inequality and the continuous differentiability of $u(\cdot)$, it follows that

$V(B,\sigma)$ is decreasing continuously in $\sigma$, so let $\delta = \sigma^e - \sigma^w$. If $\delta < 0$ then $\sigma^e < \sigma^w$

$$\begin{aligned}
V(B^e,\sigma^e) - V(B^w,\sigma^w) &= V(B^e,\sigma^w+\delta) - V(B^w,\sigma^w) \\
&> V(B^e,\sigma^w) - V(B^w,\sigma^w) \\
&> V(B^e,0) - V(B^w,0)
\end{aligned} \tag{15}$$

Alternately, if $\delta > 0$, then by continuity of the value function, we can find $\delta$ sufficiently small so that

$$V(B^e,\sigma^w) - V(B^e,\sigma^e) < V(B^e,\sigma^w) - V(B^e,0) + V(B^w,0) - V(B^w,\sigma^w) \tag{16}$$

Where the right hand side of Equation (16) is positive from Equation (14). This gives us that, for $\delta$ sufficiently small

$$\begin{aligned}
V(B^e,\sigma^e) - V(B^w,\sigma^w) &= V(B^e,\sigma^e) - V(B^w,\sigma^w) + V(B^e,\sigma^w) - V(B^e,\sigma^w) \\
&= V(B^e,\sigma^w) - V(B^w,\sigma^w) - (V(B^e,\sigma^w) - V(B^e,\sigma^e)) \\
&> V(B^e,\sigma^w) - V(B^w,\sigma^w) - (V(B^e,\sigma^w) - V(B^e,0) + V(B^w,0) - V(B^w,\sigma^w)) \\
&= V(B^e,0) - V(B^w,0)
\end{aligned} \tag{17}$$

The result follows. □